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Sustainability Conversations for Impact: Transdisciplinarity on Four Scales

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SUSTAINABILITY CONVERSATIONS FOR IMPACT:

TRANDISCIPLINARITY ON FOUR SCALES

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Sustainability is a dynamic, multi-scale endeavor. Coherence can be lost between scales – from project teams, to organizations, to networks, and, most importantly, down to conversations. Sustainability researchers have embraced transdisciplinarity, as it is grounded in science, shared language, broad participation, and respect for difference. Yet, transdisciplinarity at these four scales is not well-defined. In this dissertation I extend transdisciplinarity out from the project to networks and organizations, and down into conversation, adding novel lenses and quantitative approaches.

In Chapter 2, I propose transdisciplinarity incorporate academic disciplines which help cross scales: Organizational Learning, Knowledge Management, Applied Cooperation, and Data Science. In Chapter 3 I then use a mixed-method approach to study a transdisciplinary organization, the Maine Aquaculture Hub, as it develops strategy. Using social network analysis and conversation analytics, I evaluate how the Hub's network-convening, strategic thinking and conversation practices turn organization-scale transdisciplinarity into strategic advantage.

In Chapters 4 and 5, conversation is the nexus of transdisciplinarity. I study seven public aquaculture lease scoping meetings (informal town halls) and classify conversation activity by "discussion discipline," i.e., rhetorical and social intent. I compute the relationship between discussion discipline proportions and three sustainability outcomes of intent-to-act, options-generation, and relationship-building. I consider exogenous factors, such as signaling, gender balance, timing and location. I show that where inquiry is high, so is innovation. Where acknowledgement is high, so is

intent-to-act. Where respect is high, so is relationship-building. Indirectness and sarcasm dampen outcomes. I propose seven interventions to improve sustainability conversation capacity, such as nudging, networks, and using empirical models.

Chapter 5 explores those empirical models: I use natural language-processing (NLP) to detect the discussion disciplines by training a model using the previously coded transcripts. Then I use that model to classify 591 open-source conversation transcripts, and regress the sustainability outcomes, per-transcript, on discussion discipline proportions. I show that all three conversation outcomes can be predicted by the discussion disciplines, and most statistically-significant being intent-to-act, which responds directly to acknowledgement and respect.

Conversation AI is the next frontier of transdisciplinarity for sustainability solutions.

DEDICATION

I dedicate this dissertation to the community of civic leaders, researchers, educators, citizens and data

scientists who contribute to sustainability collaborations. You bring hope to our human-environmental

systems, one conversation at a time.

The aquaculture community who led the lease scoping meeting conversations was wonderfully inquisitive and welcoming. Each lease scoping meeting was a lesson in community psychology and marine science. Thank you, anonymous farmers, participants and other interviewees, for your candor and insight.

The greatest acknowledgment goes to my fiancé, Peter van Walsum, Ph.D., who was at my side all the way to the finish line. He dove into the literature with me, and made helpful observations about collaboration, aquaculture, and human nature. Peter, thank you for your clarity, passion, and love.

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CHAPTER 1

INTRODUCTION

Humans are biologically programmed to cooperate. Dating back to the 1970s scientists have analyzed cooperation in the natural world (Trivers, 1971), modeled it (Axelrod and Hamilton, 1981), debunked it (Thaler & Sunstein, 2006), and evolutionarily traced it (Henrich, 2016). They conclude that prosocial traits such as agreeableness, conscientiousness, and fairness are inherited and are essential to our survival. In effect, our culture has taught our genes to collaborate (Henrich, 2016; Boyd, 2017). Despite this, cooperation is not easy, as humans do not always perform in rational ways.

Our fragmented society -- composed of religious, regional, economic, and digital fiefdoms -- seems to have worn away at our collaborative nature. In fact, in their opinion report, "The Dialogue Divide," where Feldman and McCorkindale (2020) surveyed 5,000 people in the U.S., Germany, Brazil, India and the UK, 70% of respondents considered dialogue with someone holding differing views to be a "problem" or "major problem."

The awareness of the dueling possibility and fragmentation, along with improved technologies, is bringing collaboration into focus. Over the last ten years there has been a growing interest in local communities and pro-social impact networks (Ehrlichman, 2021), citizen-academy research (Hart & Silka, 2019), game theory and cooperation (Hoffman & Yoeli, 2022), and dialogue (Isaacs, 2016; McGreavy et al., 2021). Behavioral researchers warn that diverse groups can become biased, acrimonious, or driven to premature consensus (Page, 2017) -- all the more so with today's polarized social media (Pennycook & Rand, 2021).

In this dissertation I examined four scales of collaboration where diverse groups thrive: research projects, organizations, networks, and conversations. In Chapters 2 and 3 I looked at transdisciplinary research projects and organizational collaborations, respectively. Transdisciplinary projects are purpose-

driven groups coming together to co-create insight, blending scientific and alternative knowledge in a manner that honors different ways of knowing, and that brings about solutions in our human and natural world (Silka, McGreavy & Hart, 2019). In Chapter 2 I proposed expanding Lang et al.'s (2012) sustainability-related transdisciplinary research framework by adding novel academic disciplines: Applied Cooperation (specifically, behavioral insights), Organizational Learning (specifically, dialogue), Knowledge Management (specifically networks), and Data Science (specifically, natural language processing).

For the organization in Chapter 3, when I examined a transdisciplinary organization, the Maine Aquaculture Hub, these novel disciplines contributed to differentiating capacities (skills, plus motivation and resources to apply them). Specifically, the capacities of network convening, strategic thinking and conversation helped, respectively, with scaling up impacts (via networks), imagining and deliberating strategy (via strategic thinking), and responding to opportunity in a generative way (via conversation).

In Chapter 4, the role of productive conversation (Skifstad & Pugh, 2014; Pugh, 2020), came to center stage. Conversation had entered the fabric of the transdisciplinary models for Chapters 2 and 3, but I then considered conversations that were among ad hoc collaborators, not among research team members (as in Chapter 2), nor within organizations (as in Chapter 3). Chapter 4 explored the language and function of dialogue (Dixon, 2019) and how dialogue practices evolved into my Columbia University team's productive conversation model with additional elements of facilitation. I attended, recorded (manually) and coded transcripts from seven aquaculture lease scoping meetings (public town halls about siting aquaculture farms). With these and a sampling of five other conversations, my research team and I sought to detect how specific moves that make up the utterances in conversation (Zelasko, Pappagari & Dehak, 2021), could lead to collective benefits. I measured how the proportion of the five "discussion disciplines" creates innovation, accountability, and connectedness. (In the chapters that follow readers will come to know the five discussion disciplines: Integrity, Integrity-Q, Courtesy, Inclusion and Translation, and their opposites, such as inauthenticity, certainty, exclusion, abstraction, and sarcasm.)

Specifically, in the lease scoping meeting transcripts I evaluated the way in which cognitive diversity and identity diversity played out in interactions. I assessed how these elements affected sentiment and meaning in conversation. I found that increasing inquiry (Integrity-Q) correlated with options being generated. Increasing acknowledgement (Inclusion) correlated with the intent to take action. Increasing respect (Courtesy) correlated with relationship-building. Snarky moves reduced all outcomes. I also measured interactions contributing to psychological safety (Edmondson & Lei, 2014), such as the intensity of the Courtesy and Inclusion discussion disciplines; costly signals (Spence, 1973), such as disproportionate investment in connections; and indirect speech (Pinker et al., 2009), such as innuendo. I asked how pivotal, high-emotional moments in conversations could lead to the development of relationships. Based on these findings, I end Chapter 4 with a seven-point solution for improving conversation skill and practice.

In Chapter 5, my research team used machine learning to detect and quantify the impact that discussion disciplines have on outcome-types attractive to sustainability contexts. We used three model types: One a graphical approach, called TF*IDF (term frequency/indirect document frequency, similar to search engine optimization), two neural networks, and a rules-based lookup-and-append process. The advanced neural network (Google's open source BERT application, or Bidirectional Encoder Representations from Transformers) had the best predictive ability, and was used to label 591 transcripts from several open-source corpuses. That labeled data was, in turn, used in a regression model to test the explanatory power of the discussion disciplines on the outcomes of innovation (options-generation), accountability (intent-to-act), and mutuality (relationship-building), as had been done with the smaller, seven-transcript aquaculture lease scoping meeting data. The strongest result was the explanatory power of Inclusion (acknowledgement) as a driver of intent-to-act or closure. This corroborated research by Zhang et al. (2020) who found that a similar conversation feature, "coordination" related to closure. This also corroborated Rand et al.'s (2014) finding that observability contributes to prosocial actions related to the environment.

My AI for conversation research could provide a means for improving sustainability stakeholders' ability to co-create futures, persevere, and adapt. With that hope in mind, I propose improving sustainability conversations through investments in conversation training, networks, improved models, better data sets and instrumentations, and easy-to-use tools. Together, those interventions will expose the patterns inside our conversations, and empower us to interact for good.

My research on "Sustainability Conversations for Impact" focused on only one industry, aquaculture, at one time, in one region. My NLP models excluded some context, and nonverbal inputs like cadence, voice inflection, facial expressions, or physical gestures. Resource limitations prohibited more advanced AI and data development. I would hope that my models, anonymized aquaculture data, and benchmarks could be open-sourced for conversation research.

This dissertation expands researchers' toolbox transdisciplinarity inside of four scales: research teams, organizations, networks, and conversations. It provides novel lenses for strategic planning, teaming, and sense-making for groups. Finally, it proposes productive conversation for communities to invent their sustainable futures.

CHAPTER 2

A TRANSDISCIPLINARY RESEARCH FRAMEWORK WITH CONVERSATION

Abstract

Transdisciplinary research -- using a pluralistic engagement process to co-produce knowledge -- propels sustainability science problems toward solutions by better and more equitably incorporating the diverse elements of human-environmental systems. Transdisciplinarity is inclusive, open-minded, and reflective. However, the inclusion of varied disciplines and epistemologies in human-environmental systems research is not easy. It requires appreciating where, in the knowledge co-production process, that one or more novel disciplines can enlighten or "lighten" the research — e.g., where those disciplines from inside and outside the academy can offer theoretical, empirical, or even relationship benefits.

Scholars concur that transdisciplinary research involves constructing shared language, co-producing knowledge, adopting deliberate project process, using systems thinking, applying diverse ways of knowing, anticipating multiple scales, and using effective project team practices. I argue that adding novel research domains can make these elements more effective. I also suggest that the ability to extend transdisciplinarity into the operations of organizations, and the networks that link them, is a benefit of adding these additional domains. Applied cooperation, the study of human (inter)actions and behavioral insights, may inform the scope and definition of the transdisciplinary collaboration. Organizational Learning, especially dialogue, may improve the relations, interaction, and sense-making during knowledge co-production. Data Science, especially Natural Language Processing (NLP), the computational study of language in digitalized texts, can be used to point out latent collaboration risks, opportunities and outcomes. Knowledge management (KM), the co-creation and exploitation of knowledge for organizational performance, weaves through transdisciplinary research, bridging meaning with stakeholders, who themselves integrate knowledge into their organizations and networks.

An implication for this line of thinking is that transdisciplinary researchers can more authentically and more efficiently co-produce and use knowledge with stakeholders. Adding to the arsenal of

methodologies, data sets, boundary objects, and stakeholder relationships can make transdisciplinarity more productive, accepted and sustainable for solving human-environmental systems problems.

2.1 Introduction and Literature Review

Human-environmental systems interact in ways to extract, protect, manage, assign or improve shared natural resources. Garrett Hardin (1968) postulated that "the commons," including environmental or other resources held in common, were destined to be destroyed if not privatized or regulated by the state. He claimed that: 1. Individuals, acting out of self-interest, would be incentivized to consume as much as they could of common or shared resources, and, 2. in so doing, they would diminish the resource beyond repair. He added that the two evils of this tragedy are no constraints on use and free riding.

From a game theoretic perspective, Hardin's logic seems sound. People who play a one-round game and who cannot communicate are likely to devolve into an evolutionarily stable system (ESS) of defecting (non-cooperation). Scholars objected to Hardin's assumptions and his call for private ownership or government control (e.g., Berkes & Feeny, 1989; McCay & Acheson, 1987; Ostrom, 1990): They provided a chorus of questions and criticisms, "What are the rules-in-use for this game in practice?" "Are actors communicating?" "What if there were norms that favored respect for the resource and other humans?" And, "What is the role of our self-organizing human institutions and resource stewards?" After all, these researchers could trace evidence of sustainable commons management to prehistoric times, and even documented examples (Schaefer, 1959, as cited in Dietz et al., 2002).

Before answering those questions, let's take a bird's eye view of the prisoner's dilemma used to model cooperation. The analysis starts with a 2x2 payoff matrix from the perspective of the rows (Axelrod & Hamilton, 1981), as illustrated in Figure 2.1. For Player A, playing a one-shot game, the upper left, Cooperation-Cooperation ("Reward") is second highest reward, A's Cooperation with B's Defection ("Sucker") is lowest reward, A's Defection withB's Cooperation (Temptation) is highest reward, and A's Defection with Bs Defection (Punishment) is 2nd lowest reward. Without

communicating, Player A fears being a Sucker, but is uncertain B might cooperate. Then, reasoning "rationally," Player A assumes Player B would have the same calculus, and would more likely defect. So, tragedy ensues, where Player A defects, and so does Player B. Rewards are always lowest when people act "rationally" in a single period ("one-shot"), no-communication game.

Player A's one-shot move

	Cooperation	Defection
Cooperation	Both gain moderately	Best for Player A (Temptation) Worst for Player B (Sucker)
Defection	Best for Player B (Temptation) Worst for Player A (Sucker)	Second Worst for Both (Punishment)

Player B's one-shot move (row label)

Figure 2.1: Contextual Payoff for the Prisoner's dilemma

2.1.1 Cooperation success factors

Not long after Hardin's "tragedy" pronouncements, game theorists and biologists showed that communication and reciprocity can lead to cooperation. For example, Trivers (1971) studying the de-facto game-theoretic calculations of animals, suggested that we may have a genetic predisposition for reciprocity. Axelrod and Hamilton (1981) later demonstrated that when two players are interacting on a repeated-game basis, reciprocity is an environmentally stable system, specifically a generous TIT FOR TAT. (This was later refined as a win-stay, lose-shift strategy [Nowak, 2006].)

Nor was it only the game theorists who took a view opposite to Hardin. A decade before Hardin, Schaefer (1959) was intrigued by the evidence of cooperative management of the fishery commons. Schaefer and others just after Hardin asserted that tragedy or calamity is not a pre-ordained outcome if

actors can communicate, negotiate access rights (create excludability), and interact over time (Berkes et al., 1989). Moreover, they argued that "open access" is not the same as a "common property" regime (access and use rights). These researchers argued that the "tragedy of the commons" is not a dilemma, but a coordination and regime problem (Berkes et al., 1989).

Panchanathan and Boyd (2004), writing from the cultural-evolution angle, went as far as to show that humans' form institutions and culture that support such cooperative regimes. These human practices have coevolved with our species. Similarly, Ostrom (2009b, p. 2009) remarked that "[h]umans have an evolved capacity to adopt norms," specifically trustworthiness and reciprocity, "Gaining reputation for being trustworthy is an asset that can increase individual-level outcomes." Panchanathan and Boyd (2004) put a finer point on it: norms and institutions evolved precisely to regulate our cooperative behavior. This regulation comes through reputation, punishment and monitoring. Later experiments showed that individuals self-regulate more effectively when a behavior is monitor-able (Rand, Yoeli, & Hoffman, 2014).

In summary, humans have evolved to cooperate, and this act accompanies the components of innate reciprocity, norms, the ability to communicate, and the ability to create various access or excludability regimes.

2.1.2 Complexities of human-environmental systems

Today, it is generally accepted that Hardin's 1968 pronouncement was flawed. Norms, cultures, and observability may bolster cooperative behaviors around human-environmental systems. While we can be optimistic about collaboration, Ostrom (2009a) stressed that human-environmental systems behave erratically because of these very characteristics. She noted that human-environmental systems act in nonlinear, recursive ways, perform differently at different scales in different contexts, and are prone to shocks of ecological, institutional and human origins (Ostrom, 2009a). Each of these characteristic presents obstacles for researchers and stakeholders:

1. *Human-environmental systems act in non-linear, interdependent ways*. Unintended consequences may ensue when changes of human, social, or physical systems occur after a delay, or provide feedback in an unpredictable manner. One can see the oscillation and over-shoots or collapses as described by system dynamics (Kim, 2000; Kish et al., 2021). Some changes are abrupt or irreversible.

2. *Inputs and outcomes occur on multiple scales and across multiple time periods*. Practices at one scale may not work at other scales. Each scale has to be modeled differently as properties (physical, institutional, economic, behavioral) may act or appear distinctly on specific scales, or there can be feedback between scales (Kates et al., 2001; Deitz et al., 2002). Importantly, participants (and regimes) may not stay around to engage through a physical change in environment. As a result, controlled experiments involving whole social-environmental systems are difficult to run.

3. *Context and scope can make research become political and costly*. Effective human-environmental knowledge systems require salience (relevance), legitimacy (inclusiveness), and credibility (rigor) (Cash et al., 2003). The physical, social, moral, economic and institutional context can improve or reduce the amount of effort required to get research right and monitor it consistently (Gurney et al., 2019). Thus, choosing and communicating the boundary or goals of the research can be fraught. For example, mistaking the scope can compromise legitimacy with indigenous peoples (McGreavy et al., 2021), while lacking a controlled environment can compromise credibility (Cash et al., 2003; Hart & Silka, 2020).

4. *Humans are predictably unpredictable*. While humans do have some predictable autonomic and rational responses, they are influenced by priming, norms, default values, and salience, among other choice architectures (problem-framing that accommodates human bias or risk-management behavior) (Bujold, Williamson & Thulin, 2020; Hallsworth & Kirkman, 2020). They can be

affected in invisible ways by their networks' complex spreading phenomena, such as long or wide

bridges of influence (Lehmann & Ahn, 2018). Thus, predicting human behavior —whether as

regulator, consumer, scientist, or environmental steward— is very difficult.

2.1.3 Gaps in Sustainability Science Research Frameworks

Kates et al (2001, p. 641) describe "Sustainability science," as a field which studies humanity

with nature, and global with local, as it "seeks to understand the fundamental character of interactions

between nature and society. Such an understanding must encompass the interaction of global processes

with the ecological and social characteristics of particular places and sectors."

Researchers have developed useful frameworks, theories, and models to address the challenges of

studying human-environmental interactions (e.g., Partelow, 2016). Ostrom's Social-Ecological Systems

(SES) framework is one framework designed to incorporate the characteristics of human-environmental

systems (nonlinearity and interdependence, scales, context, irreversibility, and even human

"irrationality") (Ostrom, Janssen, & Anderies, 2007). However, the authors, themselves, pointed out that

frameworks and models only provide a limited understanding of human behavior. People facing the same

situation vary substantially in their behavior, and the institution's influence boundaries could impact its

performance.

McGinnis and Ostrom (2014) updated Ostrom's SES framework to more completely incorporate

dynamic interactions and multiple scales. This advancement and the growth of researchers contributing to

frameworks (Pulver et al., 2018), signaled a mounting interest in expanding the SES aperture. Multiple

researchers called for multidimensional, non-linear, multi-scale, shared-blame, analysis. Yet, the

proliferation of frameworks and models concerned scholars, who warned that their complexity was

directed at convincing researcher colleagues rather than at broader sustainability science stakeholders

(Pulver et al., 2018). In the words of Clark, Van Kerkhoff, Lebel, and Gallopin (2016a, p. 4572), "It

follows that in the face of complexity of the systems we seek to understand for sustainability, the ultimate requirement for researchers seeking to produce usable knowledge may simply be humility."

2.1.4 Emergence of Transdisciplinary research

In this section I synthesize a definition of transdisciplinary research. Ostrom et al (2007, p. 15177) explain the rationale for the first characteristic of transdisciplinary research: combining disciplines. The authors pointed out that discipline-specific frameworks cannot fully represent complexity:

> If sustainability science is to grow into a mature applied science, we must use the scientific knowledge acquired in the separate disciplines of anthropology, biology, ecology, economics, environmental sciences, geography, history, law, political science, psychology, and sociology to build diagnostic and analytical capabilities.

Scholars studying human-environmental systems have made considerable progress in addressing sustainability science complexities by putting pluralistic collaboration at the center of their research. This is the first building block of transdisciplinary research. Transdisciplinary research crosses academic disciplines and/or industry domains.

Discipline-crossing is not new. For the last fifty years, researchers have advocated for this. The 1970s marked some of the earliest calls for interdisciplinary research and practice. While researchers' original goal was to break down disciplinary silos (and the risks that silos caused blind spots, redundancies, or accusations of academia's irrelevance), an emerging goal was pragmatism. Reaching beyond the academy to subjects and their insights could reduce the time to insight (through broader exposure to application domains), reduce time to implementation (through reduced learning curves for civil society), and reduced errors of unintended side-effects. For example, Apostle et al. (1972, 9) pleaded:

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The guiding principle is not the need to demolish the disciplines, but to teach them in the context

of their dynamic relationships with other disciplines and with the problems of society… [I]t may

be argued that one of the reasons for the tarnished image of science is public reaction to its power

to produce specialized applications of knowledge, without a corresponding development of the

synthesizing framework which can illuminate their side-effects and long-term implications.

This suggests a refinement of the transdisciplinary research definition: Not just multiple disciplines, but

specifically inclusion of civils society; and not just civil society's inclusion in the project, but rigorous

translation between research and practice. (See also: Belmont Forum, 2022). . For example, Stokols

(2006), writing from the discipline of psychology, argued for transdisciplinary research in collaboration

with communities.

Stokols pointed out that neither the concept of integrating scholarly disciplines, as with Apostle,

Berger et al. (1972), nor the call for participatory action research (Kurt Lewin, 1951, as cited in Stokols,

2006) were novel by 2006. But, Stokols seemed to cross a threshold at the time: He called for a three-

pronged transdisciplinary integration framework across organization participation scope, geographic

scale, and analytic (disciplinary) scope (Stokols, 2006). Stokols' (2006, p. 67) called for this

multidimensional starting point to generate "novel conceptual models and empirical investigations that

integrate and extend the conceptual theories and methods of particular fields."

Lang et al. (2012) reviewed transdisciplinarity within sustainability science over twenty years.

The authors concluded that transdisciplinarity must re-conceive social and scientific problems together.

Lang et al. observed that transdisciplinary research has a sort of boomerang effect, bringing change from

the research endeavor back to science and society participants:

Transdisciplinarity is a reflexive, integrative, method- driven scientific principle aiming at the

solution or transition of societal problems and concurrently of related scientific problems by

differentiating and integrating knowledge from various scientific and societal bodies of knowledge (Lang et al., 2012, p. 26).

In fact, at the time of Lang et al.'s writing, transdisciplinary research was at an inflection point. Jahn et al. (2012, p. 9) went so far as to call transdisciplinary research "interventionist":

> In our understanding, transdisciplinarity is more than a research approach that is better suited to cope with the complex problems that scientific progress itself continuously creates. Rather, it indeed fundamentally addresses the relation between science and society. It is interventionist in the sense that it methodically frames, structures, and organizes the societal discourse about the problematic of an issue at stake.

Combining Lang et al. (2012), Jahn et al. (2012), Stokols (2006), and Apostle and Berger (1972), the scope of transdisciplinary research includes: 1. Multiple academic disciplines; 2. Academia and civil society; and 3. A feedback loop between research and implementation. As a result, Jahn et al. (2012) claim, transdisciplinary research is improves knowledge co-design and production, integration, extension, convergence and intervention. **In sum, transdisciplinary research is discipline-integrating, sector-crossing, and action-biased.**

2.1.5 Persistent Puzzles in Transdisciplinary Research

Scholars have asserted that transdisciplinary research improves the scope of analysis, includes civic society, accelerates knowledge integration, and changes social discourse. Yet, four puzzles persist:

1. **How can we accelerate knowledge flow?** Rapid knowledge transfer and application can be inefficient with hierarchical institutions, where knowledge hoarding and delays in knowledge flow can persist (Davenport & Prusak, 1998; Dixon, 2000). Knowledge management scholars have shown that networks, by contrast, provide reach, scale, local adaptation, and transparency, and thereby promise a set of benefits to help accelerate the co-production and use of knowledge

(Wenger, 1998). However, networks require design and management. Networks can lose energy, err from their original goals, and spiral into bias, sometimes manipulated by a minority (Watts, 2011; Pugh & Prusak, 2013; Hansen & Pries-Heje, 2017; Ehrlichman, 2021). Networks need to be designed carefully for intentionality, alignment and coherence (Pugh et al., in prep, 2022).

2. **What is the contribution of conversation?** Most humans describe interactions by the event, milestone, or time-interval. However, it is often from conversation to conversation (or from utterance to utterance) that knowledge is built or validated (Dixon, 2019). Transdisciplinary researchers see the value in building rapport, trust, and transparency. When researchers use the conversation as a unit of analysis, it can be instructive (for example, Johnson & McCay, 2014; Isaacs, 2016). Yet, it is rare that researchers discuss the research data as an accumulation of meaning through conversations (Druschke & McGreavy, 2016; Daigle et al., 2019).

3. **How can we accelerate the inclusion of alternative ways of knowing**? Pulver et al. (2018), in their review of transdisciplinary, sustainability science frameworks, pointed out that, while the political or social origins differ across the human-environmental systems research approaches, there is consensus about the need to protect the vulnerable. This protection could not be possible (or, at least scalable) without understanding human meaning and motivation. While many sustainability science researchers incorporate themes of trust, norms, and affect, their premise is often that human behavior is "rational" in the economic sense of the word. However, Tversky and Kahnemann (1973) showed that humans operate on both rational and autonomic systems and have biases. Humans also have conscious and unconscious emotional or economic motivations (Thaler, 1985; Thaler & Sunstein, 2008). These motivations and biases are essential to our ways of knowing. Our ways of knowing are informed by our sensory perceptions, our identities, and our group affiliations. For example, indigenous knowledge systems may incorporate intuition or unspoken group norms, in addition to perception. Daigle et al. (2019, p. 783) capture this fluidity:

The Passamaquoddy word, 'Menakatoluhkatomon' (we move together), illustrates the relational aspects of tribal culture to the social ecological networks within the environment. It also describes the collective nature of decision making or 'kinship ties' through clan networks as it relates to living within these social ecological areas.

4. **How can we ensure that the empirical models are reusable and scalable?** Researchers of human-environmental systems have been criticized for using case comparisons, not large-N data sets. The products are often frameworks and theories, not models. I use McGinnis and Ostrom (2014) definitions: "Frameworks" are lists of elements directed toward organizing knowledge, and that can be used to construct causal arguments, and organize inquiry. "Theories" posit causal relationships among those elements. Meanwhile, "models" are empirical descriptions of reality, including the functional relationships between independent and dependent variables. Some researchers contend that the frameworks and checklists, so frequently espoused by human-environmental systems researchers, focus too much on inventorying and classifying system components, and not enough on measuring, modeling and evaluating interactions (Agrawal, 2001; Partelow, 2016). There are notable recent endeavors to combat this: Gurney et al. (2019) provide a promising example of operationalizing McGinnis and Ostrom's (2014) social ecological systems framework. Gurney et al. (2019) quantify multiple locations of coral reef commons management. The researchers did not claim victory. They noted that it took many stakeholders many months of effort to agree to "essential variables," and, during evaluation, to normalize local with national data, a direct investment in extending the empirical findings between scales. This involved "triangulation across participatory, theory- based and statistical approaches" (Gurney et al., 2019). Stressing their status as early pioneers in multi-scale empirical work, Gurney et al. (2019) called for similar multi-scale measurement and evaluation.

2.2 A revised transdisciplinary research capacities model

Researchers at the Center for Behavior and the Environment (a subsidiary of RARE.org), have proposed merging social, behavioral, and environmental science (Bujold, 2020). Bujold et al. (2020), reviewed extensive research on sustainability science, and pointed out that, while institutions, rules, and incentives are publically-touted solutions to sustainability gaps, human bias and reputations play an even larger role. The authors did an extensive retrospective on the predictors for pro-social, pro-environmental behavior change, and concluded that successful human-environmental systems interventions address bias and shortcuts (building from Tversky & Kahneman [1973]). Bujold et al.'s (2020) model includes information, rules, social systems, monetary rewards, choice architectures and emotional appeals. Applied Cooperation researchers Cinner (2018). Rand et al. (2014) and Centola and Macy (2007) strongly influenced this list, with their emphasis on seemingly "irrational" or "emotional" human tendencies. For example, Bujold et al. cited Rand et al. (2014) to demonstrate links between prosocial behaviors, choice architectures, social influence (observability, norms), and habits.

If transdisciplinary research seeks to be discipline-integrating, sector-crossing, empirical and action-biased, it has a lot to learn from Rare.org's model. Rare.org's model adds to sustainability science the diverse academic disciplines of Applied Cooperation, Organizational Learning, Knowledge Management [KM] and Data Science. These carry rich histories alongside the sustainability science field, and may address transdisciplinary research's persistent puzzles of knowledge-flow, conversation, ways of knowing, and scale.

I propose taking up these disciplines inside of multi-scale transdisciplinarity practice. I will discuss each in turn:

2.2.1 Knowledge Management: Knowledge-transfer and production, Network Design

Knowledge management is the practice of leveraging knowledge (know-how, insights) across people, place, and time for the purpose of productivity, innovation, or scale (Dixon, 2000; Davenport and

Prusak, 1998). Knowledge (co)creation and transfer are the central objectives of knowledge management. Lang et al.'s (2012) transdisciplinarity process stages (initiation, knowledge co-development, and integration of knowledge) resemble the widely-referenced knowledge management domain's knowledge transfer process, the socialization-externalization-combination-integration (SECI) of Nonaka and Konno (1998). The SECI model has been updated in the select-plan-discover-broker- reuse steps of Knowledge Jam (Pugh, 2011) and Knowledge Continuity process (Hovell, in Pugh, 2014). Knowledge Jam and Knowledge Continuity add deliberate brokering or embodiment of knowledge, measurement, and facilitated conversation. Pugh (2011) defines the Knowledge Jam as a transdisciplinary process that co-creates knowledge across, and within, diverse stakeholder groups. Knowledge Jam uses boundary objects, rigorous joint scaffolding of the knowledge topics, legitimization and sponsorship by leadership, conversation between knowledge originators and brokers, and explicit integration of knowledge into practical applications. The primary difference in these processes from Lang et al.'s (2012) transdisciplinary framework is a centering on conversation.

An effective mechanism for the creation and transfer of knowledge is the knowledge network. It is the organizing construct for continuous and adaptive knowledge creation across organizational boundaries (Wenger, 1998; Pugh & Prusak, 2013, Ehrlichman, 2021). Using structures like routine gatherings or asynchronous discussions, knowledge networks seek to create shared intent, intent-design alignment, and practice-coherence. Intent could be knowledge-products, scale economies, knowledge translation, and/or individual member support (Pugh & Prusak, 2013; Algeo & al., 2019). The knowledge network can be a productive convener of transdisciplinary research, a conduit for knowledge, a critical agent in implementation, and, as I discuss in Chapter 3, a resource to the ongoing organization that inherits the transdisciplinary research findings.

2.2.2 Organizational Learning: Dialogue, Conversation, and Strategic Thinking

Organizational learning is a collection of behavioral and cognitive practices for the organization's collaborative resilience and renewal. These practices were synthesized by Harvard, MIT and other

universities in 1990. They were revolutionary for their time, as they centered on the notion that collective thinking, not just hierarchy or protocol, is the seed for productivity, problem-solving and employee satisfaction (Senge, 1990). Organizational learning's core elements included systems thinking, mental model identification, dialogue, and double-loop learning (learning how we learn) (Senge, 1990).

Transdisciplinary research has integrated systems thinking from the field of organizational learning. A less frequent import from the field organizational learning is dialogue. The dialogue practices, first introduced by David Bohn in the 1980s, were included at the MIT Center for Organizational Learning at its inception (Isaacs, 1999b). Dialogue seeks to discover and generate collective insight and purpose through an emergent form of discourse.

This is not easy today, noted the Dialogue Divide Project, a joint research project of University of Southern California, ICF Next, and the Institute for Public Relations (2020), who found that 76% of US respondents stated that it was difficult to engage with people of different views in respectful political dialogue. Yet, the researchers noted that there is reason for optimism, as respondents were in agreement that leaders could role-model and institute non-partisan dialogue. Turco (2016), studying firm-wide conversation, similarly pointed out that leaders' advocacy and role-modeling can help dialogue take hold. This "radical transparency," as Turco described it, requires leaders to seek out a variety of opinions, hire diverse candidates, and change the content and process of conversation. Turco (2016, p. 12) found that productive conversation improved rapport, innovation, and accountability: "[D]ecisions executives made had more legitimacy with the workforce because employees had been invited into the conversation and knew their voices had helped shape the decision-making context." Skifstad and Pugh (2014) similarly described business outcomes of productive conversation as problem-solving, innovation, and closure.

Strategic thinking extends organizational learning practices into planning by leadership teams. Strategic thinking applies the practices of dialogue, story, inquiry and systems thinking toward strategy development (Liedtke, 1998). Chapter 3 introduces the strategic thinking practices —Intent-Focused,

Systems Perspective, Hypothesis-Driven, Thinking-in-time, and Intelligent Opportunism — which enable participants to co-generate a map of the possibility space for action and differentiation.

2.2.3 Applied Cooperation: Modeling behavioral Insights, dual process theory

In the early 2000s. Game theorists, anthropologists and social psychologists were introducing coupled evolutionary models of human biology, institutions, and group norms (e.g., punishment and reputation) (Panchanathan & Boyd, 2004). In another domain, legal scholars were merging behavioral science with legal research (Sommers, 2006). Still in another domain, cognitive scientists were studying the impact of cognitive bias on information-use in groups (Stasser & Titus, 2003). While all of these disciplinary "crossovers" had different approaches, what was converging was that there could be quantifiable improvements in collaboration: preparation, performance, and prediction. And, on the other hand, there could be priming (pre-interaction preferences) that could inhibit knowledge-creation or absorption. All have found their way into the intellectual corpus of Applied Cooperation.

Transdisciplinary research has to navigate a tricky maze between credibility of scientific method, inclusivity of different ways of knowing (legitimacy), and different conceptualizations of its products (relevance or salience) (Cash et al., 2003). Applied cooperation theory (Hoffman & Yoeli, 2022) may help navigate this maze, by using cognitive-, behavioral- and neuroscience, and game theory. Applied cooperation also incorporates the evolutionary origins of cooperation in our culture, such as the mechanisms of reciprocity, signaling, risk, attention, compliance, and indirectness, to name a few. For example, this field has predicted the mechanisms and effects of interpersonal reciprocity (motivated by reputation), network reciprocity (inversely correlated with numbers of connections), group reciprocity (correlated with numbers of groups, while inversely correlated with group size), and so on (Nowak, 2006).

Behavioral insights integrate humans' "dual-processes" (the co-existence of cognitive shortcuts [thinking fast] with deliberation [thinking slowly]) (Tversky & Kahneman, 1974). Sample behavioral

insights include our tendency to do good when observed (Rand et al., 2014), to respond to choice architectures (Thaler & Sunstein, 2006), to cooperate differently when one has repeated games (Axelrod & Hamilton, 1981), to maintain reputation (Panchanathan & Boyd, 2004) and to problem-solve and prepare better in racially-diverse groups (Sommers, 2006).

Social psychology, behavioral psychology, and game theoretic outcomes can be measured using careful study design and randomized control trials (Hallsworth & Kirkman, 2020). The behavioral insights model, MINDSPACE (messenger, incentives, norms, defaults, salience, affect, commitments, and ego) has been successfully used by national and local governments, and international development Organizations (e.g., UN, World Bank) (Hallsworth & Kirkman. 2020, 51-54). The MINDSPACE model helps bring research into policy. This includes sustainability behavior, such people reducing their energy consumption when observed (Rand et al., 2014).

2.2.4 Data Science: Machine learning/Natural Language Processing

What data science promises to transdisciplinary human-environmental systems research is large-N analysis of physical and social behavior. Data science has been rapidly growing in sustainability science with the explosion of sensor and internet data. Natural Language Processing (NLP) is the interpretation and extraction of facts from unstructured data, such as documents, websites, or live conversations. NLP's origins, text analytics, date back to the 1980s. Early text analytics involved a process called information retrieval. This is finding the presence of a word, phrase or form of speech inside of a text or digitized utterance. What's possible now, with increased computing power, is to use statistical methods in NLP models, such as term-frequency/indirect document frequency, or TF*IDF, and neural networks, which can discern and predict text patterns in documents and transcripts with considerable accuracy. Such statistical models can be used across tens of thousands, if not millions, of utterances and conversations to find a signature of a conversation transcript, and relate that to conversation outcomes, and, in turn, to human and environmental outcomes over time.

What this means for transdisciplinary human-environmental systems research is the ability not only to find patterns across seemingly noisy conversation data (for example, between stakeholders on the topic of land use), but also to find the patterns that have disproportionate impacts on outcomes. One can determine the likelihood that a conversation will converge, expand ideas, and build vital relationships, or go awry, close down ideation, or obfuscate information. One can use NLP models to assist stakeholders in understanding their interactions, such as participation in resource-focused town halls or social media.

2.3 Toward a new model of transdisciplinary research

In their review of the literature on transdisciplinary research, Lang et al. (2012) provide a simple, three step process for describing transdisciplinary research. In this process, similar to the SECI, knowledge jam, and knowledge continuity processes, Lang et al. show that transdisciplinary research spans intentional design, through phases of planning, knowledge-co-creation, and knowledge (re)integration. Finally, the process loops back, with learning reflectively and collectively. Boundary-spanners (stewards, interpreters, and advocates) who bring the new disciplines, such as data science, are able to bring important skills in recognizing risk of bias in knowledge co-production, reaching across diverse networks, and engaging in productive conversation,

Lang et al.'s (2012) knowledge co-production process framework provides a helpful armature for showing how the novel academic disciplines respond to the puzzles described above (Figure 2.2). This can highlight the most important opportunities for improving conversation's role (Organizational Learning/Dialogue), accelerating inclusion of diverse ways of knowing (Applied Cooperation/Behavioral Insights), improving knowledge flow (KM/Networks), and adding instrumentation (Data Science/NLP). Figure 2.2 shows these new disciplines' most important roles under the stages of Lang et al.'s (2012) three stages of transdisciplinary research. It is noteworthy that all stage, to a greater or lesser degree, benefit from all four.
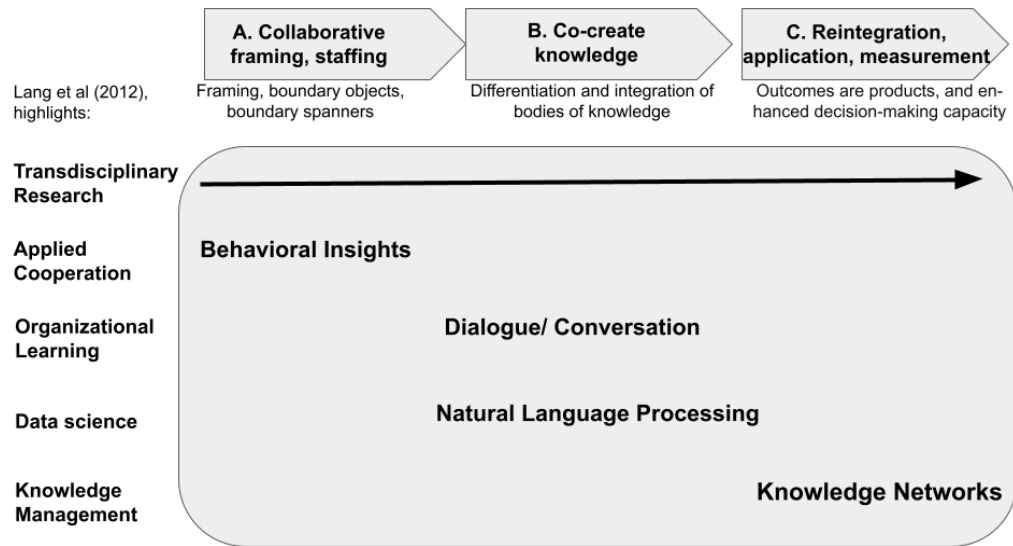
Figure 2.2: An expanded transdisciplinary research framework adapted from Lang et al. (2012)

Applied cooperation's behavioral insights particularly inform us about priming, default values, norms, and the importance of messengers early in the research. This may help with bringing participants to the table, helping design studies, and preparing for people to act in a variety of logical and (predictably) biased ways. Organizational learning's dialogue practices remind us to build psychological safety throughout the process, and especially while the project is in its most ambiguous, nail-biting stage of research. Dialogue or conversation can be the unit of action. Data science, and particularly NLP, can help us to measure the conversation patterns, over time, and monitor how specific conversation features help define and deliver transdisciplinary research and improve its legitimacy in the eyes of stakeholders. With data science one could also model collaboration at different scales, for example diverse research participants coming together in Stage A; inclusive research conversations in Stage B; and networks engaged in implementing sustainable common pool resource management practices in Stage C. The knowledge networks sub-domain of KM offers perspective on rapid knowledge integration using the network if the network leadership attends to intentionality, alignment and coherence (Pugh et al., 2022, in prep).

2.4 Conclusion

I have discussed cooperation success factors, complexities in human-environmental systems, transdisciplinary research puzzles, and some promising transdisciplinary research extensions from four domains only recently associated with sustainability (Bujold et al., 2020). The expanded transdisciplinary research model for creating sustainability solutions (Figure 2.2) directly addresses puzzles such as diversity in ways of knowing, participation in knowledge-creation, using conversation as the nucleus of action, and engaging at different scales. This expanded-discipline model does so by designing and managing conversation (Organizational Learning), accelerating knowledge reach and flow through networks (KM), better understanding norms and bias (Applied Cooperation), and evaluating language empirically (Data Science).

The practical implications of the expanded transdisciplinary research framework are that the researcher has a broader canvas, a broader corpus of empirical and case data, and a broader network. Solutions incorporating these additional disciplines will be perceived as more legitimate (e.g., using behavioral insights to incorporate indigenous ways of knowing), project teams more innovative (e.g., using organizational learning and systems thinking to better understand non-linear connections), and policy better informed (e.g., using once-siloed data contained in game-theoretic models, online platforms, or social media analytics labs).

Another practical implication may be that these other disciplines' practitioners and researchers will bring their own application domains, networks and connections. The added diversity, reach, scale and local adaptation of such networks (Pugh & Prusak, 2013) may help academia, policy-makers and civil society adapt more quickly and creatively to changes in environment, economy, and politics. For example, scholars in conspiracy theory many be able to combine their perspectives on fake news with the body of research on knowledge network behavior.

Finally, these novel disciplines -- which have originated in the messy business of running a business, interacting on an ongoing basis (rather than strictly in transdisciplinary research projects) -- pave the way for transdisciplinarity on the organizational, network, and conversational scale. I discuss those additional scales in Chapter 3 and 4. These novel disciplines also paved the way for sing transdisciplinarity at a lens to interpret conversation AI. They featured strongly in the design and interpretation of the conversation AI, which is the subject of Chapter 5.

CHAPTER 3

TRANSDISCIPLINARITY AS STRATEGIC ADVANTAGE:

THE CASE OF THE MAINE AQUACULTURE HUB

Abstract

Transdisciplinarity has grown as an academic subject over the last forty years. Human-environmental systems researchers and civil society have strongly committed to pluralistic approaches to research, decisions and implementations. Transdisciplinarity, by leveraging diversity, and the cognitive and motivational changes that diversity may bring, improves collective understanding and improves the likelihood that human-environmental systems are sustainable. With transdisciplinarity widely accepted as central to the salience, credibility and legitimacy of research, the National Science Foundation has made transdisciplinarity (dubbed "Convergence") a priority.

Transdisciplinarity practices have been developed around projects and programs, and less around ongoing organizations and networks. In this chapter, a case study shows how *implicit* transdisciplinarity capacities, operating in the context of an ongoing organization, align to, and complement, *explicit* transdisciplinary capacities using categories typically proposed with transdisciplinary research. Specifically, social or network capital appears to extend an organization's reach and legitimacy. Strategic thinking (intent-alignment, shared analogies, testable hypotheses, and opportunism) appears to accelerate sense-making, the exploitation of strengths, and deliberation. Finally, skillful conversation enables leaders to engage productively and to work through tension and ambiguity.

I observed the Maine Aquaculture Hub (the "Hub") organization during an important inflection point in the Hub's life, as it explored new positioning. Using social network analysis, I found that the Hub's deliberately-cultivated ties improved access to industry players and thereby improved strategic flexibility. Using meeting observation, interviews and quantitative conversation analysis, I found that strategic thinking practices and conversation skills resulted in improved industry insight, swift options-

generation and logical, respectful deliberation. Finally, I propose that such implicit transdisciplinarity capacities may be useful for organizations operating and planning in today's complex, dynamic ecological, social, and political contexts.

3.1 Introduction

One of the biggest insights in social science over the last sixty years has been an optimistic one: Humans can manage collective, or "common pool," resources sustainably and equitably. While Hardin (1968) posited that activity informed by individual self-interest would lead to resource depletion, destruction or neglect, research indicated that societies throughout the globe developed collaborations to create, enforce, and monitor institutions to manage shared resources (e.g., Ostrom 1990; McCay & Acheson 1987). Through a variety of evolutionarily-stable practices — such as communication, institution-forming and norm-adherence —humans were embracing collective action and self-restraint (Panchanathan & Boyd, 2004; Dietz, Dolšak, Ostrom, & Stern, 2002; Berkes & Feeny, 1989). Social ecological systems (SES) researchers, who sought to understand these complex systems and inform the design of management institutions to govern them, have provided models for problem-framing and analysis. While there is no "panacea" (no single formula for managing humans and environments), scholars have agreed that effective collaborations 1. Engage diverse research disciplines, capacities and epistemologies; 2. Use methods that are transparent and scalable; and 3. Pay attention to feedback to inquire into, and adapt, those methods, capacities and epistemologies (Ostrom et al., 2007).

Scholars studying human-environmental systems found that boundaries (disciplinary, organizational, and epistemological) can impede research effectiveness (Guston, 2001). Cash et al (2003, p. 8086) described the practices of crossing these boundaries, in the context of research, as needing to balance the "salience, credibility, and legitimacy" of science. Sustainability science researchers began to see that research co-design with stakeholders could improve knowledge-integration (Jahn et al., 2012; Partelow, 2016). Today transdisciplinarity has matured as a practice and research interest. In 2016 it was even announced as a priority of the National Science Foundation (e.g., NSF, 2022), dubbed

"convergence," which NSF defines as "the merging of ideas, approaches and technologies from widely diverse fields of knowledge to stimulate discovery and innovation."

There is some ambiguity about the definition of transdisciplinarity: Some limit it to crossing academic disciplines (e.g., NSF, 2022), while others require it to engage civil society (Cash et al., 2003; Lang et al., 2012), while others also include implementation (Jahn et al., 2012). Some consider it to extend it to organizations in an organization's operations (Bujold et al., 2020).

With transdisciplinarity taking place day-to-day in the organization, beneficiaries of transdisciplinarity are the entity (and its employees), and its human-environmental systems, (co)designing, operating, managing and benefiting from transdisciplinarity practice. We call these institutions, partnerships and service providers collectively "organizations." These groups do not cease to be transdisciplinary when the research ends, nor do they need to be attached to a research project.

In a review of research into transdisciplinary research practice, one finds consensus elements of shared language (e.g., Guston, 2001), co-producing knowledge (e.g., Clark et al., 2016a), adopting deliberate project process (e.g., Lang et al., 2012), using systems thinking (e.g., Johnson et al., 2019), applying diverse ways of knowing (e.g., Freitag, 2014), recognizing multiple scales (e.g., Ostrom, 1990), and using effective team collaboration practices (e.g., Stokols et al., 2008). However, lesser-understood are the implicit transdisciplinarity practices and capacities that emerge as a by-product of those explicit practices. Implicit transdisciplinarity resides in the relationships, routines, language, and reasoning of actors in organizations over time. I use the term "implicit" additionally because it is governed by multiple functions (e.g., project management, human resources, engineering, or product operations).

This leads one to pose several questions: Can implicit transdisciplinarity practices and capacities be useful in achieving coherence and operational effectiveness? Can such practices be a source of strategic advantage for an organization? That is, do they give the organization a differentiated position relative to competitors? For example, do they create customer switching costs, barriers to entry into a

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competitive field, enduring partnerships, or foresight? (Porter, 1985). Here I use "strategic advantage" rather than "competitive advantage" because the former term can be controversial among nonprofit or social enterprise professionals.

This chapter presents research into the implicit transdisciplinarity capacities for a nonprofit organization, and examines those capacities as a source or strategic advantage. Our case is the Maine Aquaculture Hub (the "Hub"). The Hub is an organization based at University of Maine (UMaine), that aims to advance aquaculture industry growth and capacity-building through integrated education, funding, and strategic planning. In the second half of 2021, near the culmination of the Hub's three-year National Oceanographic and Atmospheric Administration (NOAA) grant, the Hub's Core Team sought to generate a strategy for the Hub's next stage of operation. The Core Team used a balanced outside-in (industry structure), inside-out (capabilities-based) planning process (Mainardi & Kleiner, 2010). The Core Team's goal sought to leverage current capabilities, address aquaculture industry needs, and occupy an economically-viable niche in a crowded, fragmented landscape of NGOs, social enterprises and service-providers. In the act of strategic planning, the Hub Core Team enjoyed implicit transdisciplinarity capacities -- social or network capital, strategic thinking, and skillful conversation -- which contributed to planning efficiency and strategic differentiation. These were measured using interviews, social network analysis, and conversation analysis.

This chapter concludes with a call for transdisciplinary organization leaders to invest in three implicit capacities: individual conversation capacity, team strategic thinking capacity, and network capacity. I propose that transdisciplinary researchers would also benefit from designing their projects and programs for such implicit capacities, and that, further, organizations would benefit from incorporating transdisciplinary capacities as a source of both strategic advantage and of planning effectiveness. These implicit transdisciplinarity practices may help organizations more quickly integrate diverse stakeholders, manage planning risk, move past conflict, and capitalize on collective learning.

3.2 Literature Review

This section first defines transdisciplinarity, and its historical practice dimensions of shared language, knowledge co-production, standardized project management and team processes, systems thinking, diverse ways of knowing, and scale-anticipation. Next, it explores the explicit (declared, deliberate) and implicit (emergent, latent, underlying) practices.

3.2.1 Transdisciplinarity as a vehicle for sustainability science

For the last forty years researchers' goals from transdisciplinarity have variously included knowledge integration, extension, convergence and even intervention. While most agree that transdisciplinarity is an act of knowledge co-production between research and civil society (sharing, integrating, co-creating or extending knowledge), not all agree on its placement in the ongoing life of the organization or the degree to which researchers should be playing an activist role. Let's consider some history.

The 1970s marked some of the earliest calls for "interdisciplinary" research and practice. While researchers' primary purpose was to break down disciplinary silos (and the risks that silos caused to the reputation of science), there was also an opening beyond the academy to societal knowledge. For example, Apostle et al. (1972, p. 9.) pleaded:

> The guiding principle is not the need to demolish the disciplines, but to teach them in the context of their dynamic relationships with other disciplines and with the problems of society…[I]t may be argued that one of the reasons for the tarnished image of science is public reaction to its power to produce specialized applications of knowledge, without a corresponding development of the synthesizing framework which can illuminate their side-effects and long-term implications.

Stokols (2006, p. 67) agreed on the need for a synthesizing framework, and called for knowledge extension: "[N]ovel conceptual models and empirical investigations that integrate and extend the conceptual theories and methods of particular fields." Lang et al. (2012) suggested that transdisciplinarity

addresses social and scientific problems together. Thus, transdisciplinarity has a sort of boomerang effect, bringing change back to science and society participants, alike:

> Transdisciplinarity is a reflexive, integrative, method- driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge. (Lang et al., 2012, p. 26)

Hart and Silka (2020) put this eloquently later, stating that transdisciplinarity entails acting "with," rather than "on," a system. Jahn et al. (2012) contended that the term "discipline" does not go away, but that transdisciplinarity is a combination of disciplinarily and interdisciplinary, with cross-discipline "convergence" as the ultimate goal of transdisciplinarity. Jahn et al. (2012, p. 9) go further to call that transdisciplinarity "interventionist":

> In our understanding, transdisciplinarity is more than a research approach that is better suited to cope with the complex problems that scientific progress itself continuously creates. Rather, it indeed fundamentally addresses the relation between science and society. It is interventionist in the sense that it methodically frames, structures, and organizes the societal discourse about the problematic of an issue at stake.

Partelow (2016) in a comparison of sustainability science and social-ecological systems research, described "sustainability science" as transdisciplinary. Sustainability science's "core agenda," contended Partelow (2016, p. 401), is "empirical research [which] aims to be problem-driven and solution oriented," producing "diverse knowledge generation and practical phases such as the more normative study or assessment of sustainability." In fact, the *defining characteristics* of sustainability science, according to Partelow, are being problem-driven and solution-oriented. Partelow (2016, p 402) went on to note that sustainability scientists, in collaboration with stakeholders outside of academia, generate "transformative knowledge." Partelow drew our attention to the messiness of this enterprise of knowledge reaching a form

practical enough to feed action, or be a "solution." He continued, arguing that a nagging gap for sustainability science, is aggregating "knowledge generated from different methodologies or perspectives" (2016, p 402). However, knowledge, and not the day-to-day mundane actions in its wake, were Partelow's concern.

So, what of those day-to-day mundane actions? Jahn et al. (2012) raised the term institution as not just knowledge co-creator, alongside researchers, but implementer. Jahn et al. (2012, p. 2) stated transdisciplinary research "is not an institution," but that it traverses back and forth from thought to action, and from entity to entity -- between society, research, and the public institutions. What may be unique in Jahn et al.'s definition is the word "action" which appears to challenge the word "solution." Transdisciplinarity can be found not only in transitory knowledge production projects, programs or "solutions," but also in enduring entities, *as part of their ongoing operation.*

Expanding on Jahn et al.'s (2012) action orientation, in this writing I use the term "transdisciplinarity" to encompass four things: 1. A diversity of participants, including researchers and society; 2. A coordinated co-production, integration and expansion of knowledge; 3. Collaborative organizations which continue past (or independent of) research completion; and 4. The co-design of current and future shared capacity. To expand on this, I probe into transdisciplinarity researchers' call for deliberate, co-designed and managed collaboration, leveraging diverse perspectives. A number of common practices appear repeatedly throughout the transdisciplinarity literature. These can be summed up as seven distinct components: shared language; knowledge co-production methods; deliberate project management process; systems thinking; the leveraging of diverse ways of knowing; the recognizing of multiple collaboration scales; and team collaboration practices (see especially, Lang et al., 2012; Jahn et al., 2012; Hart, 2020). In the following sections, I review each of these components in turn. I use the term "capacity" to refer to the ability of the collaborating entity or entities to enact these practices consistently and reflectively, and their availability and willingness to do so.

3.2.2 Shared language creates bridges and initiates a standard of respect

Lang et al. (2012) suggested that agreement on "shared language" is a first step to contracting and forming transdisciplinary collaboration. Shared language is having enough agreed-upon terminology to negotiate the mission and coordinate activities, without compromising the collaborating individual disciplines' rhetorical integrity (Druschke & McGreavy, 2016). Groups use shared language to describe constructs of identity (who), content (what) and disciplinary process (how), such as a joint definition of the transdisciplinarity stakeholders and problem (Silka et al., 2013); shared descriptions of the approach; and symbols which can animate, or encapsulate, the collaboration (Clark, et al., 2016b). With shared language, participants engage in ways that make shared meaning a priority investment of time and attention.

The interface between participants' distinct identities, knowledge, and disciplinary approaches can be described as a "boundary" (Guston, 2001). Boundaries may persist to maintain the credibility or coherence of individual disciplines, or legal authority. "Boundary work" according to Gieryn (1983, p. 791-792) may be necessary for the "expansion," "monopolization," and "protection of autonomy" of the scientist, in order to separate themselves from the non-scientist. For human-ecological systems, boundary work may entail not only demarcation, but also selective integration of participants' unique knowledge (Guston, 2001; Johnson & McCay, 2014; Clark et al., 2016b; Silka, 2019). Boundary work uses communication symbols, and often jointly produces shared products, or "boundary objects" (Clark et al., 2016b.) Group members who work at the boundary, or "boundary workers," translate language and context, and build social capital (relationships) (Guston, 2001). Boundary workers take responsibility for a balance of boundary-permeability, preservation, and management (Johnson & McCay, 2014).

Silka (2013) suggested that language "translation," is a never-ending boundary worker responsibility, as each encounter with concepts may surface unique meaning for different participants. Silka provided a collection of language translation strategies to bridge silos over time as those silos become evident in transdisciplinary teams' speaking and knowing. For example, she went beyond grids or

taxonomy mappings, to include "yoking" (such as "environmental justice" which combines conservation and social justice) and analogies (such as comparing a network to a baseball team) (Silka, 2013). Druschke and McGreavy (2016, p. 46) added rhetoric to a shared language practice, with rhetoric defined as:

> [T]he academic discipline devoted to the persuasive power of language, including argument, public discourse, and civic engagement, [which] seeks to understand how people interact with one another and their environments, and how human communities form..

Consistent with the boundary researchers, Druschke and McGreavy (2016, p. 50) added that a critical element of rhetoric is disciplinary preservation:

> Finding common ground between these different perspectives is important, but rhetoric reminds us that these differences never entirely disappear…This insight enables researchers to work together despite competing perspectives, find points of identification between contrasting voices, translate between disciplines, address points of contention, and find productive aspects of disagreements and conflict.

By making shared language a priority, transdisciplinary collaborations benefit from articulation and attention, at once striving for a shared universal vocabulary, and a respecting a local or disciplinary vocabulary.

3.2.3 Agreed upon knowledge co-production methods aid knowledge completeness and fit

"Knowledge co-production," whether the produced knowledge is instilled, distilled and/or embodied (Stewart & Pugh, 2013), is the central activity of transdisciplinary research. For example, Clark et al. (2016b) illustrates a "distilled" knowledge-product that uses agreed-upon language to juxtapose social versus sustainability impacts of conservation interventions. Rare.org (2020) describes "embodied" knowledge-products such as conservation committees and their jovial mascots. Guston (2001) described instilled knowledge-products where the process, brand and norms of the participants (such as an

agricultural extension organization) included an "instilled" reflective learning process, routinely part of day to day team interaction.

Typical knowledge co-production methods involve the negotiating of an intent, scaffolding or structuring of ideas and their connections, creation of knowledge (through observation, elicitation, experiments, sense-making, synthesis, packaging); and integration of and extension of that knowledge in a target organization or system (Dixon, 2000; Pugh, 2011; Lang et al., 2012). Knowledge co-production methods include the rituals and methods for integrating different ways of knowing (perception, identity, and collectivity), as I shall discuss below (McGreavy et al., 2021).

An elusive, yet important, co-production method component is assessment against agreed upon goals (Norstrom et al., 2020). Measurement (e.g., of progress, of participation, of impact) can sharpen attention, fuel sense-making, and lead to course-correction and/or resource re-assessment (Lang et al., 2012; Norstrom et al., 2020). Measurement is elusive because outcomes are often separated in space or time from inputs, and determining causality is challenging, especially in human-environmental systems (Partelow, 2016). Lang et al. (2012, p 39) reflected on this elusiveness:

> Yet, it is even more challenging to accurately track societal impacts of transdisciplinary research. Such impacts often occur with significant delays; causal relations between a project and its impacts are often difficult to establish because of the complexity of the problems addressed and the complexity of the solution options adopted; impacts might include effects that are important but not easily measurable, such as increased decision-making capacity.

Agreeing on the knowledge co-production form and methods ahead of the collaboration helps reduce surprise and helps inspire a sense of progress. Ambiguity or unaddressed disagreements can compromise the efficiency, relevance and inclusiveness of jointly produced knowledge (Pugh, 2011).

3.2.4 Deliberate project management processes improve coherence and scalability

Project management's central objective is team members' coordinated action. The transdisciplinary collaboration's flavor of project management extends project management: It includes process steps such as schedules, decision-trees, applications, acceptance criteria and/or checklists. But, transdisciplinary project management also adds the processes for defining and attending to the participants inside and outside the boundary who bring their unique mental models (Lang et al., 2012). Having a deliberate project management processes improves coherence among team members, as well as the potential to add new team members as the collaboration progresses or scales up or down over time (Lang et al., 2012). Lang et al. (2012) pointed out the "need for finding the right level and scale of participation that is manageable and can be maintained over the entire lifespan of the project" (Lang et al., 2012, p. 37). This is a distinctive project management process of transdisciplinarity.

Silka et al. (2019) and Hart and Silka (2020) observed that successful project management is a higher order role than managing schedules and scopes. Project management includes space and time for turn-taking, use of multi-sited convenings, formal mental model-discovery, collective decision-framing, disciplined partner-identification, and rituals for engagement.

3.2.5 Systems thinking helps discern unexpected influences and feedback

A critical component of human-environmental systems research that calls for transdisciplinary approaches is the presence of nonlinear interactions among diverse factors — physical, chemical, biological, social —over time (Dietz et al., 2002; McGinnis & Ostrom, 2014). "Systems thinking" is the practice of imagining, visualizing and measuring interactions among factors. Systems thinking describes a set of elements that work interdependently and dynamically to generate impacts or outcomes, often in self-reinforcing or oscillatory patterns (Kim, 2000).

Systems thinking became a research discipline starting in the 1940s (Kish et al., 2021). It involves exploring relationships among heterogeneous elements—such as water supply, fuel prices, policy and

democratic participation — and mapping the impacts of these elements on each other. Transdisciplinary teams, by definition, bring heterogeneous concerns and perspectives, some opposing, and some overlapping. With a systems thinking perspective, teams can ensure that the transdisciplinary collaboration explores interactions and unintended consequences (Senge, 1992; Johnson et al., 2019).

Kish et al. (2021) wrote about three waves of systems thinking: functional, interpretivist, and critical. Over the span of seventy years, systems (boundaries, components, dynamics) have been progressively perceived as, first, ontological components, second, epistemologically defined, and, third, defined by normative claims (Kish et al., 2021). Similar to Jahn et al. (2012), Kish et al. (2021), writing about systems thinking today, identified an emerging interventionist role for the systems thinker, who is not just a facilitator, but also a "critic, advocate, and activist" (Kish et al., 2021, p. 5). Regardless of our opinion on the activist role of the systems thinker transdisciplinarity needs systems thinking to aid in collective sense-making about the contents and interactions within and across the collaboration boundary.

3.2.6 Practicing different ways of knowing improves problem-solving productivity and justice

The concept of "ways of knowing," goes back to John Dewey (Ryan, 1997). In a nutshell, it is the unique perspective one brings to information to generate meaning, and it influences what one experiences when one acquires knowledge. This occurs individually and socially. For transdisciplinarity, a core ingredient of ways of knowing is the identification of, respect for, and incorporation of cognitive and neurological diversity. Bruner (1990) discussed this respect for diverse ways of knowing as "open-mindedness." In a statement as true today as it was over thirty years ago, he declared:

> I take open-mindedness to be a willingness to construe knowledge and values from multiple perspectives without loss of commitment to one's own values… I take the constructivism of cultural psychology to be a profound expression of democratic culture. It demands that we be conscious of how we come to our knowledge and as conscious as we can be about the values that led us to our perspectives. It asks that we be accountable for how and what we know. But it does

not insist that there is only one way of constructing meaning, or one right way. It is based upon

values that, I believe, fit it best to deal with the changes and disruptions that have become so

much a feature of modern life. (Bruner, 1990, p. 30)

A commitment to respecting and practicing different ways of knowing is an essential component of

transdisciplinarity, as transdisciplinarity seeks to include unique perspectives in knowledge-production.

Without that commitment, there is insufficient motivation to respect, distinguish and/or integrate

evidence, perceptions, or group norms unique to participants. Freitag (2014) used the term ways of

knowing to distinguish "traditional," "local," or "subaltern" knowledge (Freitag's comprehensive term:

"alternative knowledge"). Freitag urged transdisciplinarity practice to mash-up Western, positivist

scientific ways of knowing and alternative knowledge, as a philosophical and practice shift:

The epiphany that knowledges outside of professional science have something to offer is just a

first step, soon followed by scholarship on the nature of knowledge itself, how it is learned,

measured, and recorded. Successfully incorporating diverse ways of knowing requires a

philosophical shift in what constitutes expertise, how research is conducted, and the nature of

research relationships (Freitag, 2014, p. 41)

Including diverse ways of knowing can provide legitimacy for transdisciplinarity-produced

knowledge in the eyes of participants' organizations and affiliations (Lang et al 2011; Freitag, 2014).

Noted Hart et al. (2015, p. 9) "[T]his ability to modify research plans based on diverse forms of

knowledge and know-how greatly increased the prospects for co-creating useful solutions" but it also

adds time and expense. (The authors added that using boundary workers reduced that cost.)

Ways of knowing can be rooted in perception, identity, and group norms experienced by the

participants. Thus, transdisciplinarity methods need to be context- and participation-specific, such as

using randomized control trials for the quantitative researcher, and journaling, storytelling, witnessing,

and rituals for people acting outside the Academy (Freitag, 2014, examples mine). In addition to the

equity merits, differences in ways of knowing contribute to performance and productivity. Differences in heuristics, perspectives and interpretations improve a group's ability to generate options, listen, and recall (Sommers, 2006; Galinsky et al., 2015). Page (2008), modeling diversity in perspectives and heuristics for groups, illustrated that when groups make numeric predictions, the error of their collective prediction can't be bigger than the average of their individual errors. He concluded, "Diverse predictive groups must be more accurate than their average member" (Page, 2017, p. 3). Almaatouq et al. (2021) corroborated this in the lab recently, showing empirically that diverse groups outperform individuals on complex tasks.

The knowledge management (KM) literature advocates understanding of knowledge originators' ways of knowing as a critical step to help participants with encoding and retrieving knowledge (for example, Knott & Dewhurst, 2007). Understanding how an originator has encoded knowledge, and using that for aiding knowledge retrieval, decreases the disruption to the retrieval process. In facilitating knowledge-capture and knowledge-elicitation, knowledge managers remove the politics from ways of knowing and use five frames for describing a knowledge originator's encoding and retrieval: declarative, procedural, conditional, relational/social, and systemic (Pugh, 2011). For example, by using tools that visually represent these (e.g., a process flow for procedural ways of knowing, or an organization chart for relational ways of knowing), KM facilitators' inclusive process accelerates the knowledge originators' recall for certain knowledge from a past project or story.

Practicing diverse ways of knowing alongside inclusive language, shared co-production methods, and team collaboration is essential to transdisciplinarity. In particular, that practice deepens the legitimacy (respect and inclusion) for participants and their organizations (Cash et al., 2003).

3.2.7 Recognizing multiple collaboration scales is critical to solution viability over time

In managing a transdisciplinary project or program, size matters: At different "scales," stakeholder involvement, governance regimes and ecological conditions may change. Scale may also result in discontinuous services from a natural resource, such as a watershed, which performs differently

at high or low inflection points (Clark & Hartley, 2020). Practicing in a transdisciplinary program from scale to scale may necessitate task-redesign or decomposition. Participants may use modeling to predict growth behavior, preparing for resource or staffing changes, or anticipating economies or diseconomies.

A particularly thorny dimension of transdisciplinary program scale is organizational. As a thought experiment, consider collaboration scales descending from global agencies; to multinationals; to countries; to regional organizations; to legally-defined cross-organizational coalitions, partnerships, or committees; to networks; to project and program teams; and even to individual conversations. Different scales can have different governance structures, laws, durability, incentive structures, norms and methods for addressing different ways of knowing. Different scales can also evoke the need to engage different forms of participant or participation diversity (Lang et al., 2012).

The smallest scale of collaboration, the conversation, is interesting. As discussed below, while the conversation is also part of projects or programs, in the center of the organization, conversation influences operating relationships; sense-making, planning and innovation; and commitment to action at the periphery (Hart et al., 2015; Pugh 2020; Turco, 2016).

3.2.8 Project teams sustain the mission and themselves

Research on the science of team collaboration underscores the need for structured agreements on terms, shared conceptual frameworks, measurement models, and translational (implementation-related) strategies (Stokols et al., 2008). Further, research on "project teams" calls for role definition and accountability, individual development, organizational sustainability beyond the task at hand, transparency, and repeated goal-validation (Gratton & Erikson, 2007; Hackman, 2011). One could conclude from the perspectives of these researcher groups that the transdisciplinary research called "science of team science," framed by science researchers, focused on meaning, whereas the operational team researchers focused on interpersonal concerns. However, with a closer reading, Stokols et al. (2008) signaled that there was a growing interest in issues like trust, leadership, social capital, and conflict in the

science of team science. Similarly, operational team researchers made similar claims as Stokols about meaning. Examining the business literature across multiple scales of collaborations, one can see common meta-themes. 1. Inter-organizational networks (Ehrlichman, 2021; Pugh & Prusak, 2013), 2. Intra-organizational business units (Hansen, 2007), 3, Project teams (Gratton & Erickson, 2007; Hackman, 2011; Duhigg, 2016), and 4. Real-time or near-real-time interactions, or conversations (Skifstad & Pugh, 2014; Turco, 2016) have some common success factors.

Successful collaboration practices at these four scales can be summarized into three broad dimensions. These encapsulate meaning, process and interpersonal relations. I call these "shared purpose," "collaboration structure," and "psychological safety."

A. **Shared purpose** is the shared direction and mission for the collaboration. Purpose can be both an externally-directed outcome (e.g., complete a product design project), or a shared intent to build individual members' or organization's well-being (e.g., help control one's diabetes). (Duhigg, 2016; Pugh, 2014). Shared purpose, as opposed to "shared goal," or "shared objective," connotes a shared calling, motivating diverse participants. It is the North Star.

B. **Collaboration structure** is processes, procedures and ways of relating, what Edmondson and Zuzul (2013) called "teaming routines." It includes project management processes, disciplined meeting practices, division of roles and responsibilities, including leadership; legal arrangements (e.g., intellectual property ownership), facilitation practices, decision-making mechanisms, and measurement processes. Lang et al. (2012, p. 29), describing transdisciplinarity, emphasized, in particular, the roles and responsibilities part of structure:

[I]t is crucial to establish an organizational structure in which responsibilities, competencies, and decision rules are clearly defined. In many cases, a good strategy is to establish balanced

structures between researchers and practice actors on all organizational levels including a joint leadership.

Structure can foster resilience, growth, and a foundation for trust, despite ambiguity (Sawyer & Ehrlichman, 2016). Trust's impact on the structure can be a double edge sword, argued Bieluch et al. (2015). They pointed to past studies (e.g., Focht & Trachtenberg, 2005), where high trust would lead to a hands-off approach. In that case, trust could lead to dis-engagement. In effect, collaboration effectiveness could be compromised where interactions just don't occur due to a laissez-faire attitude as a byproduct of blind "trust."

C. **Psychological Safety** refers to a group's ability to engage in risk-taking and sense-making in a particular context (Edmondson & Lei, 2014). It differs from trust, as it persists within the group. It is experienced generally (by association) not just one-to-one (by individual experience or reputation). Psychological safety may be the ultimate collaboration enabler. It has been shown to associate with knowledge-sharing, speaking up, and taking initiative (Edmondson & Lei, 2014; Dixon, 2018). In a sweeping review of team effectiveness, Google found that top team effectiveness ingredients are accountability, dependability, shared purpose and psychological safety (Duhigg, 2016). In Google's year-long research project, psychological safety was the leading predictor of team performance (Duhigg, 2016). Edmondson and Lei (2014), reviewing studies on the subject, illustrated three scales of psychological safety. For individuals, it supports confidence (voice, speaking up). They argued, for organizations, psychological safety supports ideation, learning, and change. For groups it supports knowledge exchange.

Psychological safety forms over time. It results from teaming routines, leadership role-modeling, human resource practices and policies, group composition, and the ability of group members to act transparently (Dixon, 2018; Edmondson & Lei, 2014). Psychological safety

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builds and wanes in a sort of bank account accumulated through these repeated interactions, exposures and policies over time (Dixon, 2018). In research aligned with Edmondson, Gratton and Erikson (2007), Stokols et al. (2008) and Hackman (2011) found that teams are more successful where there are heritage relationships, meaning that teams can tap into historical familiarity. (Yet, that heritage relationships should lead to increased psychological safety is not a given. Bieluch et al. [2015] researching transdisciplinary research with local governments, qualified the value of heritage relationships to exclude where past relationships were not helpful.)

Together, shared purpose, collaboration structure, and psychological safety contribute to adaptability, creativity, and mutuality for teams and other scales of collaboration. Adaptability stems from the structure (e.g., commitment to discuss the context and performance, and do sense-making formally). Creativity stems from the openness and experimentation fostered by psychological safety. Mutuality comes from shared purpose.

Table 3.1: Summary of explicit transdisciplinarity practices and capacities

Practice	Transdisciplinarity capacity	References (Illustrative)
1. Shared Language	Capacity to agree to terms and use practices, analogies and common reference models such as boundary objects.	Johnson, 2010; Guston, 2001; Lang et al., 2012; Silka, 2013; Johnson & McCay, 2014; Clark et al., 2016b; Druschke & McGreavy; Silka et al., 2019.
2. Knowledge co-production methods	Capacity to use knowledge creation methods that yield distilled, instilled or embodied knowledge products, which, in turn, are integrated across boundaries.	Pugh, 2011; Lang et al., 2012; Jahn et al., 2012; Stewart and Pugh, 2013; Clark et al., 2016a
3. Deliberate project management processes	Capacity to use deliberate transdisciplinarity project management processes	Lang et al., 2012; Silka et al., 2019; Hart & Silka, 2020
4. Systems thinking	Capacity to recognize the system complexity and non-linearity, and to incorporate feedback loops between disparate elements.	Kim, 1992, 2000; Lannon, 2007; Johnson et al., 2019; Kish et al 2021;
5. Practicing different ways of knowing	Capacity to incorporate and negotiate shared values and epistemologies, and to use those to co-produce knowledge	Gruber, 1990; Page, 2007, 2017; Pugh, 2011; Jahn et al., 2012; Lang et al 2012; Freitag, 2014; Galinsky et al., 2015.
6. Recognizing multiple collaboration scales	Capacity to have different scales reflect a single transdisciplinarity vision.	Ostrom, 1990; Lang et al., 2012; McGuiness & Ostrom, 2014; Johnson et al., 2019.
7. Team collaboration practices	Strength of team collaboration dimensions: shared purpose, collaboration structure, and psychological safety.	Gratton & Erikson, 2007; Hansen, 2007; Stokols et al., 2008; Hackman, 2011; Edmondson & Zuzul, 2013; Duhigg, 2016.

3.2.9 Implicit organizational capacities: Social capital-building, strategic thinking, conversation

Table 3.1 shows the full gambit of explicit transdisciplinary capabilities, yet this is not the full picture. Lang et al (2012) described the ideal-typical process for transdisciplinary research. In that process, the authors noted that while products, such as strategies and data sets, emerge, so, too do new, intangible team capacities, such as decision making. Lang et al. (2012) suggested that effective participants who have bridged their disciplines as a learning unit, a team or network, sense into that very act of bridging in order to generate repeatable research team capacities. Yet, Lang et al and other transdisciplinarity scholars did not translate that capacity into ongoing operations in organizations, such as managing, operating, or planning a social enterprise. These scholars stop short of defining how an organization plans for its future, and renews itself and its relations.

To survive, organizations need to be adaptable, differentiated, and capable of sense-making, decision-making, and action (Weick, Sutcliffe & Obstfeld, 2005; Hackman, 2011). Edmondson and Zuzul (2013, p. 5), quoting Lingo and O'Mahony (2010), reminded us that "often, the difficulty in innovative, cross- boundary work 'is not coming up with good ideas, but sustaining the cooperation of others to synthesize and implement them.'" In an ongoing organization, where adaptation and creativity are essential to effectiveness, organizations tap into another type of capacity. I call this adaptive capacity "implicit" capacity, as it emerges dynamically, and may be only partially recognized and measured. Adaptation for an organization needs economic output, discernment, and dynamic sense-making. Social (network) capital, team-based strategic thinking, and conversation are capacities that contribute to adaptation. Each capacity is described briefly here.

3.2.9.1 Social (network) capital

Social capital, also called network capital, is the potential value (knowledge, opportunity, physical goods, belonging or political support) that can emanate from relationships (Baker, 2001; Cross & Parker, 2006). Social capital in human-environmental systems pertains to the interfaces between the project, program or operating team members with each other, with the impacted stakeholders, and/or with the wider constellation of entities, such as land owners, policy makers, government institutions, funders, and complementary resource holders.

To better understand networks, it helps to use analysis methods from the outside in (network structure) and from the inside out (deliberate network design). Starting with outside in is Social Network Analysis (SNA). SNA is the visualization and measurement of collective social capital, across a group of individuals (also called "nodes," or "vertices"). SNA considers individuals' strong and weak relationships (also called "ties," "edges," "bridges," or "links"). SNA considers one's relations' relationships (also called "long bridges"). SNA also considers multiple, parallel, edges into a given node from different nodes. (Those parallel edges are called "wide bridges"). The structure of the edges and nodes can

influence knowledge flow, beliefs, and behavior (Graonvetter, 1973; Centola & Macy, 2007; Cross & Parker 2004; Lehmann & Ahn, 2018).

Density: A basic SNA metric is "density" (or "saturation"), calculated as the number of edges between nodes in a network as a fraction of everyone being linked to everyone else. A higher network density may have faster movement of information, but also a lower likelihood that novel information flows into an info-seeker, due to information being conveyed in multiple ways to each node. The opposite of a dense network is an "open" network, where one's connections are likely to be different from their neighbors.

Distance: An measure of information-flow behavior of an SNA is "distance." With SNA one can measure the shortest number of "hops" it takes to get between two nodes. For an entire network, average distance is the shortest number of edges to traverse to reach the entire network.

Diameter: "Diameter" is the longest of all the calculated shortest path lengths, once for each node, the shortest path length from every node to all other nodes is calculated.

Betweenness: A measure of an individual node's importance in connecting others is their "betweenness." This is the degree to which that individual sits on the shortest path between two other nodes. Average betweenness centrality for a whole network is average of the betweenness of each of the nodes. Higher average betweenness centrality means that traversing the network will entail going through a few salient nodes.

Clustering coefficient: "Clustering" is the likelihood that two people who are linked to a third person, are also linked to each other (the calculated number is called the "clustering coefficient"). High clustering is associated with cliques, which could be isolated from each other, and which, while tightly connected in their cluster, may be several hops (high distance) from the rest of the network.

Social capital, and edges observable in an SNA structure, can be built actively, for example, as a byproduct of interactions, convenings, and favors. Social capital can also be built passively, through affiliation or association (Watts, 2011). Connections (links) are only as useful as the value of the network's content in the eyes of its members and conveners. For example, where individuals are similar (homophily), being tightly connected (having high density or having dense, but isolated, clusters) may create echo chambers where information is reinforced and not contested. Conversely, where individuals are distinct (e.g., in an open network), each edge is more likely to provide novel information.

Now, consider analysis methods from the inside out. Where social capital is managed deliberately for the purpose of knowledge creation and dissemination, it is called a "knowledge network." Knowledge networks (also referred to as "communities of practice") are groups of people that cross organizational, spatial, and disciplinary and/or identity boundaries to share and co-create knowledge and to achieve collective impact over time (Pugh & Prusak, 2013). Knowledge networks have been shown to support economics and sense-making: They channel a group's energy toward product outputs (e.g., like open source software, Creative Commons, policy-writing, lobbying, and purchasing scale). They also may support individual members' or organization's problem-solving (e.g., providing a sounding board, collective sense-making, idea translation) (Pugh & Prusak, 2013; Ehrlichman, 2021). The Knowledge Network Effectiveness Framework (KNEF) (Pugh & Prusak, 2013) is a model that helps network planners to see the logic of peeling back from economics and sense-making outcomes, to member-behavior, to interaction dynamics, and to design. Pugh et al. (in draft, 2022), demonstrated that the critical success factors for knowledge network effectiveness are intentionality (e.g., approach to arriving at an agreed upon purpose), alignment (e.g., interpersonal agreements, operating models), and coherence, (e.g., ongoing measurement, feedback, incentives).

3.2.9.2 Strategic thinking

Lang et al. (2012) entertained the future-oriented thinking of transdisciplinary teams as reflective learning, feeding back into the research process, but not as sense-making or strategic planning for

uncertain futures. Mainardi and Kleiner (2010, p. 4) pointed out the importance of taking this step: To manage the tension between rapidly changing industry forces, and the strengths (or liabilities) of the organization as it makes cumulative decisions:

> The innate qualities of an organization that distinguish it from all others — its operational processes, culture, relationships, and distinctive capabilities — are built up gradually, decision by decision, and continually reinforced through organizational practices and conversations.

That sense-making is what strategy researchers call "strategic thinking" (Liedtke, 1998). Strategic thinking is defined as using imagination and engaging in possibility-development, while bringing the "whole system" into the planning conversation (Liedtke, 1998; Moon, 2013). Strategic thinking brings together both convergent and divergent thinking. Moon (2013, p. 1699) defines strategic thinking as "a way of solving strategic problems that combines a rational and convergent approach with a creative and divergent thought process to find alternative ways of competing and providing customer value."

Strategic thinking was introduced in the 1990s as a counterweight to "strategic planning," a mechanical exercise generally centered on analytical or statistical processes, modeling or evaluating markets, financials, and resources. In a survey of Korean executives, Moon (2013) showed that strategic thinking had a positive statistically significant explanatory impact on Profitability, Market Share and Sales, and that collaborative structure and attitudes significantly influence strategic thinking. During our time of data-driven, scientific planning, Moon contends, interest in strategic thinking is on the rise.

Liedtke (1998) described the five practices of strategic thinking as Intent-Focused, Hypothesis-Driven, Thinking-in-Time, Systems Perspective, and Intelligent Opportunism:

1. **Intent-Focused** (being mission-affirming, combining energy and direction). Noted Liedtke (1998, p. 127) "A group of individual strategic thinkers who cannot come together to create a consistent, coherent intent at the institutional level are as likely to dissipate and waste

organizational resources as they are to leverage them"   Ehrlichman (2021, p. 91) similarly discussed Intent-focused practices for networks:

> The objective of clarifying a common purpose is not to force agreement but to legitimize difference, and through that exploration of divergent perspectives to discover the places where values converge. When people recognize the nature of their interconnected aspirations, their perceived differences shift from barriers to gifts.

2. **Hypothesis-Driven** (using data-informed propositions, combining imagination and data). Liedtke remarked, "The most productive learning usually occurs when managers combine the skills in advocacy and inquiry. Another way to say this is 'reciprocal inquiry.' By this we mean that everyone makes his or her thinking explicit and subject to public examination." (Senge, p 252, as cited in Liedtke, 1998, p. 125). Data-informed opposition may also be a form of hypothesis-driven engagement, and need not shut down conversation to the extent that psychological safety is present.

3. **Thinking-in-Time** (using analogies, respecting the past, but leaning toward the future). Analogies provide a potent common language. While an abstract concept like "barriers to entry" may divide strategic thinking teams, shared cases, analogies and examples can be helpful teachers (Silka, 2013; Silka et al., 2019). Thinking-in-time goes beyond the traditional transdisciplinary practice of shared language: Analogies are multidimensional, encapsulating context, story, choices, outcomes, and personalities.

4. **Systems Perspective** (having an interdependency-focus). Noted Liedtke (1998, p. 122) "A strategic thinker has a mental model of the complete end-to-end system of value creation, and understands the interdependencies within it." Having a systems perspective was already named a core practice of transdisciplinarity. In the context of strategic thinking, Systems Perspective

interjects into strategic thinking such future-shaping elements as organizational strengths, opportunities, headwinds, resource constraints and partners.

5. **Intelligent Opportunism** (iteratively pivoting and projecting capabilities forward; making intent broad and flexible or adaptive). Moon (2013, p. 1699) called Intelligent Opportunism, "having a market-oriented" posture, which combines knowledge of the market opportunity and of the organization's capabilities to capitalize on the market opportunity. Intelligent Opportunism is a necessary part of a capabilities-driven approach to strategy. Mainardi and Kleiner (2010, p. 62) described this strategic thinking element as means to generate coherence:

> A capabilities-driven strategy process […] takes into account 'market back' aspirations (the position the leaders want to hold) and 'capabilities forward' concerns (the company's ability to deliver). In the course of discussion, ideas from all four schools of thought come forward: ideas about holding an unassailable position, executing with new capabilities, adapting rapidly to competitive pressures, and focusing on the core business as a platform for growth. It takes time to complete this process, and it is very difficult and stressful at times, but the company gains, in the end, from a far higher level of coherence.

In sum, strategic thinking capacity is an ability to articulate a shared mission, reflect on capabilities, connect them (and other factors) to imagined futures, and use data to do that. Strategic thinking is a critical capacity that distinguishes transdisciplinary operations from transdisciplinary research.

3.2.9.3 Conversation practices

Transdisciplinarity researchers noted that "knowledge vehicles" -- words, phrases, documents, and works -- can reflect hierarchy, status and social history (Druschke & McGreavy, 2016). These can expose and/or amplify power differences among collaborators (Freitag, 2014; Hart & Silka, 2020), and can create friction (McGreavy et al., 2021). Among these, conversation practices have the greatest

potential to create, convey, and connect. Yet, conversation practices have not been fully defined by transdisciplinarity researchers. In this research I use a dialogue-based framework for characterizing conversation features, which I call "discussion disciplines" (Skifstad & Pugh, 2014; Pugh, 2020). This framework describes the ways in which speakers (or, online, "posters") dynamically move the conversation with meaning, affect, and power (Kantor, 2012). Briefly, the discussion disciplines are Integrity (Statements); Integrity Q Inquiry); Courtesy Positivity, respect); Inclusion (Acknowledgement); Translation Synthesis, Extrapolation); amd "Snarky" (the opposite of the above, such as sarcasm, indirection). The discussion disciplines can be identified and coded for each conversation utterance (or sub-utterance, which I call a "move"). Features of utterances and moves can also be mapped to productive outcomes, such as options-generation, relationship-building, and intent to act (Skifstad & Pugh, 2014). The discussion disciplines are explained in depth in Chapter 4.

Conversations are where transdisciplinarity is both an input and an output, where knowledge, intent, meaning and values are generated. By understanding individuals' conversation moves, one can see their relative impact in real-time and across interactions.

3.3 Methods

In this section I discuss aquaculture in Maine, data-gathering and my analytic process.

3.3.1 History of Maine Aquaculture

Over 1,100 Maine residents participate in the aquaculture industry in Maine, U.S.A., and the industry has been identified as a source of innovation and job growth for the Maine economy in the Maine Economic Development Strategy 2020 (Johnson, H., 2019). It has also been heralded as an important means of improving trade balance for the United States, a source of food security, and a net improvement in wild fish weight around farms (Sadusky et al., 2022; Zajicek et al., 2021). The Maine aquaculture

industry-wide employment is forecasted to grow from approximately 1,100 to 1,700 between 2020 and 2022, a year-over-year growth rate of 19% (Haines et al., 2020).

Aquaculture is an industry managed through a combination of regulated site selection, conscientious farming, neighborly communication, and attentive interpersonal relationships. Krause et al. (2020) pointed out that aquaculture is a human-environmental system where transdisciplinary research and practice are essential to achieve both natural resource sustainability and equity. Johnson et al. (2019, p. 2) described marine aquaculture as a "coupled" social–ecological system, and thus requiring a form of research that integrates "biophysical, social, and engineering sciences with stakeholder knowledge." In Maine, in particular, where there are diverse stakeholders, including landowners, fishers, environment advocates, scientists, Harbormaster and regulators, there is a need for a transdisciplinary approach that brings diversity of opinion and action into collaborative management of the resource.

3.3.2 The Maine Aquaculture Hub

The Maine Aquaculture Hub (hereafter, the "Hub") was initiated in 2019 with funding from the National Oceanographic and Atmospheric Administration (NOAA). A joint research/practice entity, the Hub was established to foster individual, organizational, and system-wide learning about aquaculture through training, grants, and an informative industry roadmap. The Hub mission is articulated to stakeholders in its letter of interest for grants:

> The Maine Aquaculture Hub is intended to create a statewide, transdisciplinary collaboration that will enhance efficiency and communication, leverage resources and expertise, and focus collective efforts to build capacity for industry-driven innovation, diversification, and workforce development in Maine's aquaculture sector (Hub Grant offering Letter of Interest, 2020).

Transdisciplinarity is a core objective of the Hub, intending to incorporate aquaculture farmers, suppliers, harbormasters, researchers, regulators, project financiers, landowners, and consumers. The three deliverables of the Hub project as formally laid out in its three-year grant were:

1. Aquaculture Roadmap: a one-time synthesis of industry practitioners' and researchers' insights on the future of aquaculture in Maine.

2. Expand aquaculture training through continuation and expansion of the Aquaculture shared waters (AQSW): training on the science, regulation and business of aquaculture in Maine.

3. Investment in research via a Request for Proposal (RFP) to fund industry participants to conduct aquaculture research on the science, sociology, regulation or business of aquaculture in Maine.

The research in this dissertation sought to inquire into the Hub's effectiveness and long-term sustainability. The main goal was to evaluate the Hub as a transdisciplinary organization for engaging academic and non-academic stakeholders, and to assist in the facilitation of strategic planning.

The questions raised were the composition of the stakeholder network, the match between the stakeholder's needs from the Hub and its work, and the way in which the Hub's role might be changing as the industry is changing. Notable were the arrival in the aquaculture industry landscape of competing transdisciplinary organizations. The research observed the Hub as it asked: Where can the Hub fit into that space and make the most impact?

3.3.2 The Hub Core Team profile

The Hub Core Team is diverse in composition, with affiliation to industry, community development, university extension, and scientific research. The Steering Committee affiliations consisted of Maine Sea Grant (federally-funded by NOAA), the Maine Aquaculture Association (an aquaculture industry trade organization), Coastal Enterprises, Inc. (a nonprofit community investment/development organization), the Maine Aquaculture Innovation Center (a research sponsor/facilitator focused on technology transfer and commercialization), and the University of Maine Aquaculture Research Institute (a university-based research center). The Coordinator of the Hub came from a background in domestic and international marine science and aquaculture, having worked in Latin America and Europe. For the purpose of this analysis, I use the term "Core Team" to include the full governing committee. This

includes the Steering committee (including the director of the Maine Sea Grant), and the full-time Hub Coordinator (also a member of Maine Sea Grant staff).

3.3.3 Methods and Data Collection

A grounded theory approach (Remenyi, 2014) was used, involving the observation of the Hub's transdisciplinarity capacities which contributed to its options and to strategic planning, and then to generalize a theory about transdisciplinarity for the organization. . The analysis used mixed methods to construct a complement of data types, including observation, interviews, group meeting (online), constituent analysis, and web research. There were four data sets:

3.3.3.1 Strategy development Cycle

Using a capabilities-based model of strategy (Mainardi & Kleiner, 2010), this research explored the Hub's capacities, as those capacities came to light during the discussion of strategic direction. The strategy development process involved two Core Team meetings, options development, followed by a decision to develop a go-forward strategy.

The Hub's strategy decision parameters were positioning (target stakeholders and services), plausibility of the business model (revenue and resourcing), risk-management (e.g., sustainability of the team, markets, and partnerships) and future governance (leadership, decision-making unit and process). The approach to strategy development as observed for this research involved three phases, as described in Table 3.2:

Table 3.2: Three Phases for Hub Strategy Development

Phase 1 (Month 1-2, July-August, 2021):	1. Interviews with the Hub Steering Committee and Hub Coordinator (5). 2. Social network analyses using participants in the AQSW, focus groups, and RFP (grant holders). 3. Strategy Initiation meeting ("Conversation 1") with full Core Team, August 31, 2021. The goal was to review a play-back of Core Team interviews, observe a map of the Maine aquaculture ecosystem, and identify approach for options generation. I manually and digitally recorded the transcript, and coded for the discussion disciplines and strategic thinking practices. 4. Core Team members identified 22 NGO and regulatory organizations to consider in the context of the aquaculture industry.
Phase 2 (Month 3-4, September-October, 2021):	5. Discussed, documented five options with the Hub Coordinator, based on the Aquaculture Roadmap. To streamline comparisons, the team presented options in a strategy options grid designating business model elements and evaluation criteria, as well as salient names to highlight the strategic intent. 6. Created stylized "one-pagers" to engage the Core Team in analogy-development process. 7. The Core Team independently reviewed the five options in a grid against selection criteria (e.g., differentiation, risk, business models). 8. Helped facilitate a strategy meeting focused on Options Evaluation ("Conversation 2") with the full Core Team, October 19, 2021. The Core Team deliberated on target positioning, alternative business models, and alternative governance models. I manually and digitally recorded the transcript, and coded for discussion disciplines and strategic thinking practices.
Phase 3 (Month 5-6, November-December, 2021):	9. Refined the strategy options grid based on feedback in Conversation 2. 10. Revised "one-pagers" for top two options. 11. Extended the SNA, generating a repository of the ecosystem of 22 NGOs related to Maine Aquaculture, along with regulators and related service providers. Researched independent directors and leadership teams using Web sources. This was reviewed with a representative from the Steering Committee and proposed as a Hub product. 12. Presented two options in a discussion among the Core Team January 20, 2022. (This involved deliberation and a discussion of new grant writing to NOAA grant.)

3.3.3.2 Data analysis

Five interviews were conducted with the Steering Committee (4) and the Hub Coordinator (1) (the Core Team). These were between 46 and 90 minutes. Interview data were both audio recorded and manually recorded. Core themes were coded and synthesized. Topics included accomplishments, headwinds, opportunities, understanding of transdisciplinarity, and perceptions of the Hub strengths. These were validated against interviews with other industry stakeholders (6) and aquaculture industry interviews. (See also Chapter 4 Methods for related interviews.)

A data set was compiled of all participants in Hub's funded activities, including the AQSW, RFP application, and focus groups. The data were expanded to create edges between each co-member of a meeting or event (e.g., focus group or AQSW session). This was then imported into Polinode for SNA analysis.

A third data set (SNA extension) focused on twenty-two aquaculture-related organizations which were identified by the Core Team in Conversation 1. For each organization, staff and advisors (board members, technical or business advisors, or other independent directors) were identified, for a total of 610 records, of which over 90% had names which were traceable to those individuals' home organization affiliations. (For example, one business advisor was the retired CEO of a Fortune 500 company.).

A fourth data set involved observing and manually recording two Core Team meeting discussions (Conversation 1 "Strategy initiation," and Conversation 2 "Options evaluation"). These were coded for the discussion disciplines (Skifstad & Pugh, 2014) and strategic thinking practices (Liedtke, 1998).

Between meetings, I observed the Hub's explicit and implicit capacities by reviewing patterns across the interviews, conversations, and SNA data, and situating these observations in relation to the researchers' own knowledge of the aquaculture industry.

3.4 Results

The goal was to better understand the Hub's explicit and implicit capacities while those capacities were "on view," contributing to the Hub Core Team's strategic planning in real-time. From an explicit program perspective, the Hub built external aquaculture capacity at the industry level, the organization level, and individual level. This occurred through its roadmap, grant funds administration, and AQSW training, respectively. In addition, in its first three years of existence, the Hub cultivated a range of "knowledge capitals": social/relationship capital, human capital, and structural (process) capital (Stewart, 1998). These resided in the network (lists of attendees), in the knowledge gained by learners (learning content), and the Hub's methods, such as AQSW training agendas, virtual focus group agendas, and grant procedures (structural/ process capital). These explicit capitals are valuable products of the Hub. Next I review the explicit capitals as capacities of the Hub.

3.4.1 Hub's explicit transdisciplinarity capacities are its official deliverables

The Hub's explicit deliverables — roadmap, grant administration, and training — were examples of transdisciplinarity in the organization.

Roadmap: One goal of the Hub was creation of the "Roadmap." The Hub team conducted interviews and focus groups with 140 people representing 92 organizations. These inquired into the directions and requirements of the aquaculture industry in Maine, such as workforce development skills, market development directions, financing models, diversity, and engagement in the regulated lease process (Sadusky et al., 2022). The audience for the RFP document was diverse, including regulators, investors, farmers, policy makers, academics and citizens.

RFP Administration and grants: A second goal of the Hub was managing an RFP process and distributing funds to "[b]uild capacity within Maine's aquaculture industry…by establishing a responsive call for proposals that encourages industry leaders to identify the most effective means of achieving growth" (Maine Aquaculture Hub website, 2022). As of August 2021, $216,000 had been granted to five

organizations. The organizations which were awarded grants were "industry members, sea farmers… and companies that provide goods and services to sea farmers" (Maine Aquaculture Hub website, 2022). Sample topics included biotoxin testing, shared cleaning devices, and kelp blanching. A second call for proposals was issued in January of 2022, and additional grants, amounting to approximately $85,000, were awarded.

Aquaculture in Shared Waters (AQSW): A third goal of the Hub was to continue and to expand a training program for aquaculture farmers. AQSW preceded the existence of the Hub, and the Hub coordinated its activities. In eight years of operation, by August, 2021, over 270 learners had participated in the AQSW cumulatively. (Source: Core Team Interview). As of August 31, 2021, 56 students had participated in 2021 AQSW classes (29 for AQSW 1 and 27 for AQSW 2). One Core Team member remarked, "Seeing where students are starting farms is the biggest success."

3.4.2 Hub's implicit transdisciplinarity capacities on network, team and individual scales

The Hub's transdisciplinary practices, as an operation, went well past the explicit. It is in the implicit (emergent, latent) practices where emerged hidden sources of strategic advantage, resilience, and sources of day-to-day effectiveness. These capacities contributed to strategic advantage, and the design of the Hub's future:

1. **Social (Network) capacity**: The Hub's transdisciplinary activities strengthened the aquaculture industry's connections and the Hub's own productive capacity as a knowledge network. Productive capacity included access to volunteers, local knowledge, and institutions.

2. **Team-based strategic thinking capacity**: The Hub Core Team's creative capacity — bolstered by an ability to unify on its intent, to use analogies, to pose testable hypotheses, and to consider exploiting strengths — was seen in its strategic thinking capacities.

3. **Conversation capacity**: The Hub Core Team's conversation was rich with sense-making, and served as a generative resource, improving relationships, options, and intent-to-act.

The Hub Core Team was aware of these, at least conceptually, and saw these as assets. Consider these quotes from the interviews: One explained, "We have a wider lens on the industry. We've been able to see the common threads," another, agreeing, added, "We bring people in the aquaculture space together. We [listen to] many voices…We've been getting to know the municipalities and AQSW students." They recognized the value of their team with the statement, "The [Core Team] is a safe place to have difficult conversations," and, similarly, "The Core Team respects each other's interests. We are moving collectively forward." In the context of the strategy development process, one could observe how these implicit capacities could be both a source of competitive advantage and an aid in defining and adapting the Hub to its industry context.

3.4.2.1 SNA: Hub bridges disparate communities together in a network

Hub Core Team interviews revealed that Maine aquaculture had significant network performance headwinds, such as supply chain gaps, consumer misunderstandings, and social tensions, all of which created silos or, in SNA terms, self-reinforcing clusters. Friction in the communities and across the sector was described by interviewees. One participant explained, "Communities are in conflict. They have not come together on their vision for Aquaculture." Another similarly said, "There are overlaps between [aquaculture] workforce development programs."

An SNA for the Hub revealed social network connections created by, or amplified by, the Hub. These connections crossed multiple sectors, such as farmers, industry, regulators and academics. Interviewees believed that these ties were stronger because of participants' connections having been strengthened in real-time (AQSW, Focus groups, or 1:1s with the Hub Coordinator), and having been encouraged by the Hub's adept and neutral facilitators. The SNA showed all connections that resulted from hub-originated activities across 240 individuals in 2020- Spring, 2021. A total of 2,397 edges (connections) emanated from AQSW, Focus Groups, RFP evaluations, and Hub Coordinator, as shown in Table 3.3. The Hub interacted with 105 unique organizations, in 12 different convenings. In addition, 80 individuals had participated in AQSW programs.

Table 3.3: The Connections Amplified or Initiated by the Maine Aquaculture Hub

Aquaculture Hub Event 2020-2021	Edges resulting from activity	Percent of edges
Aquaculture Shared Waters Program 2.0	351	15%
Aquaculture Shared Waters Program 2021	528	22%
Focus Group – 10	66	3%
Focus Group – Fishing	45	2%
Focus Group – Industry	597	25%
Focus Group – Investors	105	4%
Focus Group – Municipalities	45	2%
Focus Group - NGOs/Advocacy Groups	105	4%
Focus Group - Regulators*	83	3%
Focus Group - Researchers/Biotech	231	10%
Hub Coordinator reach-outs beyond 13 Hub staff and Core Team	226	9%
RFP Principal Investigators	15	1%
Total	**2,397**	**100%**

Note: *Two focus groups for Department of Marine Resources and other regulators have been combined. Internal links inside the Core Team organizations (including UMaine) are not shown. Total edges with internal links in the Core Team and their organizations are 2,636.

Figure 3.1 shows the SNA structure. I have shown the connections stimulated within the focus groups, AQSW events, and RFP Principal Investigators. In this graphic, I have removed the edges associated with the Core Team and their organizations (Maine Sea Grant, Aquaculture Research Institute, Maine Aquaculture Association, Coastal Enterprises, Inc., UMaine, and Maine Aquaculture Innovation Center). Now, imagine the Hub Coordinator, circled in yellow, linking to each and every node on the diagram, adding 226 additional edges. For example, the Hub Coordinator links between the "Fishers Focus Group" cluster and the "Investors Focus Group" cluster. While in the middle of the graphic there are some nodes that appear to have high betweenneess, most clusters owe it to the Hub Coordinator to link them to other clusters. In that sense, the Hub Coordinator is a one-node bridge or "structural hole"

(Cross & Parker, 2004). From an SNA metrics perspective, the Diameter (longest of the shortest paths) has a path length of 6 without the Hub. It is only 2 with the Hub.
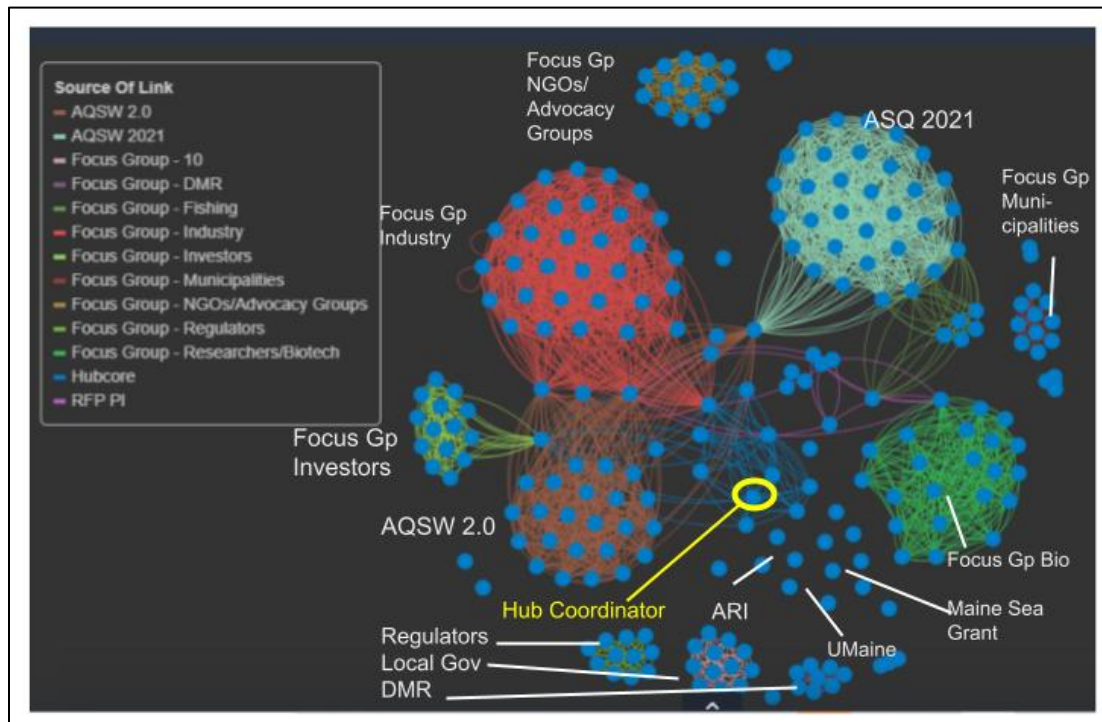
Figure 3.1: Hub SNA showing clusters that were joined by the Hub. Hub SNA for April 2021, excluding 1:1 interviews, Core Team organizations, and UMaine. Uses Polinode Lens layout without overlap.

3.4.2.2 SNA Extension

A data set of additional aquaculture relationships was also produced from 22 organizations operating in Maine on Aquaculture topics identified by the Core Team in Conversation 1. 14 of these organizations were identified in the prior SNA data. The fact that the Hub Core Team members had interacted with all 22 organizations was remarkable, even if not all of those 22 organizations were in the AQSW, RFP process, or Focus groups, as shown in Table 3.3. These 22 organizations represent 610 individuals from industries as far from Aquaculture as Finance, Retail, and data science.

Table 3.4: SNA Extension Statistics

610	Employees and/or Board (trustee, advisory) positions in Aquaculture-related NGOs, of which approximately 553 are unique (meaning 57 Board seats were occupied by people who were on one or more Boards.).
22	Organizations recommended by Hub Core Team for whom Board members were identified.
14	Of those organizations which were also part of the Hub's AQSW, Focus groups, or RFPs.
277	Unique home organizations for Board members.
120	Organization leaders or staff at the NGOs.
15	Average organizations on each board.
40	People on multiple boards*
57	People without identified home organization**

Note: *The number of people on multiple boards could be greater, given that some organizations lack focal points. For example, Alliance for Maine's Marine Economy and Maine Aquaculture Association do not list focal points). **For example, Bigelow Labs and Hurricane Island named affiliates but did not identify those affiliates' organizations.

3.4.2.3 Network as a strategic capacity

To the Hub, the value of the knowledge network -- over and beyond simply having connections, or "being a social network" -- is its ability to discover and convey knowledge quickly (reach), to adapt to local conditions, and to mobilize at scale. Specifically, the 600+- person network could mobilize around the roadmap, such as building supply chains or building brand-awareness. The Core Team felt that volunteers, who came from the network to engage as AQSW instructors, and/or focus group participants, could be the foundation of a knowledge network. An effective knowledge network could be a customer and a provider of voluntary or paid services to the Hub.

Using the Knowledge Network Effectiveness Framework (Pugh & Prusak, 2013), one can see that the Hub Core Team demonstrated its knowledge of the network's value: The Hub Core Team named outcomes (e.g., reduced aquaculture friction or fragmentation, jointly-developed products), which would be brought about by members' behaviors (e.g., interactions demonstrating respect, inclusion, and creativity). Behaviors, in turn, would be influenced by dynamics (non-linear structures or feedback loops,). Dynamics, in turn, would be shaped by the network design. Intentionality (shared rationale),

alignment (intent-defined network practice), and coherence (internal consistency between messaging and practice) would reinforce the explicit transdisciplinarity practices, such as shared language, knowledge co-production, deliberate process, and ways of knowing (Pugh et al., 2022, in prep).

3.4.2.4 Leadership Team capacity: Core Team uses teaming disciplines and strategic thinking

The Core Team's teaming skills were visible during the strategic planning process. Purpose, structure, and psychological safety were on display. The Purpose teaming skill was evident as Core Team members repeatedly returned to the mission to spread aquaculture knowledge and connections. The Structure teaming skill was evidenced by the Coordinator's routine facilitation of the Advisory team. Psychological Safety teaming skills emerged in the interviewees' remarks and the two Core Team conversations. For examples, a Core Team member in Conversation 1 remarked:

> [W]e have different missions, but we all work together. For some of our organizations we have sliders [positioning] on the different sides. But we are in the middle when we come together. It's because of the trust that we have in each other. This has made this group unique.

The Core Team engaged in strategic thinking, not just strategic planning. This can be seen through analysis of the conversations for strategic thinking activity. In this section, I summarize the Core Team's two strategy meetings. In the first "Strategy Initiation" meeting (Conversation 1) the Core Team reviewed the Hub's accomplishments, considered the competitive landscape, discussed strategic planning assumptions, brainstormed strategic advantages, and set the stage for options-identification. Conversation 1 also included a review of the interviews with the Core Team members.

In the second "Options Evaluation" meeting (Conversation 2) the Core Team discussed strategic options which were identified by the Hub Coordinator, based on white space (opportunity) identified in the Aquaculture Roadmap and in Conversation 1. In Conversation 2, the Core Team scrutinized the viability of the options, and refined them. After that meeting, the Hub Coordinator created detailed strategic options, including positioning, business models and governance.

I recorded strategic thinking activity over the course of the two conversations. In Conversation 1, 41% (54 out of 133) moves exhibited strategic thinking. In Conversation 2, 44 out of 71 (62%) of the moves exhibited strategic thinking. In Table 3.5 columns have been ordered to show the temporal dominance of each strategic thinking practice shown, left to right.

One sees strategic thinking activity suited to the sequential meetings. During Conversation 1, the "Strategy Initiation" meeting, Intelligent Opportunism (expanding on strengths) dominated, at more than twice the frequency of Intent-Focused, Hypothesis-Driven (data-driven incremental proposals), and Thinking in Time (using analogies). In Conversation 1 Intelligent Opportunism appeared to reflect more of a sense of shared pride than a confidence about the Hub's match to specific future positioning. In Conversation 1 the Core Team moves were first focused on identifying strengths, and then equally distributed between agreeing to direction (Intent-Focused), reference points (analogies), and options.

Approximately seven weeks later, in the evaluation of strategic options, in Conversation 2, "options evaluation," the Hub Core Team used roughly equal amounts of the strategic thinking moves of Hypothesis-Driven (data-driven incremental proposals), Intelligent Opportunism (expanding, or leaning into, on strengths), and Thinking in Time (using analogies).

Table 3.5: Strategic thinking statement frequency by Core Team at two strategy meetings showing effective progression.
Conversation 1 "Strategy Initiation" (approx 1:45 minutes, 8/31/21)

Move	1 Systems perspective	2 Intent-focused	3 Thinking in time	4 Intelligent Opportunism	5 Hypothesis-driven
1-20	30%	10%	10%	30%	20%
21-40	0%	0%	17%	50%	33%
41-60	0%	75%	0%	25%	0%
61-80	0%	0%	33%	67%	0%
81-100	0%	30%	20%	50%	0%
100-120	0%	18%	27%	45%	9%
121-133	10%	20%	0%	30%	40%
Average	6%	22%	15%	42%	15%

Table 3.5 (cont'd)

Conversation 2 "Options Evaluation" (approx 1:30 minutes, 10/19/21)

UtterMoveance	1 Intent-focused	2 Hypothesis-driven	3 Thinking in time	4 Systems perspective	5 Intelligent Opportunism	Not: Hypothesis-driven
1-20	17%*	50%	17%	17%	17%	0%
21-40	0%	25%	25%	0%	50%	0%
41-60	25%	25%	75%	0%	0%	0%
61-80	14%	43%	29%	0%	29%	0%
81-100	75%	25%	75%	0%	0%	0%
100-120	0%	0%	0%	40%	40%	20%
121-133	14%	14%	0%	0%	57%	29%
Average	21%	26%	31%	8%	27%	7%

Note: Includes strategic thinking activity extracted from the conversation. Greater than or equal 40% during the phase of the conversation is red, between 20% and 40% is tan, and 20% or less is light beige. Rows represent distribution across strategic thinking-related moves in that interval of ten moves. (Rows sum to 100% horizontally). Columns are weighted-averaged at the bottom to signify the dominance of that strategic thinking practice. This illustrates the difference in strategic thinking practice between the two conversations, such as starting with a Systems Perspective (Conversation 1), versus starting with Intent-Focus (Conversation 2). *In Conversation 2 a strong Intent-Focused move preceded Hypothesis-driven moves, but as moves have been compressed into groups of 10, this is not evident from the light beige color.

It is instructive to compare strategic thinking moves that dominated during the topics of the two conversations. Figure 3.2 shows that in Conversation 1, the topics of situating the strategy (reviewing the SNA and interviews) and examining sample business models (value streams and revenue sources) resulted in the most strategic moves. Strategic moves as a share of conversational moves increased as the conversation progressed. As seen in Figure 3.2, much of both conversations was about exploiting strengths (Intelligent Opportunism). In fact, the pivotal moments appeared to be when the group was talking about itself (as diverse, trusting, enduring, and neutral). Conversation 2 involved considering options that the Hub Coordinator had shaped from the Roadmap. By contrast to Conversation 1, Conversation 2 had strategic moves spread across four of the five strategy options, which were discussed sequentially, then followed by a general discussion. Again, the highest occurring strategic discipline was Intelligent Opportunism.

Table 3.6: Strategic statements, by agenda topic.

Conversation 1: "Strategy Initiation" (approx 1:45 minutes, 8/31/21)

Strategic Thinking practice* *Topic*	Hypothesis-Driven	intelligent opportunism	Intent-Focused	Systems Perspective	Thinking-in-Time	Grand Total
1. Looking back			1			1
2. Roadmap, context	2			3		5
3. Situating strategy	2	6	2	1	2	13
4. Industry landscape		3	4		2	9
5. Positioning		9			1	10
6. Business models	5	4	4	1	2	16
Grand Total	**9**	**22**	**11**	**5**	**7**	**54**

Conversation 2: "Options Evaluation" (approx 1:30 minutes, 10/19/21)

Strategic Thinking Practice& *Topic*	Hypothesis-Driven	intelligent opportunism	Intent-focused	Not: Hypothesis-Driven	Systems Perspective	Thinking-in-Time	Grand Total
1. Advisor to the Industry Maker	3	2	1		1	2	9
2. Market and brand maker	2	1					3
3. Municipality Strengthener		1	1			4	6
4. Aq. Academy Collective	3	1	3			2	9
5. Research Central	1	2	1			2	6
Discussion	1	4	1	3	2		11
Grand Total	**10**	**11**	**7**	**3**	**3**	**10**	**44**

Note: Includes only strategic thinking moves. *Strategic thinking practices in alphabetical order.

Looking at Figures 3.5 and 3.6, consider the timing and frequency of each of the strategic thinking disciplines separately. These appear to reflect the Core Team's comfort with each other, with ambiguity in the direction (positioning, business model and governance), and with the process:

- **Intent-Focused** (purposing) was later in Conversation 1 and earlier in Conversation 2. This may have been because the first conversation began with a review of the program, interviews, roadmap and the SNA, and those concepts provided a wider aperture. The Core Team appeared to be centering on the intent more readily when they re-convened in Conversation 2.

- **Hypothesis-Driven** (using testable propositions) was later in Conversation 1, and earlier in Conversation 2. This appears logical, as, in Conversation 1, Core Team members were asking questions, level-setting, and conjecturing with if-then statements. In Conversation 2 the conversation transitioned from inquiry to statements about exploiting capabilities. This is perhaps another marker of the group's confidence in itself and, by the second conversation, faith that the data-gathering process does not need micro-managing.

- **Thinking in Time** (using analogies) requires respect for the past. In strong transdisciplinary collaborations, participants generate a common repertoire to aid in boundary spanning (Silka, 2013; Clark et al., 2016). In reference conversations, one sees the Courtesy move, and by extension, Thinking in Time discipline, later in the conversation that yielded improved relationships (See Chapter 4 relationship predictors). For the Hub Core Team, Thinking-in-Time was early in both Conversations 1 and 2. This appears to be a product of the familiarity and goodwill of the Core Team (having history in common). They readily drew out instructive examples early in the conversations from aquaculture and other industries.

- **Intelligent Opportunism** (exploiting strengths) dominated the middle of the conversation in Conversation 1, and dominated the end of the conversation in Conversation 2. As I discuss below, Intelligent Opportunism associates with the Translation discussion discipline (summarizing, extending), proposing to exploit a capability toward a strategic option. Intelligent Opportunism's later role in Conversation 1 may be about enumerating competencies reactively, and in Conversation 2 may be about moving toward an actionable strategy proactively. It is likely a mark of mutual respect that the group held back the translating, Intelligent Opportunism, statements until the end of Conversation 1. Individuals let the ambiguity persist. This contrasts to the reference conversations in which translation is more frequent in the first half of the conversation, and with which individuals may attempt to justify a position.

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In the strategic planning conversations one can see that the team behavior by the Core Team is more than a system to reduce friction. It is likely applying transdisciplinarity inside of strategic thinking — using a diversity of knowing, perspective, and knowledge co-production to generate options (Hypothesis-Driven, Thinking-in-Time) and to get to closure (Intelligent Opportunism).

Strategic thinking appears to be an asset for the Hub. Yet, strategic thinking practices do not come without a price. As Liedtke (1998, p. 125) explains, "In order to incorporate strategic thinking into planning processes, we must recognize three discrete aspects of the *process*: repertoire-building, managing the strategic issues agenda, and programming." The Hub Core Team could point to AQSW as evidence of programming, and the Roadmap as evidence of managing the strategic issues agenda. However, repertoire-building (beyond the AQSW content) appeared to be new, only defined in the proposed future-state options.

3.4.2.5 Conversation Capacity: Core Team's conversation capacity yields creativity and options

A third implicit capacity is conversation. Conversation research underscores the need for suspension of judgment and inclusion across difference, through respect and listening (Isaacs, 1999b; Dixon, 2019). Conversation capacity helps to support systems thinking, options generation, and risk-taking in the act of transdisciplinary collaborations. The five discussion disciplines are extensions of Bohmian dialogue (Dixon, 2018; Skifstad & Pugh, 2013; Pugh, 2020). These are:

1. Integrity (authentic and/or data-driven statements),

2. Integrity-Q (inquiry),

3. Courtesy (respect, kindness, positivity),

4. Inclusion (pulling others in, seeing them, acknowledging them, not excluding), and

5. Translation (up-leveling, summarizing, extrapolating).

As can be seen in Table 3.7, by using the discussion disciplines with such ease, one could say that the Core Team displayed "the art of thinking together," as Isaacs (1999b) puts it.

Table 3.7: Comparison of Discussion Discipline proportions for Conversation 1 and 2

Discussion Discipline	Reference Transcripts %	Conversation 1	Conversation 1 %	Conversation 2	Conversation 2 %
Integrity	52%	60	44%	28	39%
Integrity-Q	15%	25	20%	14	20%
Courtesy	12%	10	7%	10	14%
Inclusion	11%	11	8%	3	4%
Translation	6%	26	19%	13	18%
Anti	6%	1	1%	3	4%

Note: Reference is the average across seven aquaculture lease scoping meetings (Chapter 4). Shading represents noteworthy differences from Conversation 1 to Conversation 2.

As we consider each of the utterances, recall that approximately half (41% in Conversation 1 and 62% in conversation 2) were directly associated with strategic thinking. Below we review Table 3.7 as not just evidence of conversation skills, but also centering strategic thinking disciplines.

1. Intent-Focused [*Integrity*]. Conversation 1 had particularly high Integrity, given the significant role of the facilitator, but Integrity's share (44%). was still lower than the reference data (52%). At 39%, Integrity for Conversation 2 was lower than the reference data. This suggests that more moves were acknowledgement (Inclusion), up-leveling (Translation) or generosity (Courtesy). The expression of strategic intent was in the Integrity moves. Yet, Integrity was the discussion discipline for which the highest share was not also a strategic thinking example, as shown in Table 3.7. (It is likely that intent-alignment was not in question.)

2. Hypothesis-Driven [*Integrity-Q*]. For both Conversations 1 and 2, at 20%, Integrity-Q moves were considerably higher than the reference data (15%). This is a positive sign, as Senge (1992, p. 252) claimed, "The most productive learning usually occurs when managers combine the skills in advocacy and inquiry…. Another way to say this is 'reciprocal inquiry.' By this we mean that

everyone makes his or her thinking explicit and subject to public examination." In the Lease Scoping Meetings, discussed in Chapter 4, we observed a correlation between Integrity-Q and options-generation. By extension, one would expect a hypothesis inside a conversation to correlate to the formation of options. Hypotheses-generation, associated with Integrity-Q, is evident here, particularly in Conversation 2, as shown in Table 3.5.

3. Thinking-in-Time [*Courtesy*]. At 7% and 14%% for Conversations 1 and 2, respectively, Courtesy moves were similar to the reference data (12%), but these were increasing for the Core Team. Courtesy is having "respect for what is" (Isaacs, 1999b). When associated with Thinking in Time, Courtesy is using analogies to look at aquaculture industry peers or other industry examples. In the strategic planning process, to bring each option to life, and help people imagine, the Core Team used one-pagers that resembled marketing pitches. These brought to mind commercial products, and focused imagination.

4. Systems Perspective; [*Inclusion*]. At 8% and 4% for Conversations 1 and 2, respectively, Inclusion moves in Conversation 1 were below reference data (11%) or below. Moves to clarify or reach out were not remarkable, and even light in Conversation 2 perhaps because of the familiarity of the Core Team. The act of including generally is acknowledging or welcoming a broadened lens, like the Systems Perspective strategic thinking practice. It is likely that the systems perspective was more ubiquitous than the conversation transcript reflects, given systems perspectives provided in the interviews.

5. Intelligent Opportunism [*Translation*]. At 19% and 18% for Conversations 1 and 2, respectively, Translation moves were considerably higher than in the reference data (6%). Translation associates with Intelligent Opportunism, as there is an extrapolation or projection one's current capabilities into the future. This likely reflects the more deliberative flavor of this interaction,

compared to the reference data, and the fact that the group was more committed to collective responsibility to generating and deliberating options.

3.4.3 Hub's implicit transdisciplinarity capacities emerge as source of strategic advantage

In this section we ask how the implicit outputs of the Hub — the social, strategic thinking and conversation capacities — may be a source of strategic advantage, and feed into the strategy development process. The strategy development model used by the Core Team asked three primary questions: "Where do we compete?", "How do we win?" and "How do we sustain competitive advantage?" These required the Core Team to test their assumptions about positioning, business model, and governance, and to envision deploying capabilities into the white space (unclaimed strategic positions) between other organizations and service providers in the aquaculture industry. As Mainardi and Kleiner (2010) theorized, the Core Team, as leaders, was committed to applying the Hub's operational capabilities. The Hub Core Team appears to see that its implicit capacities are a resource for adaptation to a growing, yet uncertain, aquaculture industry.

3.4.3.1 Network capacity informed the Hub's positioning options

Positioning is about direction and focus. The network that resulted from the activities around AQSW and the roadmap inspired a diversity of potential target beneficiaries, such as consumers, farmers, suppliers, investors, researchers, policy makers, regulators, and restaurateurs.

In Conversation 1, the Hub Coordinator presented a two by two map of the aquaculture industry landscape illustrating this. The horizontal dimension was the "degree of convening," showing a range of serving individuals through convening networks. The vertical dimension was the "degree of coverage of the value chain," showing a range from aquaculture research to commercial processing. Core Team members jumped in and added to the entities. While Core Team members collectively recognized those 22 players, their experience of the Hub as network convener may have informed their knowledge of more

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entities' capabilities, and the white space where the Hub could play. This experience also let them ascertain the suitability of options that spanned the commercial to core research.

3.4.3.2 Team capacity (strategic thinking practices) enabled validation of business models

A business model is the combination of economic activities that yields stakeholder and economic value. Focusing on the other competing or collaborating entities helped Core Team members think expansively about comparative business models. For example, potential future income streams were not limited to grant funding, but also fees, advertising, badging, competitions, and subscriptions for the Hub's services. Economic models further included leveraging volunteers, as in effective knowledge networks.

Considerations of business models different from the Hub's current grant-based model were a bold move, and likely resulted from strategic thinking practices. Core Team members used analogies (Thinking-in-Time) and extrapolations from current Hub performance data (Intelligent Opportunism). For example, one member recalled having done informal 1:1 coaching, and posited that such a thing could be done for a fee or part of a training subscription.

3.4.3.3 Conversation capacity lifted undiscussable options

Governance decisions involve the ownership or reporting structure, including the entity form (private v. public, for-profit v. non-profit, fee or other revenue v. grant-funded). The Core Team deliberated whether the Hub would be under an umbrella organization, independent, or a joint venture. They also deliberated whether it would be definitely advocating for aquaculture or passively providing information. Being able to address such "undiscussables" resulted from strong conversation skills.

The contribution of the Hub's activities and practices to their implicit and explicit capacities can be seen in Table 3.8. These implicit transdisciplinarity capacities, cultivated alongside, or derivative of, explicit capacities, can be regarded as a source of strategic advantage.

Table 3.8: Summary of Hub's explicit and implicit transdisciplinarity capacities

Practice	Transdisciplinarity capacity	Hub's Explicit capacities	Hub's Implicit capacities contributing to strategic advantage
1. Shared Language	Capacity to agree to terms and use practices, use analogies and common reference models.	AQSW	• ST: Thinking-in-Time (Analogies) provide shared understanding of industry players • DD: Conversation disciplines particularly Integrity-Q (inquiry), inclusion, translation
2. Knowledge co-production methods	Capacity to use knowledge creation methods that yield distilled, instilled or embodied knowledge products, which, in turn, are integrated across boundaries.	Roadmap	• NW: Network convening to elicit knowledge. • ST: Hypothesis-Driven, intelligent opportunism • DD: All conversation disciplines
3. Deliberate project management processes	Capacity to standardize transdisciplinarity project management processes	AQSW, Focus group, RFP	• NW: Deliberate network cultivation rituals • ST: Intent-Focused
4. Systems thinking	Capacity to recognize the system's complexity and non-linearity. Incorporate feedback loops.	Roadmap	• ST: Systems Perspective • DD: Conversation disciplines of Integrity-Q, Inclusion
5. Practicing different ways of knowing	Capacity to incorporate to negotiate shared values and epistemologies, and co-produce knowledge	AQSW	• ST: Systems Perspective, Thinking-in-Time (analogies) • DD: Use of "one-pager" advertisements making options come to life)
6. Recognizing multiple collaboration scales	Capacity to have different scales reflects a single transdisciplinarity vision.	Three scales	• All: Networks' social capital, ST and Conversation practices • ST: Hypothesis-Driven (AQSW scale up),Thinking-in-Time (analogs at larger NGOs)
7. Team collaboration practices	Strength of team collaboration dimensions: shared purpose, collaboration structure, and psychological safety.	Project management and team well-being	• NW: Offline Core Team collaborations • ST: All strategic thinking disciplines / All conversation disciplines • DD: All conversation disciplines

Note: ST = Strategic thinking practices, DD = Discussion Disciplines in conversation practices.

3.5 Discussion

Using the example of the Maine Aquaculture Hub, I examined how seven common transdisciplinary research practices can support intended outcomes in both explicit and implicit manners. As an organization, the Hub had developed collaborative intelligence: First, the Hub's social (network) capital has the potential to improve local adaptation, scale, and information speed, while also raising the switching costs for Hub customers (Stewart & Pugh, 2013). Where the Hub is the connector (in SNA

terms, the "structural hole"), these diverse stakeholders might not come together without the Hub's serving as broker. Second, the Hub's strategic thinking improved intention, ideation, use of analogies, coherence, and capacity exploitation (Liedtke, 1998). Third, the Hub's conversation capacity reduced communication gaps as the Core Team deliberated on difficult issues, and conversation capacity improved resilience (Dixon, 2018). As these implicit capacities were aligned to the seven explicit transdisciplinarity capacities, they were also grounded in respectful pluralism.

There are several important conclusions for leaders. One is to have strategic thinking practices in balance, and even to anticipate sequences of those practices, as we saw with the Hub's two conversations with distinctly different ideation and deliberation goals. Liedtke (1998) points out that strategic thinking is more than a different way for individuals to be intellectually engaged. It is a form of dialogue, often spread out across time and separate interactions. For example, leaders need to be aware of their tendency to be skeptical (Hypothesis-driven), self-directed or confident (Intelligent Opportunism), or overly competitive or comparative to readily-available analogy (Thinking-in-Time). Moreover, leaders are often trained to be advocates, even blinder-wearing (Intent-focused). Strategic thinking requires inquiry and inclusion, which are conversation skills.

A second conclusion relates to sequential interaction. When a group has options, it may engage with the options unevenly, simply because of the natural flow of participation from intent, to inquiry, to analogy, to systems, to strength-exploitation. The Hub Core Team initially widened its the strategic thinking aperture with the shift toward inquiry (Hypothesis-Driven) at the end of Hub Conversation 1. The five options were placed on the agenda in Conversation 2 with the idea that all were equally valid. Thus, greater amounts of intelligent opportunism late in Conversation 2 may inadvertently have given later options more attention. Leaders need to be aware of these types of patterns if they wish to have equal deliberation of all options. Notably, the convener of strategic thinking is a "process facilitator" who develops the collective capacity of participants to be strategic thinkers by prodding and amplifying the strategic thinking practices even when the group is tired.

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My research suggested that this strategic thinking ability of the Core Team may have been aided by the Core Team's capacity for conversation. For example, equitable Translation moves likely reflected a sense of equity in the Core Team, as there is no one dominant leader who translates for others with more knowledge or facilitation responsibility. The act of translating the organization's strengths into something (turning strengths outward, extrapolating, or adapting/pivoting, as in Intelligent Opportunism) is a central skill for capabilities-based strategy (Mainardi & Keliner, 2010). The conversational agility of the team amplified strategic thinking skills. Had there been weaker conversation capacity, the group may not have been able to take into consideration difficult options that could have reshaped the Core Team members' roles. Trusting that providing data-driven suggestions would provoke inquiry and not defensiveness (being Hypothesis-Driven), the Core Team appeared to be ready to imagine such changes. In fact, one Core Team member suggested relinquishing their seat on the Hub Core Team, should the Hub change its focus.

Transdisciplinarity researchers may benefit from looking at the implicit, hidden capacities, of social (network) capital, strategic thinking and conversation. These are particularly remarkable in our research because they play in the network, organization, and conversation scales. The Hub leveraged the network for adaptation and reach, the organization (Core Team operation) for decision-making, and the conversation capacities for integrating individuals' disciplinary insights. I saw that these implicit capacities also presented options for novel positioning of the Hub, its business models, and its network influence. In the case study of the Aquaculture Hub, implicit transdisciplinarity capacities — the strength of the network, the balance of strategic thinking disciplines, and individual conversation skills —became differentiators in the positioning, business model exploration and governance deliberations.

Lang et al. (2012, p. 38) remind us that what's important is action: "Transdisciplinary sustainability projects aim to generate actionable knowledge for collective action in order to mitigate or resolve sustainability problems." The network, strategic thinking, and conversation implicit capacities may be assets for other organizations-in-action who value a triple bottom line of people, profit and planet.

The seven-part, explicit-implicit transdisciplinarity framework builds on a rich transdisciplinarity heritage. The framework can help an organization's current and future action – serving as an armature for future-search, options-identification and informed decision-making.

While the case of the Aquaculture Hub is instructive, it is still a work in progress. Outcomes of the implicit capacities will only come over time. In addition, the Core Team brought decades of heritage relationships (Gratton & Erikson, 2007), resulting in hard-earned psychological safety (Edmondson & Lei, 2014). An extension of this research could be to explicitly introduce network weaving, strategic thinking practices, and conversation disciplines together to another like-minded organization, and see whether the capacities could be accelerated, and, if so, what modulates their impacts.

There are implications of the Hub's case study for both transdisciplinarity science and organization science. Sustainability stakeholders would be well-served to extend transdisciplinary research insights beyond the research program or project, and into to the operation. Specifically, facilitation methods that yield social (network) capital can speed knowledge co-production, and integrate diverse ways of knowing (Cross & Parker, 2004; Ehrlichman, 2021). Strategic thinking capacity (intent-alignment, shared analogies, testable hypotheses, and opportunism) can accelerate sense-making and prioritization (Liedtke, 1998; Moon, 2013). Skillful conversation can enable leaders to engage productively and work through tension and ambiguity (Skifstad & Pugh, 2014; Isaacs, 1999b; Scharmer, 2018).

In the end, transdisciplinarity may be a strategic advantage for an organization, not just a project or program. For researchers, transdisciplinarity practices may make solutions stick. For organization scientists and managers in ecologically-oriented organizations and social enterprises, these implicit transdisciplinary capacities provide options for networked business models, proactive leadership, and improved sense-making. Sustainability organizations, particularly those in a period of transition, should embrace implicit capacities as part of repertoire.

CHAPTER 4

SUSTAINABILITY CONVERSATIONS FOR IMPACT:

THE CASE OF THE AQUACULTURE LSM

Abstract

Where interactions over natural resources and livelihoods require considerable knowledge -- e.g., science, statistics, logic, and place -- absence of certain perspectives may produce decisions that are not robust, or not perceived as legitimate by stakeholders. However, polarization (around politics, economics, science, and identity) is ubiquitous today, thwarting collaboration across difference.

Moving through (rather than around) ambiguity and tension, productive conversation aims to add perspectives, reduce conflict, and improve groups' collaboration capacities. It also has been shown to overcome biases, premature closure, and inaction. There is considerable research on elements of effective group interactions, such as turn-taking and paraphrasing, which suggests that there are specific elements that make conversation effective. But, for conversations about human-environmental systems, the research is nascent. There is a need for models incorporating endogenous conversation features (such as interaction moves that acknowledge or synthesize), and exogenous factors (such as signaling, power-differentials, gender-balance; and historical, ecological and regulatory states).

My research considered marine aquaculture industry conversations ("lease scoping meetings," or LSMs) occurring in ad hoc, open-invitation, public settings that aimed to address community concerns – e.g., navigational, aesthetic, ecological, and livelihoods. Analyzing meeting transcripts and conducting semi-structured interviews shed light on endogenous and exogenous influences on conversation effectiveness. My research lenses included the sciences of networks, organizations, organizational psychology, and behavioral insights.

The data showed that productive conversation can positively influence participants' group identity, collective knowledge, and motivation to cooperate. I argue that there is a need to build the capacity for skillful, equitable, and data-informed participation in conversation.

4.1 Introduction

Clark et al. (2016a: 4570) define sustainable development as: [T]he promotion of inclusive human well-being, and that well-being is shared equitably within and across generations… built on the *enlightened and integrated stewardship* of the planet's environmental, economic and social assets" (Italics mine). Sustainability scientists have long known that "enlightened and integrated stewardship" entails investing in competencies, communications, norms, and institutions (McCay & Acheson, 1987; Ostrom, 1990). Including diverse perspectives increases the likelihood that decisions are more salient, credible and legitimate (Cash et al., 2003).

This was the premise of transdisciplinary researchers in the human-environmental systems domain, and they have advocated for a variety of "integrating" practices, such as boundary work (Guston, 2001; Cash et al., 2003), shared language (Kates et al., 2001), and shared ways of knowing (Freitag, 2014). Where actors hold different positions – for example, on resource preservation, livelihoods, biodiversity, recreation, and private property – they can push institutions to innovate (Silka et al., 2019). Yet, diverse groups may become biased, acrimonious, or driven to premature consensus (Galinsky et al., 2015; Page, 2017).   The practices of dialogue have been shown to have a remarkable impact on reducing conflict and polarization (Dixon, 2019; Willison et al., 2017). Productive conversation extends dialogue. Combining the relationship benefits of dialogue, and productivity benefits of facilitation, productive conversation has been shown to improve closure and ideation (Skifstad & Pugh, 2014).

Maine Marine aquaculture is a complex social ecological system, sitting at the crosshairs of livelihoods, biodiversity, traditional fisheries, amenity migration, cultural heritage and state-wide revitalization (Johnson et al., 2019, Johnson, 2020). Distinct values and interests surface in the aquaculture leasing approval process, which involves a sequence of formal and informal conversations among stakeholders. These conversations take place at the water's edge, in neighborhoods, and in the media (Hanes 2018; Johnson & Hanes, 2018). By analyzing conversation during seven Maine aquaculture "lease scoping meetings" (LSMs), I explore conversation's endogenous influences (conversation patterns

and impacts) and exogenous influences (context, participation, signaling). The research questions in this chapter consider how conversation can play a purposeful role in improving innovation, accountability, and belonging related to aquaculture, and by extension, to other human-environmental systems.

4.2 Literature Review

Why is difference both an obstacle and asset to collaborations related to human-environmental systems? This section answers that question. First, it addresses the role of psychological safety-building, and why dialogue has been proposed to affect psychological safety. Next, it looks at limitations in the practices of dialogue and routines of facilitation as they are being used for sustainability. It proposes the concept of "productive conversation," a hybrid of facilitation and dialogue. It then looks at the mediators of conversation effectiveness: signaling and indirect speech, gender proportions, and turn-taking. This is followed by the methods section, where Maine aquaculture is described as a domain of analysis. Maine aquaculture has been an arena for conflicts over livelihoods, conservation, and aesthetics, but may also be a useful industry for citizen investment in conversation and the creative capacity conversation brings.

4.2.1 Toward Collaboration Across Difference

Galinsky et al. (2015), in a review of the literature on diversity, showed that diverse societies tend to be more prosperous. They point out thatdiverse groups make better decisions, are more innovative in both cooperative and competitive situations, and make better quantitative assessments. The authors also point to studies that show that diverse groups engage in deeper thinking -- for example, individuals better prepare, and write more thoughtful summaries (Galinsky et al., 2015; Sommers, 2006). Almaatouq et al. (2021) in an MIT-Wharton study demonstrated quantitatively that, while individuals are the most efficient at simple tasks, groups of diverse perspectives and heuristics solve complex tasks more efficiently than individuals.

Yet, Galinsky et al. (2015) warn, diversity does not come without cost. Look no further than the news to see tensions raised by diversity failures -- income disparities, resource scarcity and Covid-19's

human isolation. Diversity without civility results in polarizing speech on environmental matters in media (for example, Bago et al., 2021). In a survey of 5,000 people in the U.S., Germany, Brazil, India and the UK, Feldman and McCorkindale (2020) found that individuals considered engaging with people with different views a "major problem." In the US, 57% stated that it was "difficult to engage in respectful dialogue." Feldman and McCorkindale (2020, p. 5) write:

> 45% of respondents said the ability for people in their country to engage in respectful dialogue with those who hold opposing views was a major problem. Nearly two-thirds of respondents (64%) in Brazil agreed, as did more than half (57%) of the U.S.; nearly half (49%) in India agreed. Approximately one-fourth of respondents in the U.K. (28%) and Germany (26%) say that the ability to engage in respectful dialogue with those with opposing views was a major problem. *However, at least 70% of respondents in every country said this was, to some degree, a problem.* (Emphasis mine.)

Difference is a central concern of sustainability researchers. On matters of human-environmental systems, Ostrom (2009b) claimed that negotiating difference (especially differences that causes power difference) strongly determines the destruction avoidance, maintenance or restoration of social-ecological systems.

4.2.2 Psychological Safety

Psychological safety is a measure of the ability of individuals to perceive that they can take interpersonal risk, such as "speaking up," without loss of face (Dixon, 2018). Psychological safety is different from trust, in that psychological safety is a characteristic of a group or culture, won through practices, policies, and outcomes. Trust, on the other hand, is a characteristic of a direct relationship, won through personal experience with another individual (Dixon, 2018).

Psychological safety is a core ingredient in collaboration. In a review of two decades of research, Edmondson and Lei (2014) observed that psychological safety can be an antecedent, mediator, moderator, and/or outcome of group processes. Psychological safety improves information sharing, learning, engagement and satisfaction (Edmondson & Lei, 2014; Frazier et al., 2017). Edmondson and Zuzul (2013) further underscored psychological safety's critical role in transdisciplinary teams, who require vision, structured participation, and a culture of open participation. Google researchers found this as well (Duhigg, 2016). Measuring team effectiveness determinants, Google researchers showed quantitatively how psychological safety impacts productivity and job satisfaction, even more than technical capabilities (Duhigg, 2016). Dixon's research showed that lacking psychological safety can hinder transactive memory (memory of what others know) and hinder the (co)creation of knowledge (Dixon, 2018). In my own research into the critical ingredients for collaboration across scales (e.g., in a team, across units, across networks), I found that effective collaborations all require purpose, structure and psychological safety (Pugh & Algeo, 2020), as described in Chapter 3.

One might look to a meta-analysis of psychological safety across hundreds of studies by Frazier et al. (2017) to operationalize this for human-environmental systems concerns. In fact, Frazier et al. (2017) found that leadership, "interdependence," peer support, role clarity, and group dynamics were consistently reported as drivers of psychologically-safe group processes. However, Frazier et al. (2017) found less of a relationship between psychological safety and citizenship behavior or creativity. This is a healthy reminder that sustainability-related sustainability "citizenry" may be difficult to change by just introducing psychological safety practices. By contrast, Bujold et al. (2020), in a review of the community sustainability-intervention literature, showed that psychological safety and shared pride help diverse community stakeholders to implement effective sustainability programs.

4.2.3 The Dialogue-Facilitation Debate

Certainty is often at the root of failed interaction (Isaacs, 1999b). When group participant fail to suspend beliefs or attributions -- by being "certain" -- their position-taking reduces the likelihood that groups

which are otherwise cognitively diverse, and collectively intelligent, fail to generate options (Page, 2007; Stasser & Titus, 2003), fail to generate enduring collective intelligence (Scharmer, 2018), or fail to commit to collective action (Isaacs, 2016; Dixon 2019). Dialogue's practice of "keeping an open mind" (Clarke & Barton, 2020) is a proposed remedy for certainty. Isaacs (1999a) refers to this as dialogue's "suspension" practice. Suspension, the opposite of certainty, has been shown to increase group intelligence even in highly hierarchical groups, by enabling people to "speak up" (Dixon, 2018). Isaacs (1999a), explained dialogue's full complement of practices to include "suspension," "voice" (enacting agency, authenticity), "respect" (allowing others or systems to "be" without judgment), and "listening" (hearing what is said, not one's abstraction thereof). Isaacs (1999b, p. 9), noted dialogue's ability to unleash understanding and personal transformation:

Dialogue […] is about a shared inquiry a way of thinking and reflecting together. It is not something you do to another person. It is something you do with people. Indeed, a large part of learning this has to do with learning to shift your attitudes about relationships with others so that we gradually give up the effort to make them understand us, and come to a greater understanding of ourselves and each other.

Dixon (2021, p. 17) describes dialogue as a way of talking and thinking together that establishes a "common meaning." Dialogue does this by helping participants to incorporate new information with curiosity, rather than defensiveness. In the words of Isaacs, using the etymology of the Greek words "dia" and "logos," dialogue means literally, "meaning flowing through" (Isaacs, 1999a). Thus, a critical outcome of dialogue is not just information-exchange, but the ability for participants to create a "flow" of meaning which can grow collectively (Scharmer, 2018). Weick (1993) dubbed that flow of meaning "collective mind," which resulted from the capacity for collective sense-making.

Dialogue has resulted in the capacity to do problem-solving in otherwise polarized groups, for example, between Democrats and Republicans (Dixon, 2021), between inmates and officers in maximum

security prisons (Willison et al., 2017), and between warring Southeast Asian countries (Isaacs, 2016). In sustainability science research, "dialogue" is used for problem-solving in sustainability dilemmas (Silka, 2013; Silka et al., 2019). Dietz et al. (2003, p. 1910) use the term "analytic deliberation" for structured dialogue among scientists, resource users, and interested publics about human-environmental systems. Analytic deliberation "improves the effective use of information, enhances conflict resolution, consensus and adaptive governance, and builds cooperation" (Robson & Kant, 2009, p. 547, Cited by Daigle et al., 2019). McGreavy et al. (2021) noted that dialogue was an important vehicle for indigenous research methods in sustainability science programs, "inclusive of spaces of learning, identity formation, and relationship-building" (p. 943) enabling groups to question "conceptions of time, power, and place…[and to] challenge linear determinism" (p. 940).

Yet, dialogue is not easy. Learning dialogue takes time. Dialogue capability development for a group includes action-inquiry, physical equity (e.g., sitting in circles or concentric circles), and repeated, reflective interactions. Such interactions build what dialogue practitioners call "container strength," which is analogous to the sustainability science researchers' sometimes refer to as a trust-bank. Schein (1993), and later Dixon (2018), contended that for a new group to create a "container" (a shared history of risk-taking, and understanding) may take three, two-hour sessions, or approximately 60 person-hours for a ten-person group. Even skillful practitioners need repeated, time-separated interactions to achieve high levels of flow or generativity (Scharmer, 2018). Perhaps the biggest objection to dialogue is not cost, but its indirect connection to action, an objection Isaacs heard repeatedly from leaders in the South Asian Trim-Tab dialogues (Isaacs, 2016).

Consider a parallel development to dialogue: the facilitation practice. Facilitation as a role and profession began in the late 1970s with the notion of "process facilitation" in business (Schein, 1978), with similarities to mediation. Facilitation has been embraced across disciplines and industries to frame and manage options, reduce conflict, and accelerate action. The growth has been substantial: For example, the International Association of Facilitators, founded in 1994, boasts chapters in 55 countries, and five

levels of formal certification (International Association of Facilitators, 2021). Facilitation-related research has continued in the Academy. For example, Pentland (2012) found that effective groups have a number of facilitative ingredients: routine convening, turn-taking, interactions occurring vertically and horizontally across status levels, process and content transparency, and social sensitivity. Woolley, Malone and Chabris (2015), building on their 2010 research (Woolley et al., 2010), found that adept facilitation (whether by a neutral party or by skilled group members) resolves task-based disagreements, generates options, and improves group productivity. Similarly, in more recent research, Bleijenberg (2021) has shown that facilitation can convey procedural fairness by adding conversation features like inquiry and summarization. Bleijenberg further found that participants' sense of fairness and satisfaction increased even when their interests were not addressed in the meeting content.

Like dialogue, facilitation comes at a cost. Professional facilitator certifications can take 16-40 person hours (International Association of Facilitators, 2022; Wilkinson, 2012), with months of additional practice for master facilitator certification. Nor is facilitation a cure-all. Inflexibility and bias of individual participants can stump even the best facilitators, as Stasser and Titus pointed out (2003). Reviewing ten years of research into "hidden profiles," Stasser and Titus found that anchoring bias and peer-pressure are formidable obstacles to facilitation. Nonetheless, facilitation has been shown to play essential roles in helping environmental stewardship planning and implementation (Bujold et al., 2020).

4.2.4 Toward a Practical Model of Productive Conversation

A primary goal of dialogue is to enable a group to generate common meaning, or what Weick and Roberts (1993) called "collective mind." Isaacs (1999b) called this "collective intelligence." Bleijenberg (2021) showed that not only is common meaning emergent in citizen dialogue, but expectations are emergent and result from conversation structure. In other words, notes Bleijenberg, expectations arise more often from concrete, fair and equitable engagement about the subject in the conversation, than from prior positions.

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Dialogue has brought consensus and generative inquiry into difficult problems, in government (Dixon, 2019; Bleijenberg, 2021), prisons (Dixon, 2021), international diplomacy (Isaacs, 2016), and indigenous human-environment systems research (McGreavy et al., 2021), to name a few.[1] Yet, Isaacs (2016), found that the underlying complexity of dialogue training content — for example, mental models, abstraction-tendencies, certainty, structural dynamics (Action Positions), and more — could be a barrier to learning (Argyris, 1988; Isaacs, 1999b; Kantor, 2012). Abstraction has evoked a similar concern of sustainability science researchers. The break between academic model and layperson action is what sustainability researchers call the "loading dock problem" (Cash et al., 2006). For example, even among us dialogue practitioners, terms like "voice" and "suspension" have issues of "polysemy," mistaken as the pitch of a voice, or a characteristic of a story's plot, respectively.

Independent of the terminology challenges, Pugh (2016) found that, while dialogue was necessary, it was not sufficient for teams to find closure and frame action. The world needs effective dialogue and effective facilitation to foster institutions and individuals' contribution to sustainability. On the one hand, it takes considerable personal and group investment to consistently use dialogue practices (voice, respect, listening and suspension), and to invest in the container to sustain them. Facilitation would seem a solution, which promises speed, structure, and follow-through. On the other hand, facilitator-dependence may result in group members' not internalizing novel information, not suspending judgment, nor engaging in new ways of thinking on their own (Wilkinson, 2012).

As a practical matter, taking sides in this debate may be futile. To combat certainty, we need the psychological safety outcomes and suspension of dialogue, and to deliberate conclusively and move to action, we need the expediency and action-directedness of facilitation.

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[1] While at Dialogos (1997-1999) and serving as a facilitator in the Leadership for Collective Intelligence program and Director of Learning Strategies, I also contributed to successful applications of dialogue practice in consulting, financial services, unions, high tech, oil & gas, and high schools.

This was the puzzle that my faculty encountered at Columbia University in 2012 while I was Academic Director of the Information and Knowledge Strategy Master of Science Program. The graduate students were failing to take responsibility for mutual learning in online discussions. Students needed not only dialogue's generativity, but also facilitation's turn-taking and a bias for action. We found that asynchronous and synchronous forms of interactions could contribute to mutual learning, such as deliberation offline, inclusion of participants by using the @ symbol in posts, and review through summarization or linking. However, students didn't effectively use these tools. We introduced the "discussion disciplines" as a dialogue-facilitation "mash-up," which we called "productive conversation" (Pugh, 2016, 2020):

- **Integrity**: Making authentic, data-driven statements. ("That is a cold weather forecast.") *Integrity incorporates the statement part of the Voice dialogue practice.*

- **Integrity-Q**: Asking authentic questions. ("Have we reached the coldest day of the year?") Integrity and Integrity-Q incorporate the Voice and Listening dialogue practices.

- **Courtesy**: Respecting the participants in the conversation in a general way, showing general goodwill and positivity. ("We want to be good neighbors.") *Courtesy incorporates the Respect and Suspension dialogue practices.* In online settings this also included respecting the forum. In other words, keeping conversation "out loud," where all participate, rather than outside of view.

- **Inclusion**: Engaging in a gracious way with others and acknowledging them. Avoiding alienating participants through terms or acronyms. In other words, drawing others in. For example, in research across the academic spectrum, people find scientific, academic or formal language foreign or off-putting (Hart & Linda Silka, 2020). ("Feel free to ask questions.") *Inclusion is an expansion of the Respect and Listening dialogue practices.*

- **Translation**: Synthesizing, seeing connections or meta-themes, propelling action. ("For the last several years it has been cold in February, so I'm not expecting the cold to be over soon.")

  Translation is an expansion of the Suspension dialogue practice.

By combining dialogue's sense-making and generativeness (as in the disciplines of Integrity, Integrity-Q and Courtesy), and facilitation's bringing people in and up-leveling (as in the disciplines of Inclusion and Translation), we saw our Columbia students empathize, build upon each other, and act on ideas that they collectively generated (Pugh, 2016).

4.2.5 Turn-taking, sequence and pivotal moments

Woolley et al. (2010, 2015) found that an important determinant of team productivity was equitable contribution by participants, or "conversational turn-taking." Pentland (2012) further showed that turn-taking's impact was amplified when it stepped outside of reporting relationships. Turn-taking is especially important in virtual, sensory-poor interactions (with and without video), as concluded Tomprou et al. (2021). All of these researchers found that contribution equity and sequence could be influenced by facilitation or facilitative moves, such as time-keeping or shared goal referencing.

McCardle-Keurentjes and Rouwette (2018) added that, relative to un-facilitated groups, facilitated groups had better content co-development sequencing or staging and collective discernment. Specifically, facilitation helped progress conversations through stages of content expansion, into sense-making and deliberation:

> [f]acilitators mainly ask questions from the rational and social validation category, and this question type declines over the course of the discussion process. Questions prompting reflection increased over time. Information management questions were mostly used in the beginning and middle part of the session. In the groups led by a [non-facilitator] chairperson, a less clear picture emerged…The only consistent result for unsupported meetings is that information management primarily took place at the end of the sessions (McCardle-Keurentjes & Rouwette, 2018, p, 757).

Scharmer's (2018) work showed that not only content, but relationships, could evolve in the conversation's sequence. He observed that groups follow a predictable social evolution model: Groups begin in a status of "politeness." This can then be pivoted into "breakdown," which forces members' to engage in disagreement. If members can work through tension using curiosity, not blame, and inquire into the tension, Scharmer observed, groups progress into a new state of generative capacity, or, what Scharmer calls, "presencing," or "flow" (Scharmer, 2018, p 24, 56). Notable is the fact that, in breakdown, the group has a pivotal collective experience which could either stall out, or advance to the next stage in the sequence (Scharmer, 2018, p 24, 56). Confidence and affinity felt by the group stemmed from the shared breakdown and collective witnessing of the recovery from that breakdown.

Isaacs (2016) provided a specific example of the importance of these stages in his Trim Tab dialogues study, which engaged political leaders in dialogue about the future of South Asia. Isaacs (2016, p. 12) concludes, "Several thresholds and challenges did emerge, however, the navigation of which enabled the experience of coherence and shared meaning to deepen over time." If the sequence was short-circuited, for example, when one leader was isolated outside the process, the group's stages stalled in a breakdown.

One would expect to see patterns of content and conflict in conversations, growing from information expansion, to "breakdown," with a denouement characterized by a productive, collaborative resolution. Following Scharmer (2018), one would also expect that getting caught in a stage (extended "politeness," in other words, "conflict avoidance"), would result in weaker relationships, weaker deliberation-capacity, and weaker container-strength.

4.2.6 Indirect speech

A class of speech I call "snarky" is a cocktail of conversation types which include insult, rudeness, innuendo, irony, threat, surprise, hyperbole, defensiveness, contradiction, false modesty, obfuscation, false comparisons, and condescension (Sarsam et al., 2020; Kumar, et al., 2020; Lehmann &

Ahn, 2018). Some of the snarky moves are not spoken words, but interruptions, disruption, or inappropriate laughter. Sarcasm is one form of snarky speech that has been studied, and recently modeled in natural language processing, by linguists (Sarsam et al., 2020; Kumar, Narapareddy, Srikanth, Malapati, & Neti, 2020). It is the use of surprise, hyperbole or diminution that conveys a message indirectly.

Indirect speech is a specific type of snarky speech similar to sarcasm. It generally manifests as double-meaning, and the outcome can be a shift in power. It can create affinities and exclusions (e.g., the in-group signals to other in-group members, or establishes in-group status), and it can destabilize participants by causing them to shift their focus to interpreting the ambiguity (Pinker, Nowak & Lee, 2008). Pinker et al. described indirect speech in game theory as an evolutionarily stable system. Indirect speech enables plausible deniability, personal or group benefit or power, and reputation- maintenance (maintaining self-image). The authors pointed out that there are three scenarios for indirect speech: 1. Tangible consequences (e.g., driver's bribing a policeman, risking arrest); 2. Few tangible losses, but personal benefit (e.g., favoritism by a Maitre d' for a restaurant-goer without a reservation, risking embarrassment); and 3. Maintaining norms and self-image (e.g., claiming the "emperor has clothes," risking relationships). In some cases indirect speech could be simply avoidance of conflict. In other cases it could throw conversation into ambiguity, and shift control toward the speaker or their in-group. The latter might occur when the facts of the conversation are ambiguous or in dispute. The speaker then uses indirect speech to work around an incomplete understanding of the prior knowledge or opinion of the listeners.

4.2.7 Signaling

Each investment in relationships ahead of a conversation can provide participants with information about the context and the participants' motivations. Using classical economic models, Spence (1973) showed that investing in "costly signals," such as education degrees, "signaled" (conveyed) to an employer that the individual had a differentiated readiness or motivation. The critical element of signaling

is not absolute investment levels, which are difficult for the observer to know, but the perceived or relative investment. As an illustration, Spence demonstrated the interaction of labor supply and employer demand (and pay rates) would favor men's, and disfavor women's, signaling their investments in education. This was not because of the market dis-favoring educated women, nor that employers knew, a priori, about the value of a unit of education. Education simply had a higher marginal signaling value to men versus women. Spence notes that "The source of signaling and wage differentials is in the information structure of the market," and that women receive lower wage offers because of signaling, not performance (Spence, 1973, p. 373). A similar distortion could influence the tendency for people to signal around environmental actors. For example, one might signal their environmental virtue (e.g., recycling, hanging out clothes rather than using electric dryers) more in an urban environment, where that is less common, than in a suburban environment, where it is more common.

Hoffman, Yoeli, and Nowak (2015) used evolutionary game theory to quantify impacts of a special (and sometimes subconscious) type of signaling: intuitive cooperation. In their "Cooperate without looking" (CWOL) analysis, the authors described an experiment where Player 1 was deciding whether to cooperate with or without determining the reward (in their experiment, a high or low value in an envelope). Upon learning about whether Player 1 "looked," and whether Player 1 continued play, Player 2 could continue play or defect. The authors showed that CWOL can create a Nash equilibrium of cooperation. The researchers interpreted this to mean that "Player 1's expected gains from succumbing to temptation were less than their gains from ongoing cooperation." Hoffman et al. went further to make the conclusion that "not looking smoothes the temptation of Player 2 to defect. Variability in temptations [difference in the high or low value in the envelope] doesn't matter." This experiment relates to other cooperation research, where we cannot judge a person's intentions or reliability, and, where we'd expect them to defect, or defect after seeing what cooperation would bring (Bear & Rand, 2016). Hoffman et al. (2015) noted that we are biologically primed to distrust people who hesitate, and we can detect

momentary hesitation, even eye dilation, associated with contemplation. Bear and Rand (2020) added that we tend to trust intuitive cooperators.

4.2.8 Gender

Woolley et al. (2010,) found that social sensitivity -- the tendency to accommodate others, to engage them, or to acknowledge them -- strongly improves group collaboration outcomes. The authors also showed that social sensitivity appeared to be correlated with the presence of females on teams. Woolley et al. (2015) reflected on the 2010 research, stating that this effect was not one of diversity, but of adding specific skills:

> [T]eams with more women outperformed teams with more men. Indeed, it appeared that it was not "diversity" (having equal numbers of men and women) that mattered for a team's intelligence, but simply having more women. This last effect, however, was partly explained by the fact that women, on average, were better at "mindreading" than men (Woolley et al., 2015).

Kendall and Tannen (2001, p. 548) pointed out that gendered speech is recognizable, and that social sensitivity can be manufactured, as speakers have agency: "[L]anguage functions as a symbolic resource to create and manage personal, social and cultural meanings and identities."

On the other hand, gendered language (e.g., directives for boys, or suggestions for girls) is a sticky social construct. Kendall and Tannen (2001) point out that, as speakers find a balance between establishing conversational status and making connection, women's language tends to establish matching and reciprocity, and include "subjectivizers" (e.g., "I think," "It could be that…"), while men's language tends to focus on position in a hierarchy. When doing the opposite of their gender-norm, until recently the speaker was met with distrust, shaming or criticism. As said, this gendered language, specifically women's language, has been shown to be associated with social sensitivity (Woolley et al., 2010, 2015). Kendall and Tannen (2001) suggest that both genders, when skilled in conversation, may provide social sensitivity. As we shall see in Chapter 5, lower status speakers use more coordinating language (language

of acknowledgement) when speaking to higher status targets. This is particularly true of women lawyers speaking to Supreme Court justices, note Danescu-Niculecu-Mizil et al. (2012). Women lawyers use disproportionately more coordinating language when speaking to the justices. However, this is not reciprocated. Judges use more coordinating language with (lower, but perhaps less-lower) status male lawyers than with female lawyers.

These gender- and status-related findings have been variously corroborated and refuted over the years (Tannen, 2011), but many agree that gender-associated conversation outcomes can be modulated by facilitation, participation balance (turn-taking), norms, and expectations (Pentland, 2012; Buchanan & Pentland, 2015; Woolley et al., 2015). Gender may impact conversation outcomes, but not always as creativity or collective motivation. Women's being a significant minority in an industry (e.g., in construction or aquaculture) may frame participants' expectations of their behavior. Women may experience the dual requirements for both productivity and sensitivity (Kendall & Tannen, 2001; Tannen, 2011). Ultimately, how gender contributes to group effectiveness will depend on a combination of conversation competency, context and motivations – integrating exogenous norms, as well as the subconscious influences of language.

4.2.9 Quantitative Evidence

Qualitative assessment of conversation -- as "deliberative dialogue" (Plamondon, Bottorff & Cole, 2015) and as "working dialogue" (Clarke & Barton, 2020) – is a promising endeavor, and has been undertaken, in part, to grow conversation capacity. However, to the best of our knowledge, no research *quantifies* conversation moves, conversation context, and impacts conclusively using large-scale language analytics.

Skifstad & Pugh (2014) described a starting point. When posts for an online, corporate community of project managers and technologists were coded for discussion disciplines and their opposites, the researchers found that the discussion disciplines together had a positive statistically-

significant impact on outcomes, as measured by the participants' successful options-generation and

closure. Conversely, the discussion disciplines' opposites (e.g., snarky posts) had the opposite effects.

The researchers observed that Integrity and Courtesy tended to relate to relationships-building outcomes,

and Inclusion and Translation to options-generation outcomes. This suggested that both dialogic and

facilitative practices contribute to productive outcomes. The limitations of that work were significance

(approximately 400 posts, or 40 discussions, were coded, and therefore the researchers could not attribute

outcomes to specific discussion disciplines), limited context (online posts), and limited participant

diversity. In addition, manual coding over several days by a team of five students was not sustainable.

As I detail in Chapter 5, Zhang et al. (2020) evaluated conversation language features,

specifically coordinating language and sentiment. They did this in the context of an asynchronous, text-

based crisis hotline. Zhang et al. provided another insight on conversation by highlighting coordinating

language, which functions like the Inclusion discussion discipline. While this provided a statistically

significant factor (alongside conversation length, response speed, and sentiment), it only partially

explained the reasons for closure in such conversations.

What is needed is a quantitative approach that more thoroughly explains the endogenous factors

(e.g., rhetorical patterns, non-verbal communication, sequence) and exogenous factors (e.g., gender,

context, signaling) influencing conversation outcomes.

4.2.10 Generating capacity for conversation

The interface between participants' distinct identities, contents, and disciplinary processes can be

described as a "boundary," which I described in the Chapter 3 as being intended for maintaining

autonomy, or for delineating integrations. Crossing boundaries requires translation, or nexus, skills. When

these are limited, participants may not seek middle ground (Page, 2017). Boundary-workers thus perform

a valuable service, demarcating and translating between science and non-science, and between distinct

disciplines, domains, or positions (Gieryn, 1983). Feldman and McCorkindale's (2020) "dialogue divide"

study respondents indicated the view that political leaders and institutions could play boundary-worker roles. This call for boundary workers -- a neutral, skilled convener or facilitator -- is consistent with Woolley et al. (2015), Pentland (2012), and Buchanan and Pentland (2015) who reported that leaders provide important nexus roles in projects.

Knowledge networks may provide the requisite facilitative capacities and norms to enable boundary-work. Knowledge networks come together across disciplinary and organizational boundaries to create shared understanding, and have been shown to promote boundary-spanning (Wenger, 1999). Networks have been shown to create four distinct outcomes: 1. Knowledge products (such as case studies and shared procedures), 2. Scale economies, 3. A trusted sense-making space for participants; and 4. Collective translation or adaptation of ideas from context to context (Pugh & Prusak, 2013).

Networks require three important design elements: Intentionality (leaders' shared goals), alignment (goal-design alignment), and coherence (dynamic consistency between network design elements and intents) (Pugh et al., in prep). Networks foster the inclusion of different ways of knowing through the act of choosing an "expert-learner balance" (Pugh & Prusak, 2013). Philosopher and psychologist Jerome Bruner (1990, p. 100), eloquently described that interdependence:

> Action required for its [ways of knowing] explication [is] that it be situated, that it be conceived of as continuous with a cultural world. The realities that people constructed were social realities, negotiated with others, distributed between them. The social world in which we lived was, so to speak, neither "in the head" nor "out there" in some positivistic aboriginal form.

Knowledge scales up through this distributed, socially-based development. Networks add the intentionality, alignment and coherence to make that happen.

4.3 Methods

This section overviews the methods for acquiring and studying conversation data in context. The mixed method approach included analyzing the conversations in the Maine aquaculture lease scoping meetings (LSMs) (community town hall meetings on prospective aquaculture farms) and determining the relationships between conversation moves (dialogue acts) and the practical outcomes of relationship-building, options-generation, and intent-to-act. I start with background on the Maine aquaculture context.

4.3.1 Aquaculture in Maine

In stewarding Maine's stunningly beautiful natural resources, Maine citizens balance stakeholder needs, such as livelihoods, preservation, climate adaptation, and cultural preservation. Maine has significant economic and societal pressures: Maine's population is the oldest in the US, limiting workforce capacity and organic growth, the Gulf of Maine's sea temperature rise has the highest increase recorded in the world, and Maine has weathered centuries of exploitation by out-of-state actors.

Maine Governor Janet Mills' 2020 10-year strategic economic development plan, "Maine Economic Development Strategy 2020-2029: A Focus on Talent and Innovation," calls out aquaculture to create high-wage jobs (H. Johnson, 2019). Aquaculture is "the cultivation of aquatic species, including land-based and open-ocean production" of such species (Johnson et al., 2019). The stakes are high: in 2018 Maine aquaculture contributed $137.6 million to the state's economy, including 1,078 full- and part-time jobs and $56.1 million in labor income (Johnson, 2020), with an expected compound annual growth rate through 2022. Haines et al (2020) forecast the extended aquaculture workforce to grow from 1,669 in 2022 to 2,218 by 2030, which is a compound annual growth rate of 3.6% (Haines et al., 2020).

While this amounted to only .1% of Maine's labor force in 2021, competitiveness for shared waters, and lack of public understanding of aquaculture are driving skepticism among certain interest groups (for example, see Alley, 2021). Acceptance of aquaculture is not evenly distributed in Maine: As evidence of this, Hanes (2018), studying Department of Marine Resources (DMR) aquaculture lease

hearings, found that "oppositional" and "uncertainty"-related comments differed substantially by region. The regulatory environment is also confusing to stakeholders, for example, with co-managers being the Maine DMR, the US Coast Guard, the US Fish and Wildlife Service, and the National Oceanographic and Atmospheric Association. (Mussel Bound Lease Hearing, April 6 and 7, 2020).

The leasing process provides a useful example for studying environmental sustainability conversations across diverse stakeholders. Aquaculture farmers apply for one of three types of leases, Limited Purpose Aquaculture (LPA) (renewable annually, up to 400 square feet, for research or hobby purposes), Experimental (up to three years, four acres, non-renewable), and Standard (up to 20 years 100 acres, for long-term operations) (DMR, 2021). The standard lease application process takes several years with environmental and economic reviews by the Maine Department of Marine Resources (DMR). The DMR evaluates leases based on their impact on egress, fishing, navigation, public use and enjoyment, support for the ecology (flora, fauna) in the region, and impact of noise. Lessees must abide by DMR rules, and prove that they have a reliable source of feedstock.

Before going to the lease hearing, Standard (and sometimes Experimental) lease applicants convene a lease scoping meeting (LSM), an informal town hall with neighbors or any other interested parties to discuss the potential impact of the lease to the area. These could be called "Good Citizen gatherings," as they are open sessions, without the pressure of a hearing or DMR's presence. These are an opportunity to engage with the community, validate the lease location, and build relationships. Most LSMs involve local government officials (e.g., town council, harbormaster). Some involve lobbyists or opponents, scientists, and other aquaculture farmers. LSMs tend to be amicable, but tensions can rise. Aquaculture opponents may express concerns over property values, navigation, biodiversity, competition, and regulation. In seven LSMs that I attended between October, 2020 and May, 2021, only one involved a facilitator.

4.3.2 Data collection and coding steps

This section summarizes the data collection and its analysis. In sum, this entailed observing, manually coding, validating, and analyzing correlations between conversation moves, outcomes and outputs. Seven LSMs took place over Zoom from October, 2020 to May, 2021. Notes were manual transcribed and then typed up with careful attention to speaker tone and word choice accuracy. The choice not to audio-record was taken to preserve the culture of neighborliness and non-litigiousness.

Next, transcripts were broken up into moves (breaking down utterances into building blocks of intent), yielding approximately 745 total conversation moves. These were then manually coded for the discussion disciplines and the discussion discipline opposites (total of 10 different potential codes). Also identified were pivotal juncture(s) in each conversation, such as where a dramatic or contentious truth-telling led to the participants proposing new options, demonstrating greater respect for others,or individuals making a statement of intention to take action. Utterances were also coded for gender and role-type (e.g., environmental advocate, farmer, policy maker, riparian landowner, and regulator). The proportions of moves, coupled with the pivotal junctures, were called the conversation "signatures." The coding process involved a validation step by an undergraduate student, wherein each disagreement on coding was discussed, resolved and documented. Figure 4.1 is an excerpt of a transcript that I have parsed into moves, and coded for discussion disciplines. It is possible to summarize by gender and by discussion discipline.

M/F	Item	Comment (move)	Discipline	Rationale
Farmer	24	This is the point where we listen and talk and hear what you have to say.	Inclusion	Open / include
n/a	25	10 seconds	Inclusion	Open / include
Harbor-master	26	I have not been on one of these [scoping meetings]. I heard [person of authority] signed off. I was shocked. It's bigger than I thought.	Anti-Courtesy	Word "shocked" is trigger word. Defensive
Harbor-master	27	I was seeing the same materials as before.	Integrity	Statement of fact. Assume he saw previous lease or earlier version.
Harbor-master	28	That lobster trap needs to go. There's no hauling in the town of [town name].	Integrity	Statement of fact.
Farmer	29	[Relative to the experimental lease] some changes to the species. No change to the gear.	Translation	Wrapping up, recapping.
Harbor-master	30	I'm good with everything you said.	Courtesy	Positivity

One utterance, three moves

Injects doubt. Could have derailed the meeting here (common pattern)

Sides with farmer and refers to reg policy or lack of reg policy (common fisher pattern)

Farmer is not defensive (previously: "we want to be a good neighbor")

"Pivotal juncture" opened inquiry (40 more moves)

Figure 4.1: Illustration of discussion discipline coding for a public lease scoping meeting.

After transcripts were coded for discussion disciplines, they were coded for outcomes. Outcomes included relationship-building (evident in a change of move proportions from negative to positive), options-generation (evident in the creation of alternatives to the lease location or implementation process), and intent-to-act (evident in statements of intended action by the farmer or by other participants, such as found in remarks like "I will follow up with you"). Siddiki and Goel (2015) call these "impacts." I reserve the term "impact" for the explicit or implicit sustainability advancement resulting from these outcomes or collections thereof.

Two lease hearings convened by Maine Department of Marine Resources (DMR) were also observed to better understand the end-product (lease changes, relationship-building with neighbors, and proposed future neighborly acts like pollution removal).

Using Zoom or phone, semi-structured interviews were conducted with four farmers after they had led LSMs. In the interviews were inquiries into the context of the LSM conversations, the hidden meanings of moves, perceived outcomes, and potential for future conversation.

Seven additional interviews provided additional context: three researchers, one regulator, one hobbyist farmer not involved in the LSMs, and two aquaculture industry network conveners. (Please see Appendix A for aquaculture farmer or participant Interview guide.)

Next, comparisons were generated for each LSM conversation transcript. This included the number of moves, by discussion discipline, relationships between the discussion discipline counts, pattern/sequence and pivotal juncture, gender differences, appearance of turn-taking, and conversations' outcomes. Also recorded were the context, such as region, aquaculture species, presence of local official (harbormaster), and group size.

As a means to study other meeting types, I attended a DMR Aquaculture Advisory Council meeting, manually transcribed the conversation, and coded it for the moves. This meeting included members of the industry, researchers, the public, and regulators. As this included many participants identical to our LSMs, this provided clarity on concerns that arose in the LSMs, and also showed evidence of the network-building skills of the players across multiple disciplines (aquaculture farmer, researcher, regulator, fisher, and landowner).

4.3.3 Designing Interventions

New conversation practice is behavioral change. For example, using conversation skills without prompting, and/or self-facilitating without needing facilitators or mediators, may take considerable effort and shifts in habits: Such a shift requires data, policy, choice architecture, emotions, incentives, and social influences (Bujold et al., 2020; Hallsworth & Kirkman, 2020). Yet, traditional dialogue training can be overwrought with layers of abstraction (Caviglia et al., 2017; Willison et al., 2017), and traditional facilitation training can be taught mechanically, without nexus skill-building (Wilkinson, 2012).

Drawing from the above literature review, training in sustainability conversation would require efficiency (e.g., in-the-moment), shared context and data, and psychologically-safe practice (Hart, 2019). Training on conversation skills and discussion disciplines has been successfully undertaken in the US,

UK, and internationally, both in person and online. In the US, productive conversation was a standard part of the Columbia Information and Knowledge Strategy Master of Science curriculum, taught in the students' first "Foundations" course, and in their first in-person residency at the start of their master's. My students observed and self-assessed on the discussion disciplines. Students' first semester self-assessed strengths were in the Integrity/Integrity-Q and Courtesy disciplines, and their self-assessed gaps were in the Inclusion and Translation disciplines. By Spring of their first year, students felt more ready to apply all discussion disciplines. The discussion disciplines served important roles in collaborative course-work, building networks, and achieving joint project outcomes. Stated one student in a public panel for incoming students, "If you only learn the [five] discussion disciplines, you got your money's worth for the program." (quoted as remembered by the author).

In the UK in a workshop hosted by the Gurteen Institute, knowledge management practitioners practiced role-modeling the discussion disciplines over the course of a three hour workshop. Participants stated that these were critical to knowledge-capture, and the advancement of departments like knowledge management and organization development which seek to create consensus around difficult issues.

In the international arena, the Project Management Institute hosted a webinar on the discussion disciplines in July, 2020 (Pugh & Algeo, 2020). In its first 18 months, approximately 42,000 Project Management Institute (PMI) professionals had listened to (and in most cases, received professional credit for) this webinar. It is called "In the Digital Fray, Don't Just Converse. Collaborate Inclusively!" Participants considered the concepts to be "needed to be implemented in our world, particularly at this time," and "taught early on in grade school up through high school before students go to college or out into the workforce." One participant wrote that, for project managers, as it is "vital that we are open to the ideas, value, opportunities, and risk brought up in those discussions. This can't be done if we don't allow ourselves to stop bias (gender, racial, or other) from actively shaping the value we assign. Bias reduces the overall effectiveness of the project team."

4.4 Results

This section covers the findings from the analysis of the seven Maine Aquaculture LSMs from October, 2020 through May, 2021. This was augmented and juxtaposed with interviews.: This section describes the impacts of the discussion disciplines, psychological safety (and its components of signaling and indirect speech), turn-taking, sequence, and gender. I also consider the impact of existing networks that might contribute to or assuage regional conflict.

Before going into the outcomes of the conversation analysis, it is helpful to remember that these conversations take place in the context of a highly-charged industry. In our interview a farmer stressed over criticisms related to navigation obstruction, "We have about 30 buoys…They're in a concentrated area. People find them obstructive. […] It gets rid of the advantage of the whole concept, what I'm trying to achieve." Another pointed out that they faced unfounded ecological judgment, "We're seeing the Gulf of Maine warming. We're not going to change that. We can't attenuate it. We're not putting nitrogen fertilizers on the water and creating algae plant blooms." One farmer interviewee sighed and just summed it up, "Some people just don't like change." Concerns from aquaculture opponents were expressed in an editorial (Ally, 2021):

> Those are the rules and regulations […] have really set the table for Maine to be an attractive place for industrialized aquaculture – large leases, long term leases and lack of transparency around transferability. But there is one more issue that may be the biggest of all. The commissioner of Department of Marine Resources is given so much latitude it is nearly impossible to reject a lease.

As can be seen, there emerged a unique vocabulary. Negative terms like "industrialized aquaculture," as in Ally (2021) and "property value-protection" were countered with positive terms like "good-neighbor" and "heritage or traditional," Yet, what I saw was not just a battle of memes, but the co-generation of (often mutually-satisfying) meaning that emerged through conversation.

4.4.1 Outcomes from discussion disciplines: Moves correlate with outcomes

Figure 4.2 shows the distribution of discussion discipline frequencies, and Figures 4.3 and

Table 4.1 show the impact of each of the five discussion disciplines across meetings. **Integrity**

(statement) moves dominate over the other discussion disciplines within conversations, as is shown in

Figure 4.2. Next is **Integrity-Q** moves, followed by roughly equal **Courtesy** and **Inclusion** moves.

Translation and Anti/Snarky moves are considerably fewer. **Integrity** leads as the highest occurring move

likely because LSMs are initiated by the aquaculture farmers' presentations about the aquaculture lease

application. Integrity also led in the online examples coded for comparative purposes.
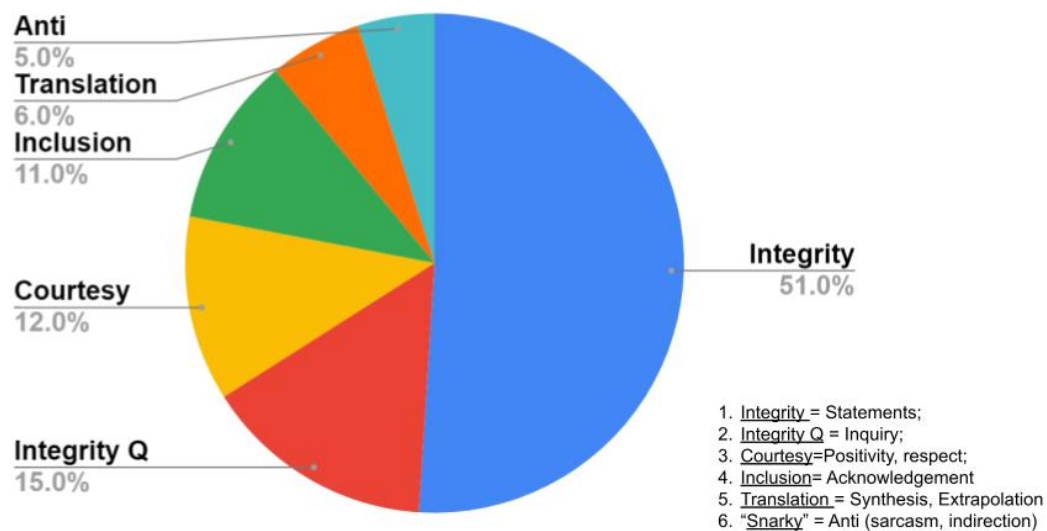
Figure 4.2: Percent of moves across seven aquaculture LSMs.

Note: Illustrates 728 moves which could be identified to an individual. All of the Anti (Snarky) moves
have been combined across transcripts.
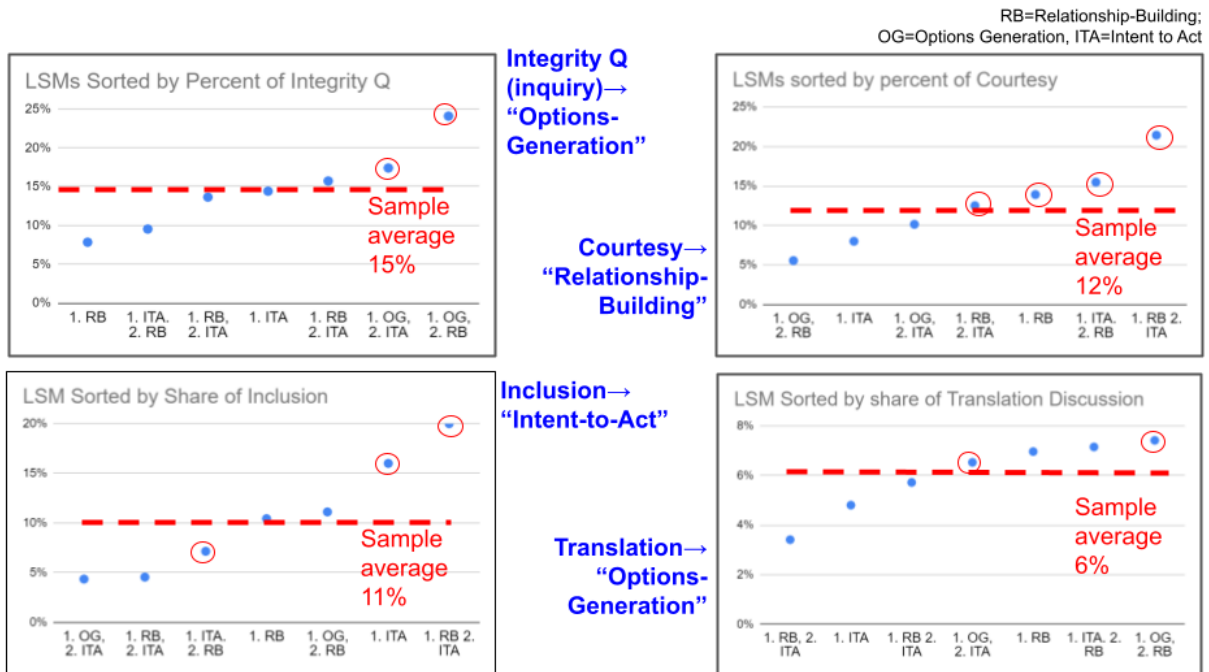
Figure 4.3: Mapping of outcomes to share of discussion disciplines. Note: Distribution of discussion disciplines, across seven LSMs, 728 moves. Discussion discipline percentages for all transcripts appear as dots. Below, at the axis, are the outcomes of each conversation**.**

Table 4.1: Summary of outcomes corresponding to share of discussion disciplines

		Options-Generation	Relationship- building	Intent-to-Act
	Integrity			
	Integrity-Q	++		
Higher than average Discussion Disciplines:	Courtesy		++	
	Inclusion			++
	Translation *	+		
	Anti/Snarky			-

Note: Distribution of discussion disciplines, across seven LSMs, 728 moves. "+" means that the outcome and the discussion discipline are related; "++" means that they are strongly related; a negative sign, "-", means that they are inversely related. There was no discernible relationship between Integrity and the three outcomes.

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Integrity-Q was high relative to the other LSMs where **options-generation** was the outcome. In two instances, farmers agreed with the participants that the farmer would move the lease coordinates or otherwise revise the lease application. Questions and probing appeared to pay off.

Courtesy appears to be the biggest explainer of the **relationship-building** outcome. What was interesting was that relationships preceded the meeting in many cases. Thus, what I observed was a change -- an increase or decrease in relatedness or mutuality that came from participants' using Courtesy. Notably, where Courtesy was the highest, the "climax" (pivot) in the conversation was earlier. There was more time for the group to collectively experience resolution. (See "Outcomes from Sequence" below.)

Inclusion seems to be correlated with **intent-to-act**. Being seen may increase individuals' sense of accountability in the LSMs. Intent-to-act tied with relationship-building as the most most-occurring outcome, and, as this is a more immediate sustainability outcome, it is instructive to consider the potential influence of Inclusion. This is a compelling outcome, in particular, because Inclusion was re-defined partway through the research to be more directly associated with acknowledgement of a specific individual, than a statement of welcome or clarification. It was also distinct from courtesy, which was more generalized respect and positivity.

Translation had inconsistent effects. Where the outcome was **options-generation** there tended to be higher Translation. Curiously, where the farmer or other participants signaled **intent-to-act**, we did not see more Translation. It appears that the mechanisms that propelled a conversation toward action ("intent-to-act") was not simply the use of a "so…," "therefore," "as a result," or "in conclusion." Rather, translation seemed to propel or reinforce the process of identifying options.

Anti/Snarky-moves (In table 4.2 but in Figure 4.3) collectively seem to be inversely correlated especially with **intent-to-act**. (The lower the Anti- behavior the more likely we see intent-to-act), as can be seen in Table 4.1. Anti- behavior, in general, was associated with poor outcomes. Where sarcasm or voice-tone were the Anti-behavior, it was difficult to judge from the digital transcript. In one case, an air

of politeness pervaded conversation, even while stakeholders grilled the farmers with questions, sometimes repeating questions that had already been answered. It took judgment on the part of myself and my fellow conversation coders to tell if questions were genuine, stalling tactics, sound bytes, or confrontations. One Farmer articulated in their interview how they combated anti/snarky behavior:

> All you need to do is to replace "but" with "and." For example: "You have a problem with my lease expansion because you have a keelboat. *And*, I need to have a proper number of lines for my oysters." You show them respect, you check, you make corrections about your paraphrase. And, do you still get your interest met after using the word "and."

There are remarkably similar mechanisms in the Integrity-Q, Courtesy, Inclusion and Anti discussion disciplines and how they appear to mediate outcomes. Both the Integrity-Q + options-generation coupling and the Courtesy + relationship-building coupling suggest that affect, sentiment, and/or motivation are involved.

As Integrity-Q, Courtesy and Inclusion were the highest frequency after Integrity, one might ask what mechanisms were in play. Did having permission to ask questions make the environment fairer and open for risk-taking? Did inclusion increase participants' presence (also called "showing up"), and, therefore, the sense of ownership experienced by participants (e.g., analogous to Zhang et al. [2021])?

Probing further into this affective realm, one might ask how psychological safety may have been a mediator, moderator, and/or outcome, and how priming or signaling in the pre-LSM context may also have contributed to participant motivation.

4.4.2 Outcomes from psychological safety: Effects of indirect speech and costly signals

In order to understand the mechanisms of psychological safety in play, I applied Edmondson and Lei's (2014) four part model: Psychological safety serves as *mediator* (in the form of inclusion of diverse perspectives and use of social sensitivity moves), as an *antecedent* (in the form of pre-meeting context), as a *moderator* (in the form of an assertion of authenticity and care), and as an *outcome* (in the form of a

sustained capacity to collaborate due to improved psychological safety) (Edmondson & Lei, 2014). This psychological safety model also provides a useful structure for assessing the game theoretic results of indirect speech and costly signals,

4.4.2.1 Psychological safety #1 as "mediator": Recognizing in-authenticity

Indirect speech enables plausible deniability, personal or group benefit, or reputation-maintenance (maintaining self-image) (Pinker et al., 2008). In the LSMs, indirect speech mediated psychological safety inside of the conversation.

Indirect Example #1: In one LSM, indirect speech created obstruction for the farmer who was convening the meeting. In the interview with the farmer after the event, there was evidence that members of the Protect our Fishing Heritage NGO (a venture between landowners and lobstermen), for which the president was quoted above, joined the LSM with the intent to play specific roles. It appeared that each speaker from that group was asking from a list of prepared questions (e.g., navigation obstruction, noise, loss of biodiversity or invasive species, invasion of Chinese technology).

Per Pinker et al. (2008), we see examples of indirect speech that yielded few tangible losses, but maintained self-image. The farmer stated, "Researchers from Maine visited Japan's Mulan Bay…" The Landowner, a few minutes later said, "I heard you say it is technology that was used in China. Were there [Chinese] pilots done in the experimental area in Frenchman Bay?" This landowner used a form of speech which appeared to drive a wedge between groups. In the Trump Era, "China" became a polarizing trope in the US, particularly in social circles concerned about US competitiveness. This individual may have felt concern with the lease's impact on their property value or enjoyment, and, signaled to other members — consciously or unconsciously — that this was a "bad deal" for the US (echoing former President Trump).

The mention of China, a trope that would have evoked emotion, after the farmer's discussion of Japan was not a unique conversation-derailer; participants repeatedly asked questions on topics shortly after the farmer had spoken directly to those very topics in the farmer's opening remarks. However, in this case, the provocation of emotions may have reduced the cognitive capacity of the participants, as has been shown to happen in social media (Pennycook & Rand, 2021). Norms forbid participants from saying, "You are diminishing my property value." Such a statement is not an official reason for moving leases, according to the DMR. Inauthenticity of indirect reduced psychological safety. These conversation moves placed the farmer on the defensive, with (lack of) psychological safety *mediating* (Edmondson & Lei, 2014). The only outcome was intent-to-act, the farmer stating that they (the farmer) would follow up.

Indirect Example #2: Another psychological safety mediator was an example of Pinker et al.'s (2008) second types of indirect speech (where there are no consequences except probing, signaling, and social norming).In table 4.2 a lobster fisher hints at a threat, but maintains self-image through indirection.

Table 4.2: Example of indirect speech

Speaker	Move #	Participant Comment	Discipline	Rationale
lobster fisher	**31**	**Fact is fact.**	**Integrity**	**Giving agreement. Signaling that they are aligned.**
lobster fisher	**38**	**We have to get along. But at some point we have a limit. At some point something's got to give.**	**Integrity**	**Statement of fact**
lobster harvester	39	Then someone else. Someone else doesn't like me.	Anti-Courtesy	Defensive. Feels someone is "out to get him"
Farmer	40	I would like it if the state had a plan.	Integrity	Statement of fact
lobster fisher	**43**	**Great, but guys got to have regulation. I have to buy tags, brand my gear, and brand my buoys. At some point that's got to happen to aquaculture.**	**Translation**	**Explains Idea**

Note: Excerpt from LSM, in sequence. In bold is example of indirect speech.

This was a dance between the farmer and the lobster harvester. In the end, the lobster harvester appeared to bond with the farmer over their mutual dislike for trawlers, and their mutual concern over the fragmented regulatory environment. It may very well be that this show of "strength" by the lobster harvester first served the purpose of mounting a position *against* the farmer, and then served the purpose of bonding *with* the farmer (in opposition to the trawlers and the regulators, DMR). If the lobster harvester had said directly, "I mistrust aquaculture. You are in trouble and will be regulated," they would not have been able to shift the negativity outside of the conversation (and, having not done that, they would have been "at fault" for creating obstacles in the LSM), and would have lost the opportunity to assess if they could bond with the farmer.

Indirect Example #3: In a third example, the lobster harvester maintained self-image and maintained control of the "facts" through indirectly denying their validity. In preceding statements, the lobster harvester raised concerns that the farmed scallops would diminish the wild scallops. The lobster harvester said, "I'm skeptical. It could be worse. It could be better." The farmer continued, and noted that research shows that lobsters do not feed in the mud where the lease was proposed. (Lobsters would have been drawn to more life-abundant spots.) Shortly after, in a second statement, the lobster harvester stated that the lobsters would be in the area of the lease, implying that the lease would disrupt lobster harvesting. Again, the lobster harvester put the farmer's statement into question without counter evidence, but also hedged, not directly contradicting the farmer. Said the lobster harvester, "I could see where it would help. I could see where it would take away." The lobster harvester may have needed to "save face," and chose indirection to do so (Schein, 1993).

In these two examples, indirection served a social purpose, either with fellow coalition-members or with the farmer through probing and parallel-messaging. In an interview a farmer mused on the fact that indirect speech, which involves imprecision, has only situational effects as psychological safety mediator:

The old Mainers and land owners go in front of the legislators. They raise doubt. Members of the committee compete for airtime. [A lobster farmer] actually performs well in front of the legislators, because he doesn't have to follow an argument. It's seen as quaint. Otherwise, [aquaculture] appears as elite. It's complicated. It works for them. But, it works at the legislature, but not at [Department of Marine Resources]. State agencies like them are looking for precision.

4.4.2.2 Psychological safety #2 as "antecedent": Benevolent costly signals

A critical means of developing psychological safety is the "signaling" undertaken by participants. In order to understand the signaling antecedents to the LSM conversation, I collected evidence of existing relationships through motifs in the LSMs, and asked of interviewees after the LSMs. Signaling, with its own type of indirection, may provide important information for influencing stakeholders who, on their own, cannot judge the farmer's future behavior or the impact of aquaculture.

It is important to consider the signaling process in our context. Costly signals in and around the LSM could have been fully discounted if it appeared that they were self-serving or manipulative. Consider some signals:

Costly Signal #1: Education: Several LSM farmers had invested in a Limited Purpose Aquaculture Lease (LPA), renewable annually (Maine Department of Marine Resources, 2021) is a costly signal. On the one hand, for the farmer this is expensive better economic or risk proposition than going immediately to a three-year experimental lease or a full, 20-year lease. On the other hand, this signals that one has invested in learning.

Costly Signal #2: Cooperating without looking: Showing flexibility unhesitatingly is a costly signal, and can signal "cooperating without looking" (Hoffman et al., 2015). For example, in one public lease hearing, the farmer was cross-examined on their statement that they would welcome anyone harvesting

crop on their lease. This offer could be significant lost revenue. In this situation, such an offer was nonetheless rational for this farmer because of the concerns a local wild-catch oyster farmer had voiced. To counter the wild-catch oyster farmers' concerns about limiting the "total crop," the Mussel Bound farmer implicitly included their own crop in total crop, most likely expecting a low probability of consumption off of their lease.

Costly Signal #3: Legally-binding commitment: Also in a public lease hearing, farmer sent a costly signal to avid naturalists who worried about trash on the local island. In advance of the hearing, the farmer agreed to write into their lease permit that they would use their own vessel and crew to remove any gear that washed up on the nearby island, even if that gear was not associated with their operation. This was costly in terms of time, gas and risk of physical injury. (Notably, someone testified that this farmer did participate in a previous cleanup.)

Costly Signal #4: Hospitality: Several LSM farmers welcomed riparian landowners, fishers, Harbormasters, and local yachtsmen onto their leases. In two cases, participants in the LSM related the experience. In one case, participants learned about this somewhat indirectly during the LSM, and I confirmed it in the interview. Yachtsmen went out to the lease and said, "Navigating around your buoys is not a problem for us, but [another yachtsman] may be alarmed." This direct reference to the (unnamed) yachtsman was included in the farmer's lease application.

Costly signals related to education, responsiveness, public commitments, and hospitality likely added to the farmers' reputations of competence, integrity and generosity. These comply to Spence's (1973) definition of costly signals, and, at the same time, provided an antecedent form of psychological safety:The farmers' expense was considerable, in terms of time, money, and reputation, and likely served the farmers in that situation far more than such signals would have served others.

4.4.2.3 Psychological safety #3 as "moderator": Shared sense-making via the discussion disciplines

Where psychological safety did not come from costly signals, personal relationships, or pre-LSM or pre-hearing experiences with aquaculture, the discussion disciplines appeared to moderate psychological safety. Using Integrity (authentic statements, backed by data) showed an attention to detail, accuracy and earnestness. Using Integrity-Q (asking questions authentically, not assuming people's positions) helped participants understand the complexities of the lease process. Courtesy (being respectful and positive) appeared to reduce defensiveness. For example, in the above example, the farmer did not criticize the individual asking about "China." Inclusion (overtly drawing people in or acknowledging them) appeared to make participants feel visible. Translation (up-leveling, summarizing, or restating) helped people to follow the conversation, as an act of shared sense-making.

4.4.2.4 Psychological safety #4 as "outcome": Relationship-building

Where there was the most Courtesy, participants formerly unfamiliar with each other (or negatively inclined toward the concept of aquaculture) appeared to demonstrate reciprocal respect and favorableness. As mentioned, this generally was manifested as a change in the group's collective posture during the course of the conversation.

For example, riparian landowners who were concerned about navigation for their sailboats and keel-boats (yachts) were skeptical in one LSM. After the farmer's costly signals (e.g., visits to the lease) and Courtesy inside the discussion, they made the following comments: "I have to say I really appreciate your working with us," and "I congratulate you on that." One spoke broadly, "To see people working cooperatively is kind of refreshing this day and age," and another, "We want to compliment you on the respect you've shown."

4.4.3 Outcomes from sequence: Pivot, opinion-shift, and turn-taking

I hypothesized was that conversation sequence and turn-taking would contribute to effectiveness, in terms of productivity and innovation (Buchanan & Pentland, 2015; Woolley et al., 2015; Tomprou et

al., 2021). While the nature of the LSMs involved considerable air time by the farmer, I did observe some isolated connections between turn-taking and outcomes. Consider Table 4.3. Shaded are LSM 1, where the outcome was relationship-building (secondary: intent-to-act), and LSM 5, where outcome was options-generation (secondary: intent-to-act). LSM 1 and 5 both benefited from turn-taking. LSM 1 had a multi-person interchange about lease transferability. LSM 5 had a multi-person interchange about lease location.

Some LSMs had notably loquacious participants. Yet, one can't conclusively say that that domination of the conversation (and, hence, imbalance) hurt the conversations. It is possible that low-contributors experienced the resolution vicariously.

Table 4.3: Farmer and next most frequent speaker (percent of moves)

LSM%	Farmer % of moves	Number of participants (and average % of moves if full turn-taking)	Next Highest Speaker's % of moves	Balanced Turn Taking?
LSM 1	44%	6 people / 11% each	16%	<u>Yes</u>
LSM 2	47%	7 people / 9% each	30%	<u>No</u>
LSM 3	16%	13 people / 7% each	23%	No
LSM 4	73%*	13 people / 3% each	13%	No
LSM 5	45%	8 people / 8% each	13%**	<u>Yes</u>
LSM 6	50%	7 people / 8% each	27%	<u>No</u>
LSM 7	44%	5 people / 12% each	25%	<u>No</u>
DMR Aquaculture Advisory Council	27% (Director) 24% (facilitator)	13 people / 7% each	14%	No

Note: Distribution of discussion disciplines, across seven LSMs, 728 moves. *For LSM 4 73% is the sum of 53% and 20% (farmer and facilitator) **For LSM 5 three people had equal contributions of 13%.

In order to see the impact of sequence in a conversation, I looked for a place where a "pivotal moment" occurred. A pivotal moment is when tension was raised (e.g., in a provocative statement), and a participant took a risk by disrupting the politeness. I discerned if these moves contributed to the outcomes and whether their arrival in the first half or second half of the conversation mattered.

Table 4.4 shows that the earlier the "pivot" in the conversation, the greater the relationship-building. This was so the two LSMs having a pivot at 37% of the way through the moves and 47%. The late pivots tended to be associated with unresolved conflict, and tended to be associated with an intent-to-act. The only exception was the pivot at 78%. There, the landowner played a disproportionately large role and took the conversation off topic in the middle of the LSM, likely leading to a late pivot, but still a change from tension to positivity.

Table 4.4: LSM Conversations' Pivotal Junctures (Summary)

Pivotal Juncture	Outcome (Primary and Secondary)
35%	1. Intent to act (Decision was made to ask at the Hearing a question about lease saturation.) 2**. Relationship building** (All expressed that they felt respected.)
37%	1**. Relationship building** (Formerly indignant participant asked farmer tomentor for his student) 2. Intent to act (Farmer planned to research lease transferability)
37%	1**. Relationship building** (Agreement with the lobster fisher that there is a need for more regulation)
52%	1. Options generation (Several locations were considered to accommodate landowner.) 2. Relationship-building (Once-distraught participant added creativity, levity.)
73%	1. Options Generation (Creative re-thinking about the lease location) 2**. Intent to act** (Farmer is going to look into moving the lease)
78%	1. Relationship building (Participant wanted an aquaculture mentor) **2. Intent to act** (Decision to research the site for land to be put into a trust)
83%	1**. Intent to act** (Farmer states intent to reach out to the lobsterman to discuss lease).
56%	Average

Note: Distribution of discussion disciplines, across seven LSMs, 728 moves. In bold are strong examples of the impact of early or late pivots, seeming to influence the outcomes of Relationship-Building and Intent-to-Act, respectively.

Scharmer's (2018) social evolution model posited that breakdown involves conflict or tension from which the group collectively either stalls or moves on to develop capacity to engage. Sample tension sources were a Harbormaster who declared, "I was shocked. It's bigger than I thought!" and, similarly, a Yachtsman who poked, "Will you need more space if they [the oysters] get larger?" Tension also arose in at least two cases when someone other than the farmer took over, such as Harbormaster: "Can you enable

my [Zoom] screen… I believe from what I'm seeing from the map, it's away from the direct line [of the navigation]."

On net, as can be seen in Table 4.4, the earlier the pivot, the earlier the breakdown, and the more the group confronted tension, and more they built relationships. In the case of the aquaculture LSMs, participants came together often in communities where they had previous exposure to each other or to each other's friends and family members. Those factors may have had equal, if not more, effect on the timing of the pivotal event. Context is the focus on the next sections.

4.4.4 Outcomes from gender: Female as villain and hero

In order to assess the impact of gender, gender was coded based on participant names. Total female moves were 150 out of 725 (just under 21%). As predicted, there is an association of female participation with "social sensitivity" (Woolley et al., 2010; Woolley et al., 2015). Social sensitivity can be found in Integrity-Q, Courtesy, and Inclusion, and degraded with Anti-moves. Figure 4.4 shows that, relative to their share of moves in each conversation (21%), women were:

- More likely to use Integrity-Q (inquiry) moves in 6 out of 7 conversations
- More likely to use Courtesy moves in 4 out of 7 conversations.
- More likely to use Inclusion in 2 out of 7 conversations
- Less likely to use Anti- (snarky) moves in 4 out of 7 conversations.
- Less likely to use Integrity (statement) moves in 6 out of 7 conversations.

Figure 4.5 shows the percentages of each discussion discipline that women contribute across the seven conversations. Women represent 21% of the total utterances across the seven LSMs, but were contributing disproportionately more (more than 21%) of the Integrity-Q, Inclusion, and Courtesy. They were contributing disproportionately less (less than 21%) of the Integrity, Translation, and Anti/Snarky moves. Specifically, women were disproportionately more likely to use inclusion and Integrity-Q (34% and 36%, respectively).

One could conclude that, if Inclusion correlates with intent-to-act and Integrity-Q correlates to options-generation, females could have an outsized impact on expanding accountability and innovation.
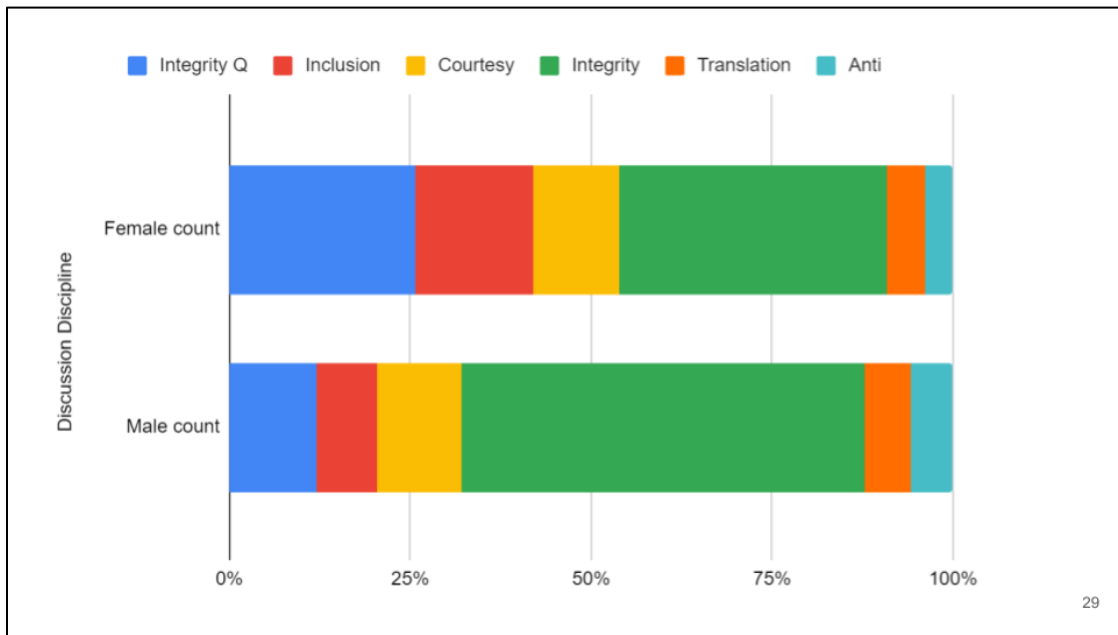
Figure 4.4: Comparison of proportion of discussion disciplines for females v. males Note: Distribution of discussion disciplines, across seven LSMs, 728 moves.
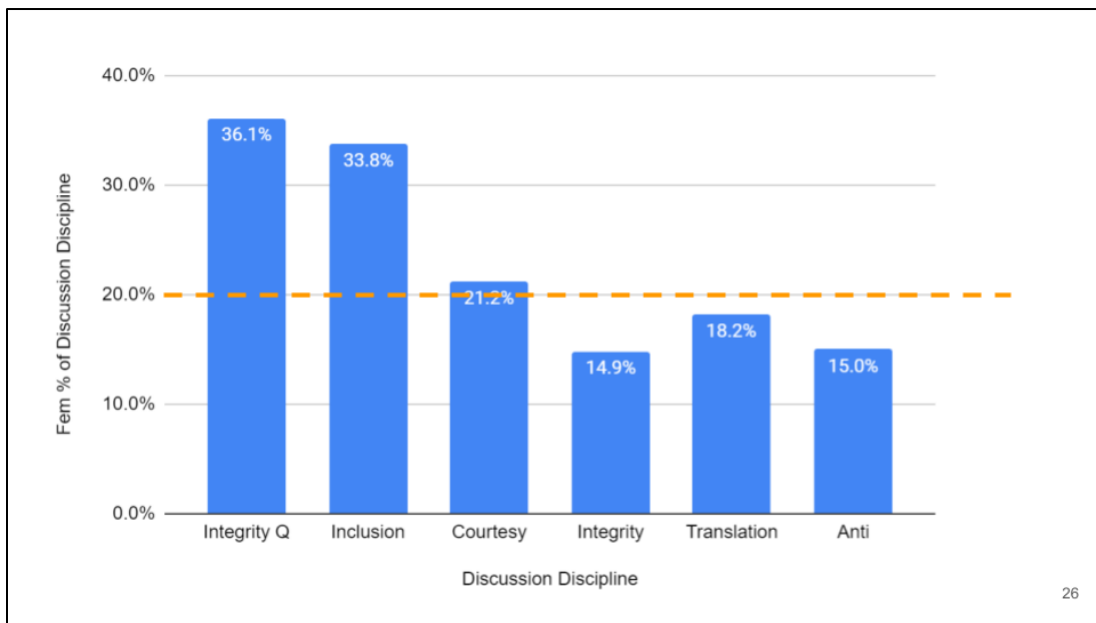
Figure 4.5: Percent of each discussion discipline moves contributed by females. Note: Distribution of discussion disciplines, across seven LSMs, 728 moves. 21% of all moves are made by females, but they contribute more than 21% of the Integrity-Q, Courtesy, and Inclusion.

Females played an outsized role, despite being a minority. They were treated as the "villain" (a farmer subject to negativity from participants) or treated as the "hero" (taking the lead to generate positivity). As villain, a female farmer encountered more questions from the anti-aquaculture sentiment than male farmers encountered.

As the "hero," a female in one LSM eased a tense conversation. On Zoom, the camera was staged at the back of a town hall. The discussion was at the front table of the room, and attendees were grousing and on their mobile phones in the pews between the Zoom camera and the front table. A couple on Zoom were getting increasingly frustrated because they could not hear, and their concerns (spoken on mics and typed in the Zoom chat) were not being responded to. The woman said, "I'm going down there." Five minutes later, she appeared in the town hall on camera. She stood by the table and joked with the councilmen and the people seated in pews. When she got the attention of the (mostly male) councilmen, she learned where the lease was situated. From the Zoom, observers could see the woman darting about in a while coat, standing over the councilmen's table and pointing to a map. The conversation was focusing on navigation and anchor types, not impacts to recreation and aesthetics. Her use of Inclusion and Integrity-Q ("Do I know you? I should know you!") appeared to shift the conversation from argumentative opinion, into "options-generation." The movement at the table became more animated, with dozens of gestures to the map ("Over there…!")

4.4.5 Outcomes from organized networks

Networks may provide advancement or obstruction to aquaculture. Some aquaculture networks have emerged with a regional focus (Hanes, 2018). In particular, Frenchman's Bay, Maine, has been the site of organized aquaculture opposition. As mentioned, in one LSM a landowner-fisher anti-aquaculture network came en masse to the LSM, and appeared to use rehearsed, repetitive questions. Compliance and discipline appeared to be high for that network. The farmer mused:

There are a lot of [protests in Maine.] These protests are mostly funded by NIMBY [Not-in-my-backyard] wealthy people using the lobsterman as a front. The current laws and regulations seem to work for lots of people except for the landowners. (Interview with the farmer)

Conversely, interviews with other farmers revealed that there are learning and scale effects of their own networks, and that they can build those networks intentionally. For example, as mentioned in the signaling example above, a farmer invested in the local community network ahead of the LSM:

I talked to my neighbors regarding the current lease. [This was a three-year non-renewable experimental lease.] [Name] was one of those. I invited him for a trip to see the lease. Some of them went, but he didn't. During that I found out about the two other sailors. It was they who said "We're not crazy about it, but we don't have a problem with it. [name] does."

In the interview, the farmer was satisfied that his having networked with neighbors accelerated the consensus in the LSM. The meeting's tension was resolved with a shared commitment to containing lease acreage. He remarked: "What was left was: '[I am] not intending to ask for more expansion to the east.' I can certainly say it and [harbormaster] can repeat it [at the Lease Hearing]." He added, "I think I've talked to all of the neighbors."

Similarly, the DMR Aquaculture Advisory Council (AAC) meeting was a network of aquaculture farmers, researchers, and regulators engaged in a respectful and information-rich conversation. The AAC showed respect and equity. Farmers pressured DMR to accelerate the lease hearing process, disburse COVID-19-related CARES Act funds, and improve data accuracy. In return, DMR employees asked farmers to communicate to the community about DMRs' workload (e.g., 3,000 applications for CARES Act funds to be processed), and other messages. In a statement of ongoing collaboration, one DMR Official asked:

[We did a] survey and partnership with [Maine Aquaculture Association] about space constraints. 22 people are experiencing space constraints…An idea was to waive the density standards through amendments with an emergency LPA. If people are experiencing these issues, we would like to know.

4.4.7 Nudging conversations and building conversation capacity

One can see numerous implications for nudging conversations, and building the capacity for conversation. Table 4.5 1. Provides a checklist for a variety of exogenous and endogenous factors that explain the conversation's impact on outcomes; 2. Associates the factors with outcomes and impacts; 3. Suggests extensions to other sustainability challenges; and 4. Calls for investments for leaders, facilitators, and boundary spanners to achieve skillful, equitable participation in conversation. Conversation practices may be learned cost-effectively, reinforced through sense-making, and tailored to different contexts. This requires investments in pilots, learning programs, and knowledge networks, and a better understanding of feedback. As discussed in the next section, using a feedback model can help practitioners monitor performance over time.

Table 4.5: Endogenous and exogenous outcomes, impacts, and capacity-building opportunities

Factors	Sample outcomes and impacts	Potential Capacity Investments (for leader, facilitator, broker)
Endogenous		
The relative proportion of discussion disciplines	Outcomes: - Inquiry (Integrity-Q) > options generation - Inclusion > intent-to-act - Translation > options generation (weak) - Snarky depresses intent-to-act Potential Impacts: - Reducing the negativity in a region - Lowering obstacles to aquaculture industry. - Improving collaborative capacity.	Get agreement among productive conversation evangelists on desired impacts and approach. Plan conversation for outcomes. Train communities, starting with leaders (e.g., farmers, harbor masters, legislators, researchers, religious leaders) on the discussion disciplines.
Psychological safety added by the conversation leader and participants	Outcomes: - Psychological safety (Courtesy and Inclusion) brings more relationships and more Intent to Act Potential Impacts: - Improving collaborative capacity	Establish Chatham House Rule, role-model risk-taking and respect for risk taking. (Manage dysfunctional behavior as a collective problem, not individual problem.)
The sequence of the discussion disciplines and pivotal statements	Outcomes: - Earlier pivotal moments improve likelihood of relationship-building. - Early questions expand options. Potential Impacts: - Individual(s) in pivot have emotional content. They may be allies, sounding boards, informants.	Manage agenda, capitalize on pivotal moments, and leverage moments of insight, or apparent shifts in opinion as discussable components of conversation. For in-tact committees and networks, inquire collectively into turn-taking behaviors and remediate imbalances.
Indirect speech as attention-seeking, influencing or power-seeking behavior.	Outcomes: - Indirect speech delays or reduces consensus. - Indirect speech is in-group sub-conversation. Potential Impacts: - Can distort understanding of the social-environmental system	Increase transparency by asking for confirmation of understanding. Use visuals (e.g., flip charts) Invite the offending participants as a unit, to witness and discuss the indirect speech. .
Exogenous		
Context, such as signaling goodwill group membership	Outcomes: - Signaling accelerate/retard participants' credibility and readiness to engage Impacts: - May retard or accelerate action	Individuals who have experienced the priming in the context around the conversation may be a mutually-reinforcing faction of skillful conversation advocates.
Learning from female contribution patterns	Outcomes: - Females are seen as villains or heroes. Impacts: - Female leadership grows with conversation.	Begin capacity building with women participants
Networks	Outcomes - Networks can derail/bolster conversation - Networks can provide support for risk-taking. Impacts: - Network-based aquaculture advancement reduces conflict, creates solidarity, innovation.	Expand existing transdisciplinary networks (e.g., Maine Aquaculture Hub) Build conversation skills within networks, and use networks as hosts for role-plays, and sense-making around conversation assessment pilots. .

4.5 Discussion

In this research I studied aquaculture lease scoping meetings, lease hearings and DMR conversations to learn how discussion discipline proportions, indirect speech, signaling, sequence, and gender influence conversation outcomes. This presented an opportunity for sustainability solution-development where difference might otherwise thwart sustainability outcomes.

Each discussion discipline used a unique, but fairly reliable mechanism, and may play a direct role in transdisciplinarity across scales. The LSM conversation data showed strong connections between Integrity-Q (inquiry), Courtesy (respect), Inclusion (acknowledgement) and Anti/Snarky discussion disciplines and outcomes. The Integrity-Q + options-generation coupling suggests having permission to ask questions made the environment more conducive to innovation. Inquiry (Integrity-Q) appeared to have made "not knowing" acceptable, consistent with Liedtke's (1998) finding that hypothesis-driven interactions expand options, as discussed in Chapter 3.

The Translation + options-generation coupling played a similar role to Integrity-Q, as Translation has more to do with content than motivational features. On the other hand, Translation that is evasive (e.g., with indirect speech) or sarcastic (Snarky), can obscure options and serve to divide a group.

The Inclusion + intent-to-act coupling reminded us that acknowledgement can reel in participants, even those who are at the periphery. Observability is a predictor of intended action (Rand et al., 2014), and participants can provide observability in the form of individual acknowledgement.

The Courtesy + relationship-building coupling suggested that positivity may enable groups to step through conflict, and to see each other as partners in solutions-development or enactment. Sommers (2006) found that diversity acts in motivational ways, with juries being more thoughtful, preparing better, and having more recall. Where difference could otherwise divide a group, attending to patterns of like the discussion disciplines may help generate information-rich, constructive and memorable boundary-spanning options (Gieryn, 1982).

In addition to the rhetoric, the conversation context and choreography had important impacts. Signaling (Spence, 1973) and "cooperating without looking" (Hoffman et al., 2015) appeared to have a

psychological safety-as-antecedent role. Conversely, indirect speech (Pinker et al., 2008) appeared to derail the conversation or create cliques inside the conversation group. This reflected the psychological safety-as-mediator role (Edmondson & Lei, 2014).

It is possible that LSM participants learned vicariously from questions asked by others, even though evidence of turn-taking was not robust. From a sequence perspective, certain LSMs did appear to progress rapidly through Scharmer's (2018) four stages of politeness, breakdown, inquiry and flow, and the longer the time in conversation after the initial tension (pivot), the higher the likelihood of relationship-building.

Gender acted in expected ways, women disproportionately using social sensitivity or relatedness moves (Integrity-Q, Courtesy and Inclusion), and men disproportionately using content moves (Integrity and Translation) (Woolley et al., 2010, Tannen, 2011). At the same time, women may have experienced mixed expectations: The expectation to be non-confrontational, but also to be an assertive problem-solver.

Productive conversation may be learned through individual and network activities. Table 4.5 provided four interventions to improve conversation factors that are endogenous to conversations, and three interventions to improve factors that are exogenous to conversation. A low-cost starting point could be to leverage an existing network, where participants could reflect on the interactions that result in a variety of outcomes. Networks provide a force of solidarity in the LSMs (Pugh & Prusak, 2013). That solidarity could advance or detract from the goals of the farmer. Cinner (2018) and Hallsworth and Kirkman (2020) provided mechanisms that those networks could use, such as choice architectures, norms, and reinforcement for new conservation behaviors. In line with Cinner, an aquaculture network could bring together network design elements and behavioral insights:

- **Scale, reach and practice-based evidence**: Networks use scale, reach, and local adaptation to achieve their goals (Pugh & Prusak, 2013). A sustainability conversation capacity-building network could engage landowners, farmers, fishers, regulators, biologists and sportspeople. Such a network could begin by convening representatives from existing associations like the Maine

Aquaculture Hub, AQSW study teams (c.f., Chapter 3), cooperatives, and NGOs. Those groups could bring their own "practice fields" for sustainability conversation pilots, such as their local town halls, team meetings, or policy deliberations, and could benchmark with network members.

- **Choice architectures**: In the network, it can be helpful to integrate differences of perspective on navigation obstruction, biodiversity, pollution, and livelihoods as conversation subjects. These can to be considered in the psychologically-safe space that the network can cultivate. Choice architectures (Hallsworth & Kirkman, 2020) can ease discussion disciplines practice, e.g., in meetings, practice scripts or role-plays. It may help to translate the abstract in the discussion disciplines. For example, to simplify one can use the mnemonic IDEAS: **I**nquire (Integrity-Q), **D**eclare (Integrity), **E**nnoble (Courtesy), **A**cknowledge (Inclusion), and **S**ynthesize (Translation).

- **Norms**: Anti-aquaculture stakeholders may fear that engaging on the topic of aquaculture would be tantamount to declaring defeat. Aquaculture advocates fear engaging with anti-aquaculture positions. Using trust development strategies (Sawyer & Ehrlichman, 2018), a conversation norm could be built from shared points of reference (e.g., "Livelihoods matter" or "We love Maine."). As we observed, individuals act more pro-socially when observed (e.g., Included, acknowledged), and pay more attention to their own action**s** when their efficacy is also observable.

In sum, networks could be the cradle for effective conversation, providing opportunities for formal and informal learning, convening psychologically-safe sense-making, measuring outcomes and impacts, and enabling members to practice being boundary-spanners. A boundary object could be a dynamic conceptual model using systems thinking (Kim, 2000), as in Figure 4.6. Motivated by a common belief in Maine's future, network members could see the linkages between evidence, conversation structures, personal competence, equity and sustainability In Figure 4.6 is such a boundary object. The top image, left, juxtaposes the current state with an alternative feedback loop. The feedback loop on the left shows that outside facilitation or other "addictions," like polarizing social media, may mask our

responsibility for productive conversation. This is a classic example of a "shifting the burden" archetype (Kim, 1992; Kim, 2000). The intervention on the lower right (blue) proposes Evidence and Network Models that inform sustainability conversation curricula through a Network Convening (arrow moving down and to the left from the blue box). Network Convening aids conversation learning through Investment in Conversation Capacity. That, in turn, De-Escalates Conflict in Sustainability Interactions, which, in turn, improves Credibility of the Conversation Model, and Desirability of Engagement. Just-in-time Productive Conversation Evidence and Network Models (in the members' practice fields, shown by the arrow moving up and to the left from the blue box) also increases Credibility of Conversation model.
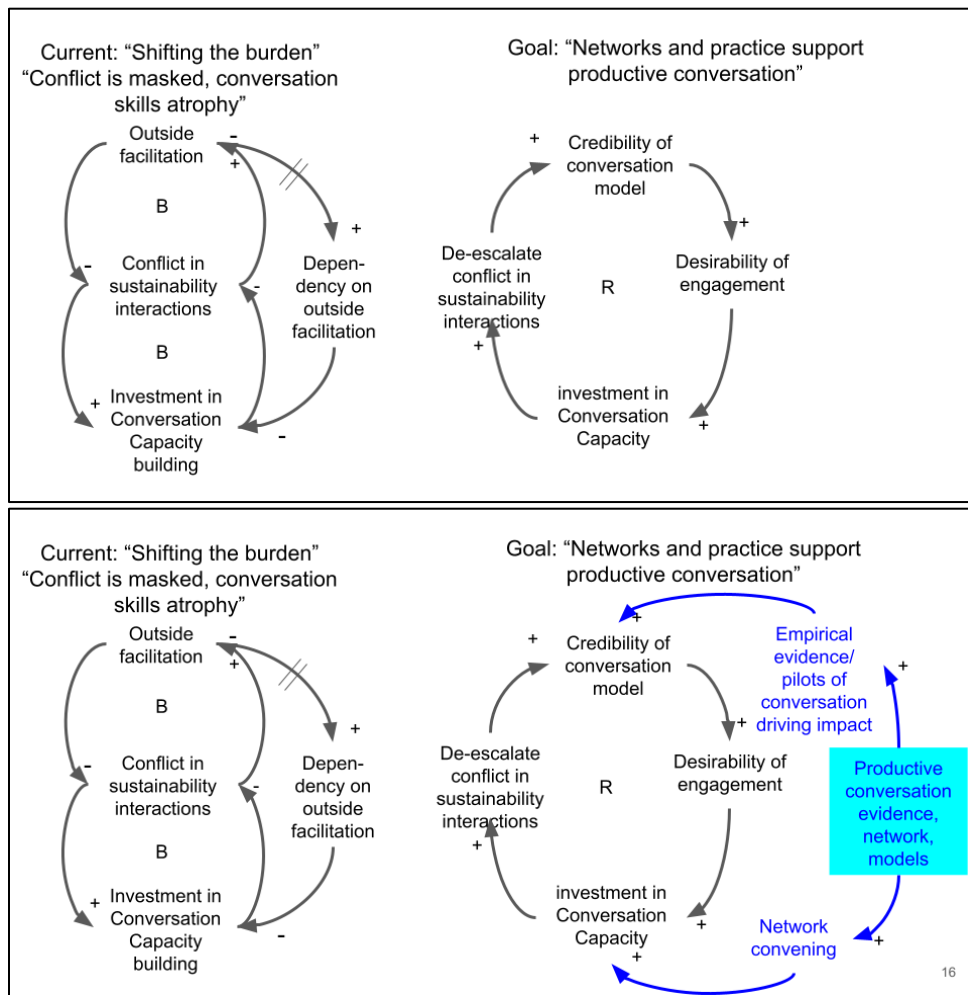
Figure 4.6: Productive conversation evidence and networks drive outcomes.
Note: In a systems thinking diagram, "R" means that the loop reinforces, and "B" means the loop balances (reverses). "+" means, when the item at the beginning of the arrow goes up or down, so, too, does the item on the end of the arrow. "-" means that they move in opposite directions.

A next step could be to invite the participants from the LSMs, starting with those interviewed, and explore the viability, direction, composition, and routines for a conversation capacity-building network (Pugh & Prusak, 2013).

The most significant implication of this research with the LSMs is the connections between outcomes (e.g., relationship-building, options-generation, and intent-to-act) and sustainability impacts. Improving conversation skills in aquaculture over time may accumulate these three outcomes, and thereby improve the aquaculture industry's capacity to do sense-making, create equitable and sustainable options and collaborate across difference on an ongoing basis. This is needed at a critical juncture for the Gulf of Maine, where traditional fishing options are narrowing, and conflict is high. Conversation feature identification, measurement, and outcomes-mapping may be transferable to diverse sustainability topics, such as climate action, marine protection, pipeline-siting, and plastic reduction. More creative and respectful engagement may make groups involved in solutions-design, policy-making and environmental stewardship more inclusive and resilient.

There are limitations inherent in written transcripts of oral conversations. While these are more information-rich than online, asynchronous threads, transcripts omit pitch, cadence, body language. Another limitation of this research is that it looked at only limited exogenous context material, such as signaling noted in the transcripts. The relative influence on outcomes of conflict history, contemporary events, and regulatory developments could not be systematically assessed from our data. A final limitation is addressed in Chapter 5, which is the small-N limitation of this research. There I will explore means to deduct conversation features at scale. I would welcome additional research on broader inputs and predictability for conversation outcomes, and on capacity-building success.

CHAPTER 5

DESIGNING SUSTAINABILITY CONVERSATIONS FOR IMPACT USING NLP

Abstract

Collaborations across diverse stakeholders are critical for framing and resolving sustainability conflicts, but often conversations become perfunctory or acrimonious. Shared, data-driven models can help democratize conversation skills—giving all stakeholders insights on the impacts of their contributions, and helping them to improve their contributions to innovation and other outcomes. Using natural language processing (NLP) one can model how conversation features and outcomes move together, and provide specific insights. NLP has been shown in mental health conversations to find relationships between features like acknowledgement-language and closure.

The result I sought was better conversation insight for better human-environmental systems management. Maine marine aquaculture was a compelling test case for sustainability conversation research. Transcripts were generated from public aquaculture town-hall-like meetings and conversational moves were manually coded for five productive features, called "discussion disciplines." Discussion disciplines included declarations, questions, respect, acknowledgement, synthesis, and negative, or "snarky," gestures which are the opposites of these five. Manual conversation analysis in Chapter 4 revealed that respectful moves correlated with relationship-building outcomes, questions correlated with options-generation, and inclusive (acknowledgement) or synthesis moves correlated with intent-to-act. The research question next in play was: Can this be scaled up using NLP to enable anyone to interpret, repair, and design productive conversations?

I evaluated three pathways to model the discussion disciplines: TF*IDF (a graphical approach), Word Embeddings (Word2Vec) (a single-layer neural network approach), and BERT (Google's Bidirectional Encoder Representations from Transformers, a multi-layer neural network). Using human tagging as a benchmark, the NLP neural network model outperformed the TF*IDF process, with 95% of

discussion disciplines correctly identified, compared to the TF*IDF's 45.2%. The Word Embeddings (Word2Vec) approach was the worst performer at 26%. Appending discussion disciplines with a lookup helped the TF*IDF and Word Embedding approaches, but Poisson normalization and Prompt-Response (rhetorical indent) identification added little.

The top NLP model was used to classify over 21,000 utterances, 591 transcripts. Transcript-level outcomes (relationship-building, intent-to-act, and options-generation) were regressed on the discussion disciplines. The findings corroborated previous research about the predictive relationship from inclusion-related conversation features to "closure": My regression analysis showed positive, statistically-significant relationships between the conversation features of inclusion (acknowledgement) and courtesy (respect), and the outcome of intent-to-act (drive toward action or "closure"). The regression analysis also found some weak, but surprising negative relationships between Integrity Q (inquiry) and relationship-building, which I attribute to the instrumentation of relationship-building and strong co-linearity between several discussion disciplines, potentially masking their individual influences.

I then recommend specific approaches for improving the data, modeling, and application for sustainability conversations, and propose establishing an open source benchmark and a network who improve sustainability conversation design and engage in sustainability conversations for impact.

5.1 Introduction: Using NLP and Machine learning to understand conversation

Most sustainability outcomes are the result of collective deliberation. Some result in innovative solutions, and some result in conflict or stalemate (Cash et al., 2003). Collective deliberation is a form of productive conversation. Productive conversation combines the generativeness of dialogue, and the directedness of facilitation (Skifstad & Pugh, 2014; Pugh, 2020). The building blocks of productive conversation, or "discussion disciplines" include Integrity [statements], Integrity-Q [questions], Courtesy [positivity], Inclusion [acknowledgement], Translation [synthesis], and their "snarky" opposites (Pugh, 2020). Conversation transcripts can be broken into moves (distinct dialogue acts), which, in turn, can be

classified by each of the discussion disciplines. In a statistically-significant way, the discussion disciplines have been shown to influence the outcomes of online collaboration, such as a community's, options-generation, and accountability (Skifstad & Pugh, 2014).

The cost for individuals to acquire productive conversation's underlying dialogue and facilitation skills is high, in terms of time and effort (Clarke & Barton, 2020; Schein, 1993; Dixon, 2019, as discussed in Chapter 4). Thus, detecting conversation moves accurately, at scale, and across large corpuses of digital conversations is a worthy task for natural language processing. By demonstrating conversation impacts using digital transcripts empirically, it is possible to reduce the cost of acquiring those skills. More importantly, this could increase the credibility and efficiency of a conversation capacity-building intervention for human-environmental systems. Regular intuitive quantitative feedback could help individual and group learning, and make conversations about sustainability a more frequently productive and innovative (Bujold et al., 2020).

Qualitative, small "n" assessment of models that combine dialogue and facilitation -- such as "deliberative dialogue" (Plamondon et al., 2015) and "working dialogue" (Clarke & Barton, 2020) – are promising, but manual coding for conversation features is not scalable. Skistad and Pugh (2014) showed that the discussion disciplines in total correlate to closure and ideation. In the crisis hotline setting, there is evidence that one discipline, inclusion (called "coordination" by the researchers, involving matching, acknowledging) correlates with closure. However, to the best of our knowledge, no research quantifies these conversation models and their impacts conclusively, nor do they appear to venture into the context of human-environmental systems. Natural Language Processing (NLP) and Machine Learning (ML) may give us the capacity and intellectual authority to advocate for conversation practices where stakeholders may be mistrustful or time-starved.

Until the late 2000s, Search, text analytics and "Conversational AI" (or "Chatbots"), dominated the natural language processing (NLP) researchers' and practitioners' consciousness. This involves

humans interacting with a robot which interprets and produces transactional replies. However, research on

human to human conversation is growing (Chang et al., 2020), recognizing human-specific habits of

speech, such as context switching, paraphrase, sarcasm, and toxicity (Chatterjee et al., 2019). Consider

these developments in AI and machine learning for NLP:

- **Detecting meaning in context**: It wasn't until the early 2000s that it was possible to understand

  meaning through information prior and post to a token (word or phrase) (Mikolov et a., 2014;

  Google, 2021). A breakthrough of Google's BERT (Bi-Directional Encoder Representations from

  Transformers) was its ability to understand words and phrases from their context and to be able to

  reuse existing NLP models (Devlin & Chang, 2018).

- **Recognizing rhetorical intent of conversational moves**: NLP researchers have begun proposing

  "rhetorical purpose" through the interplay of speakers. For example, with Cornell "ConvoKit,"

  researchers have piloted prompt and response models (Chang et al., 2020; Zhang et al., 2018;

  Zelasko et al., 2021).

- **Data and code augmentation**: Limited training data for NLP and lengthy code are no longer a

  barrier. Zheng and Zhou (2019) illustrate speedy NLP analysis using open knowledge, and

  transfer learning from model to model. Open code (like Python, BERT, TensorFlow, Parle.ai, and

  ConvoKit) can be easily obtained and validated with performance benchmarks (Deloitte, 2020).

Here I show that one can use NLP to find discussion disciplines, like Integrity-Q and Inclusion inside

of a large corpus and relate those to relationship and productivity outcomes, similar to Skifstad and Pugh

(2014). I used Maine aquaculture lease scoping meeting (LSM) data to code seven lease scoping

meetings, to handcraft a term set of discussion discipline phrases, and to test several NLP models. Using

30,000 utterance training database the research involved training and evaluating three model types: a

TF*IDF process, Word Embedding, and BERT neural network. Also varied were tokens (language parts),

enrichment using hand crafted metadata, normalization, matrix reduction types, clustering parameters,

and neural network tuning. The "winning" model was used to find conversation outcomes (relationship-building, and options generation, and intent to act), similar to Skifstad and Pugh (2014). Finally, I regressed outcomes on the discussion discipline and related my findings showing the positive, statistically-significant relationship between Inclusion and intent-to-act, and similar conclusions made by Zhang et al. (2020).

In the discussion, I suggest capacity-building and network design that would spread effective conversation skills cost-effectively. While this is more specifically described in Chapter 4, I posit some conversation skill approaches that could leverage a turn-key model and NLP toolkit. A knowledge network is a vehicle for generating new shared behaviors and norms, and for providing support for personal risk-taking (Pugh & Prusak, 2013). I recommend using a conversation AI network for collectively advancing our NLP models.

5.2 Literature Review

Advances in microchips, compute speed, reference data, and pre-training of models (transfer learning) have contributed to improved natural language understanding in sentences, utterances, and entire conversations. In this section I first express the growing interest in understanding the relationship between conversation features and outcomes, similar to those relationship discussed in Chapter 4. Next I discuss two types of human speech analytics: ***Term-frequency/indirect document frequency*** (TF*IDF), which uses matrix reduction to label speech parts using clustering (as championed by Cornell, c.f., Chang et al., 2020), and ***neural networks***, which use layers of contextual, reference, and inference calculations to understand speech features (as championed by Google with Bidirectional Encoder Representations from Transformers (BERT) (Devlin & Chan, 2018). Both may use transfer learning, which is the use of a training data corpus to initially train a model, and then use that pre-trained model to create a context-appropriate model and do work. I describe processes common to both, such as preparing the training data corpus of similar conversation transcripts, working with reference data for enrichment or tagging,

recognizing human-to-human interaction types, and discerning meaningful building blocks of utterances that have distinct meaning.

5.2.1 Example of understanding conversation features like discussion disciplines

There is a notable NLP research example in understanding the relationship between conversation features related to rhetorical intent, like the discussion disciplines, and outcomes. In previous chapters I have discussed the research into causal relationships between the dialogue practices (corresponding to Integrity, Integrity Q, and Courtesy), and outcomes such as ideation, employee satisfaction, and improved group relationships (Willison et al., 2017, Isaacs, 2016). As described in Chapter 4, the Inclusion discussion discipline (acknowledgement) was added to the dialogue practices which were the basis of the discussion disciplines.

Inclusion is interesting to NLP researchers because of its relationship to status and action. Zhang et al. (2020, p. 131:14) discuss a modified form of Inclusion called "linguistic coordination." They write, "[Linguistic coordination] involves interactional behaviors like adapting to a client's language or reflecting their concerns." Zhang et al. used Danescu-Niculescu-Mizil et al.'s (2012) markers of linguistic coordination: "articles, auxiliary verbs, conjunctions, high-frequency adverbs, impersonal pronouns, personal pronouns, prepositions, and quantifiers (451 lexemes total)." (Danescu-Niculescu-Mizil et al., 2012, p. 4) This is consistent with my manual coding of the Inclusion discussion discipline described in Chapter 4, which encompasses direct acknowledgement and pulling people in, using such words as "you" as in "did you get the answer you needed?".

Zhang et al. (2020) look at two impacts of coordination behaviors for text-based crisis center conversations: conversation closure and rating by caller. Conversation closure is interesting as it corresponds to the outcome of "intent to act" discussed in Chapter 4. Closure is an action of completion or declaration of intent by the caller, note the authors. Zhang et al. (2020, 131:11-12) clarified that

"Conversations 'close' at a moment that feels appropriate for both the counselor and texter." Closure occurred 72% of the time in Zhang et al.'s sample.

Zhang et al. (2020) found in a text-based crisis counseling setting that coordination behaviors and (positive) sentiment language correlate with conversation closure. (This is a meaningful relationship. However, they also found that stronger predictors of conversation closure were not conversation content or rhetoric, but conversation length and response speed.)

Danescu-Niculescu-Mizil et al. (2012), writing about power in conversations, draw our attention to Accommodation Theory from sociolinguistics. The theory states that the lower the power of the speaker relative to the target, the more that she coordinates, or uses matching or accommodating language. Danescu-Niculescu-Mizil et al. found that 1. Coordination language is a status-accommodation (either a situational status difference, where a speaker wants something from a target, or a formal status difference, based on role), where lower-status individuals are more likely to use coordination; and 2. It is independent of domain features (for example, independent of contextual vocabularies, such as "Your Honor," in the Supreme Court). The authors performed natural language processing research (using support vector machines) using over 50,000 utterances across Wikipedia Talk data and Supreme Court data. The authors provided evidence that speaker's language includes more coordination elements when the speaker is trying to gain favor, acceptance or positive reaction from their target when the speaker's power level is lower than the target's, than when the speaker's power is equal or higher. Write Danescu-Niculecu-Mizil et al. (2012, p. 2):

> When an individual is trying to convince someone who holds an opposing view, this creates a form of dependence and hence a power deficit in the sense of exchange theory; we find increased levels of language coordination in such cases. The relation between status level and the extent of language coordination transfers across domains, and is a reliable cross domain feature for status prediction.

The authors further demonstrated that the coordination behavior is independent of the loquaciousness or taciturnness traits of the individual. An interesting finding of Danescu-Niculecu-Mizil et al. (2012, p. 9) is that female speakers use more coordination toward higher status individuals (e.g., female lawyers [lawyers being lower status] speaking to justices [justices, of both genders, being higher status]). However, the inverse is not true. Justices, whether female or male, use more coordinating language when they talked to male lawyers (presumably of status higher than female lawyers) than when they talked to female lawyers. It is notable here, as with the research of Sommers (2006), described in Chapter 2 and 4, that difference doesn't only increase variety and collective prediction accuracy capability, as Page (2008) originally wrote. Rather, it has a marked effect on motivation and sub-conscious behavior. Page (2017) later concluded impact of diversity on motivation, which Sommers [2006] also found in jury research, where racial diversity correlated with preparedness, reasoning and recall. Finally, this is consistent with Zang et al. (2021), who found in crisis hotline research, where the temporarily lower-status hotline staff having used coordinating language resulted in more closure.

The research into linguistic coordination and the related closure outcomes of Danescu-Niculescu-Mizil et al. (2012) and Zhang et al. (2020), respectively, relates to just one of the three sustainability outcomes from Chapter 3 (intent to act) and just one of the four discussion disciplines (Inclusion). Yet, it is encouraging because of its similarity to sustainability conversations. In a sustainability conversation, especially one relating to use of a common pool resource, one would expect to see speakers looking for approval or acceptance from their targets, and would thus be likely to use coordinating language.

5.2.2 Conversation analytics basics

Natural language understanding (NLU) is using quantitative analysis of natural language to understand humans in natural dialogues, using context, forms of speech, pitch, cadence, and sequence to convey meaning. Natural Language Processing (NLP) also seeks to produce inferences.

NLP starts with voice-to-text transcriptions (e.g., Otter.com used by Zoom), using sound component dictionaries and context to represent and transcribe spoken words. Cortico.ai, for example, allows citizens to record, transcribe and analyze civic conversations in a room with a Rumba-sized appliance.

Next, raw transcripts are cleansed and divided into utterances, spoken by a unique individual, or meaningful parts of conversational interaction called "dialogue acts" (Zelasko et al., 2021) or "moves" (Kantor, 2012), which could be demarcated by punctuation or length. For processing by the NLP engines, these, in turn, get broken down into smaller units of speech, or "tokens." For example, tokens could be dependency-related or grammatically-related pairs of words (bi-grams). Chang et al. (2020), creators of ConvoKit, call these "arcs," and repeatedly-occurring arcs are collected into "Phrasing Motifs."

Once broken into tokens, the move or utterance can be represented as a vector -- a series of numbers, counting frequencies or proximities, respectively, relative to a the corpus itself (Chang et al., 2020) or to a reference model of a large body of text (Devlin & Chan, 2018). If the vectors count instances of all of the words or phrases in an entire transcript, the dimensionality of the vector could be too high for processing. The vectors in the matrix can therefore be reduced, e.g., using singular value decomposition. Subsequent steps may entail normalization, and clustering, or using a neural network learning process.

The final outcomes of NLP are utterance, dialogue act (or move) classification and analysis, the creation of speech, or by making inferences about the speakers' intents, evoking other systems, such as appliances or machinery.

5.2.3 Basic NLP pathways

Over the years there have been progressively more intelligent pathways to discover features (meaning) within and between dialogue acts. Using text analytics, phrases or terms were matched to a dictionary or lookup table, e.g., using auto-classification and information recognition, as a reference

system. NLP, by contrast, recognizes words in the context of sentences, utterances, transcripts, or other features, using data both in the sentences, and in reference systems (Hu, 2021), "Semantic" text feature recognition, like sentiment analysis, derives from context. "Syntactic" derives from grammar or rules about word sequence, and looks for matches by consulting a term-set or controlled vocabulary.

NLP initiatives have recently combined semantic, syntactic, and reference systems. It wasn't always that way. NLP in the early 2000s focused on identifying words within sentences (Google, 2021). A "one hot" model took content (e.g., a document or an utterance) and broke it into an one-dimensional (discrete) space or vector with words or word combinations as elements (Pedregosa et al., 2011). This had the limitation of not representing word relatedness. More advanced models added associations, such as related word expansions (e.g., "play" and "playful"), or category co-membership ("king" and "queen"). This continuous (rather than 1 or 0) representation of a sentence is called "word embedding" or "distributed" vector representation (Google, 2021), as illustrated in Figure 5.1.
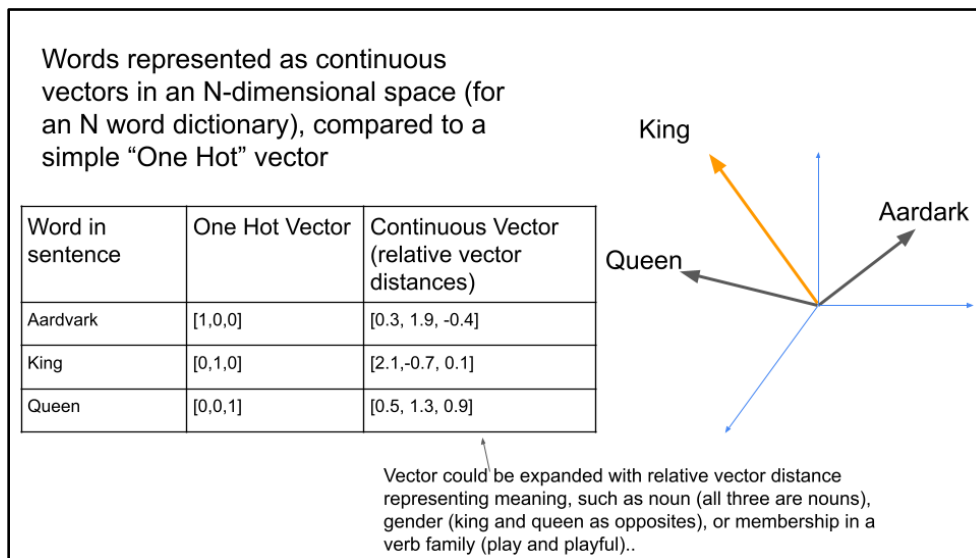
Figure 5.1: One Hot Vector's unit-model limitations, compared to a continuous vector (Adapted from Google (2021)

"Transfer learning" is taking learning from another body of text, such as Wikipedia, to help inform these dimensions through expected similarity. Word2Vec, introduced in 2013, used terms harvested from Wikipedia (Mikolov, 2013 in Demeester et al., 2016). As shown in Figure 5.2 (three panels below),

Word2Vec used probability to characterize the likelihood a term should be tagged or added to a sentence, using the historical text reference data.

Training a language model, using Word2Vec Transfer learning example (1): Model seeks the missing word,"bank" starting with average vector across words

5. Goal is to produce score for every word in vocabulary indicating likelihood it wins

bank
fish
on
the
river

4. Average the embeddings over the sentence

3. Create randomly initialized embeddings

2. Goal: We want to determine next word ("bank")

on   the   river   ---

bank
fish
on
the
river

1. Simple five word embedding matrix from Wikipedia.

Training a language model, using Word2Vec Transfer learning example (2): Model guesses randomly for the missing word,"bank"

6. :Linear transformation to make the 2 vector to 5 dimensional vector ("Softmax Parameters")

7. Logit Regression to Predict the next word (Normalize to sum to 1)

$\sigma(\chi_j)=e^{xj}/\Sigma_i e^{xi}$

bank   70%
fish   0%
on   0%
the   30%
river 0%

8. Check how we did ?

$\bullet\bullet$ x $\quad$ =

bank
fish
on
the
river

on   the   river   ---

1. Simple five word embedding matrix from Wikipedia.

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Figure 5.2: Illustration of back propagation. Note: Adapted from Google (2021)

Word2Vec, a simple neural network with a single hidden layer, was a breakthrough at the time, as

it could predict words when sentence structure was atypical. It established the use of transfer learning

(importing learning from a previous text corpus), and "back propagation," where the model could be

revised (reducing a loss function) based on reference text, as shown in Figure 5.2. Word2Vec's downside

was that it didn't take into account multiple meanings for words, such as "bank" being "Where you rob

the money," and "Where you sit by the river" (Google, 2021). More importantly, Word2Vec stopped

short of detecting what the speaker's intent in conversation was, such as to introduce a point, ask a

question, be kind, or invite another person to join. Applications later used to achieve intent-recognition

added a prompt-response or feedback-feed-forward designation (Chang et al., 2020, Zelasko et al., 2021).

In the next section I consider two computational approaches for detecting conversational

meaning: TF*IDF process and advanced neural networks. Both use transfer learning. I have chosen two

points at the "Explainability versus Accuracy" tradeoff surface, as defined by Joshi and Kumar (2021).

The more accurate types of NLP are most often described as a "black box." Joshi and Kumar (2021)

consider the TF*IDF (with clustering) process to be an example of a Graphical Model, which is in the

middle of the accuracy-explainability tradeoff surface. The neural networks are an example of a Deep

Learning model, which is in the low-explainability, high-accuracy spot on the accuracy-explainability tradeoff surface. (Also highlighted in is rule-based learning, which was used, not as a model, but for simple text matching.)
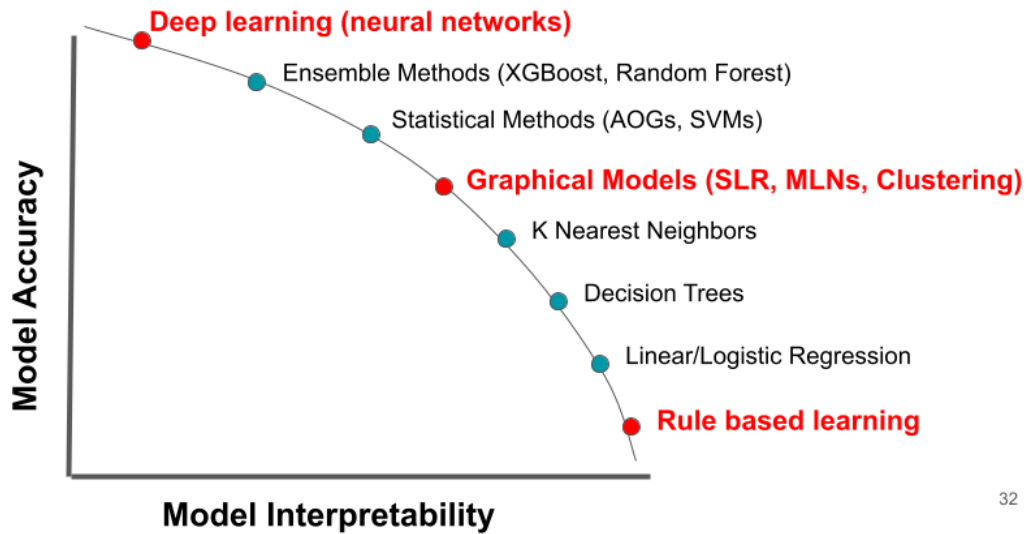
Figure 5.3: Explainability and Accuracy Trade-off (adapted from Joshi & Kumar, Arya.ai [2021])

5.2.3.1 Term Frequency-Inverse Document Frequency

Term Frequency-Inverse Document Frequency (TF*IDF) is a form of matrix population and reduction from language that finds token similarities across utterances in a corpus by computing in-utterance token or term frequency (TF) relative to the inverse of corpus-based token or term frequency (IDF). In other words, TF*IDF finds the term to be *dominating* in an utterance, but *unique* against the corpus, so as to distinguish it. The TF*IDF process maintains some corpus-based context through the use of clustering (co-occurrence) (Hu, 2021). Because of its significance in the landscape of NLP, let's expand its definition here: One creates an mxn matrix, where m is the number of unique Phrasing Motifs for an utterance (m=number of columns) and n is the number of unique utterances (n=number of rows), as described in Goralewicz (2021). (Note: I use the term "document" as with Goralewicz, but in my research the unit of analysis is "utterance."):

For a Token t in document d, the weight (Wt,d) of term t in document d is given by:

$$Wt,d = TFt,d \log (n/DFt)$$

Where:

TFt,d is the number of occurrences of t in document d.

DFt is the number of documents containing the term t. (In our case, the term is Phrasing Motif.)

n is the total number of documents in the corpus.

m is the total number of unique terms.

Thus, DFt is in the denominator, reducing the size of the natural log. TF*IDF creates a vector of term counts for each move. The matrix is reduced (using Singular Value Decomposition [SVD] process), and then a clustering process is used to arrive at clusters with common meaning. Not surprisingly, the TF*IDF model comes from search engine optimization (SEO), where one would want a high-occurrence or salience of the term in each utterance (numerator), and low occurrence (rarity in the corpus) (denominator) (Goralewicz, 2021).

5.2.3.2 Advanced Neural Networks

While the type of simple, single-layer neural net processing Word2Vec provided useful knowledge about speech from sentence and reference data, in 2017 came the ability to get word context from the contents of the sentence or utterance (Google, 2021), and with greater confidence about polysemy (same word, different meaning, like "river bank" and "rob a bank"). "Recurrent neural networks," or RNNs, introduced in 2014, used both the antecedent and subsequent words or phrases to triangulate the meaning of the word or phrase in question (that word being called a "query token"), in combination with outside reference data or dictionary. This process was called "self-attention," as the word or phrase gets insight by looking at other near tokens, or "keys." Self-attention could represent every token in the sentence or utterance, measured as the weighted sum of the similarity scores (e.g., to the dictionary, to the adjacent words or phrases). This use of context and reference substantially improved

performance over Word2Vec. The downside was that self-attention could be computing-intensive, as it could yield multiple outputs for each word in a sentence or utterance, across large corpuses.

Advances have come from computing each output in multiple neural net "layers." A so-called "transformer" could include a stack of these self-attention layers, called "contextual embeddings". Each layer understands the whole sentence, and has a score for every word (Oliinyk, 2017). Like Word2Vec, this was highly computing-intensive, and could require reduction (e.g., singular value decomposition) to manage.

Google's BERT (Bidirectional Encoder Representations from Transformers) was built primarily on the mission of transfer learning, and with the intent to reduce the inefficiencies and inaccuracies of Word2Vec and RNN. Introduced in 2017, and built on top of Google' TensorFlow open source application, BERT was trained on Google search and Wikipedia, and was intended for classifying speech (e.g., for sentiment analysis) (Devlin & Chan, 2018). BERT's transfer learning leveraged a pre-trained general-purpose model based on Wikipedia and Google data, which could be used to train on new, labeled data through self-attention. BERT used neural network layers that derived from self-attention in the sentence or utterance ("contextual" self-attention) combined with look-ups ("non-contextual" self-attention). For example, contextual and non-contextual elements allowed BERT to recognize paraphrases (Google, 2021).

Google developed BERT over several years and open-sourced BERT in 2018 so that the NLP research community could contribute. This open-source choice was similar to Google's choice to open source TensorFlow (Devlin & Chan, 2018). Major tech companies have built BERT versions. For example, Microsoft extends BERT with MT-DNN (Multi-Task Deep Neural Network). Facebook offers RoBERTa. Devlin and Chan (2018) enumerate BERT's capabilities: Word sense disambiguation, polysemy resolution (e.g., "river bank," "rob a bank"), named entity determination, textual entailment / next sentence prediction, co-reference resolution, question answering, and automatic summarization.

Some studies have shown that BERT's compute complexity can still be an issue. For example, Khalife, Gonçalves and Liberti (2020) demonstrate that using distance geometry (e.g., least squares distance method in an n-dimensional space) can outperform BERT's neural network layers from a computing-speed perspective under certain conditions. Complexity also continues to make debugging BERT a challenge.

5.2.4 Corpus preparation

In the following sections, for a typical TF*IDF process, I describe the main steps: training corpus preparation and tokenization, rhetorical intent designation, matrix reduction, and clustering. After corpus preparation and tokenization, a researcher may feed the tokenized data into other pipelines, like Word Embeddings and neural nets.

A training corpus is a set of transcripts or other collection of conversation that can be used to train the NLP model. Training corpus preparation involves identification and loading of data for analysis. There are many available transcript resources, such as the AMI corpus (Kilgour, 2021). However, it is critical to determine if a corpus has sufficient similarity. Mihalcea and Strapparava (2006) found that, comparing various topical, semantic or syntactic methods, topics similarity alone is insufficient. Tone, intent, vocabulary breadth, and grammar can also increase or decrease similarity between two corpuses.

Chosen training corpus data are then preprocessed using a text cleaning transformer, such as ConvoKit's (Chang et al., 2020), that removes capitals, punctuation, and numbers, and filters stopwords (e.g., words used frequently with limited meaning, e.g., "the," "a"). Corpus preparation may also involve loading a dictionary of terms for future tagging. For example, it could be used to label known phrases as positive or negative in a sentiment analysis process. Stemming may be used to reduce terms (e.g., from "playful" down to its root, "play") and lemmatization to expand words (e.g., from "play" to "playful," "playing," "player"). Stemming brings expedience with some error (e.g., pocketed might stem to pocket, noun, or a verb), while lemmatization adds time and compute complexity.

5.2.5 Tokenization

During token processing, tokens are generated using grammatical logic or statistical logic. For example, bi-grams may be generated as pairs of words which have dependency, such as "car-his." The dependency logic uses simplified grammar, which could introduce error by ignoring differences like coordinating or subordinating conjunctions (Berwick, 2021; Jurafsky & Martin, 2021), The advantage of tokens, rather than proper grammar, is that tokens have a more flexibility than formal human grammar. They also are more useful for more fluid languages like Czech and Finnish. The logic of dependency pairing typically leverages a 1993 "bank" of relationships as reference (Jurafsky & Martin, 2021). Meanwhile, tokenization in some Word Embeddings (specifically, Word2Vec) calls a reference database published by Facebook which serves up vectors of known English words (Oliinyk, 2017).

Parsing into dialogue acts, not just utterances, can provide advantages in discerning unique rhetorical intent (Zelasko et al., 2021). Zelasko et al. argue in favor of using dialogue acts, and stress that these are best derived by leveraging punctuation, which is removed by most text cleaners. For example, question marks have a natural relationship to intent (provoking response), but may be discarded with other punctuation in cleansing rules. Zelasko et al. (2021, p. 1167) use Facebook-derived reference data, "Hugging Face," for tokenizing their data. Using XLNet, a variant of BERT, Zelasko et al. (2021, p. 1166) work with punctuation to derive dialogue. In their ground-breaking work, they note, "To the best of our knowledge, there are no studies that attempt to understand the role of context, punctuation, or label set specificity on dialogue act recognition in depth."

5.2.6 Prompt-Response representation

ConvoKit PromptTypesWrapper (Chang et al., 2020), is Cornell's collection of transformers based on the TF*IDF process. ConvoKit is designed to discover the interplay of conversation participants. ConvoKit uses prompt-and-response to detect utterance intent by considering prior and post utterances. This performs a function similar to how Zelasko et al. (2021) use a prompt-response model which adds to the self-attention layer a "feed-forward layer." However, Zelasko et al. (2021) remark that a challenge

with prompt-response schemes is the variety of interactive, non-sequential interactions (where a prompt is separated by a response within several utterances), and the difficulty attributing the interplay to specific conversational intent.

5.2.7 Enrichment / appending

In the complexity-accuracy tradeoff surface, auto-classification uses rules to detect phrases (and phrase synonyms). The logic is simple: words pairs or phrases are sought in sequence or in relative positions in a document or transcript. For example, with MarkLogic Semaphore, rules engines for tagging/appending metadata include Boolean and conditional logic (e.g., "good" within five words of "neighbor," in sequence). Some rules engines have also been made available using Python open source code libraries (e.g., HuggingFace). Auto-classification can be used in simple search engines with known vocabularies and taxonomies, or as a step for more complex NLP model development.

5.2.8 Matrix reduction

After tokens (enriched or not enriched with appended metadata) are vectorized into the mxn matrix (described in TF*IDF model above), the next process is matrix reduction. "Singular value decomposition" (SVD) is a matrix reduction process which improves computational speed for large matrices. With SVD, the matrix is represented in terms of its eigenvalues and dimensional eigenvectors. The diagonal values of the matrix are called the "singular values." There are several different approaches to SVD. The SVD clustering algorithm used in ConvoKit PromptTypesWrapper is randomized for efficiency (Halko, Martinsson, & Tropp, 2009). SVD is preferred by ConvoKit to the simpler Principal Component Analysis (PCA), as PCA performs a matrix reduction on the vector values to find difference relative to 0 (finer granularity), whereas PCA is used when the question is the difference relative to the mean.

5.2.9 Clustering

With TF*IDF tools like ConvoKit, a K means clustering is applied to the SVD-reduced matrix of 25 columns x n rows to generate clusters. The number of clusters is an adjustable parameter. Clustering is performed using random assignments, averaging, and converging across all dimensions (Macqueen, 1967, as cited in Zhang, 2021). Visualization is helpful for clusters, as they can be represented as two dimensional plots with observations (utterances) positioned with proximity to a centroid, with a vertical coordinate of 0. Then, upon completion of clustering, each utterance has a coordinates specifying its approximate distance from the centroid of each cluster in two dimensional space.

5.2.10 Performance benchmarks

NLP tools have progressed substantially since the 2013 Word2Vec initiatives (Google, 2021). There are several standard corpuses that are used for testing the effectiveness of these models. For example, Zelasko et al. (2021) use BiGRU which is based on a standard call center data set. See, Roller, Kiela, and Weston. (2019) used a human classification comparison. In the context of others studies, researchers test the performance of the model against the Stanford Question and Answering Dataset (SQuAD) which requires the NLP to find answers to human questions posed against Wikipedia articles, and GLU, a set of 9 diverse NLU tasks. These provide a strong benchmark. With transfer learning there is another built-in benchmark: the model is trained on a neutral data set, and then tested against custom data.

5.2.11 Sarcasm and other challenges of human speech

One challenge in human speech includes "pause and resume" (where a concept is introduced, and then revisited, such as in an interaction with a Helpdesk agent). In that situation, the pronoun, such as "they" or "that" refers back to earlier utterances. Sarcasm is a complex form of speech that often has elements of pause and resume, hyperbole, juxtaposition, and surprise. For example, Kumar (2020) uses both a support vector machine (graphical model in the complexity-transparency tradeoff surface), as well as "hand crafted features" that include numerous potential antecedent features similar to pause and resume. Kumar uses this to detect (negative) sarcasm on social media.

5.2.12 Context and Gender

A final challenge of human speech is context. Context, such as geography and history, has been shown to contribute to the impact of conversations such as aquaculture lease hearings (Hanes, 2018). Presence of women in conversations has also been shown to contribute to social sensitivity (Woolley et al., 2010, 2015). Woolley et al. (2010) showed that social sensitivity makes groups effective, and that social sensitivity, in turn, is correlated with the presence of females. Kendall and Tannen (2001, p. 548) point out that gendered speech is recognizable, but that speakers have agency: "language functions as a symbolic resource to create and manage personal, social and cultural meanings and identities." Gendered language (e.g., directives for boys, or suggestions for girls) is a social construct. Kendall and Tannen (2001) point out that, as speakers find a balance between establishing conversational status and connection, women's language tends to establish matching and reciprocity, and include "subjectivizers" (e.g., "I think"), while men's language tends to focus on position in a hierarchy. When doing the gender-opposite, until recently, the speaker has been met with shaming or criticism. Thus, while one would expect to see some of social sensitivity in women's utterances, one would also expect today, in 2022, to see more balance than when Kendall and Tannen (2001).

5.3 Methods

The research methods include observation of sustainability conversations (Maine aquaculture lease scoping meetings, or LSMs), breaking those into moves, and then coding with the discussion disciplines, creating training and test corpuses, developing the NLP/ML model, and modeling the impact of discussion disciplines on outcomes. The research process also included manual expansion of discussion discipline metadata, auto-classification, and human-in-the loop parameter improvements, as illustrated in Figure 5.4. This figure also includes the numbers of utterances and transcripts used in model variations and then in the tagging of the large corpus for performing statistical analysis on the relationship between outcomes and discussion disciplines.
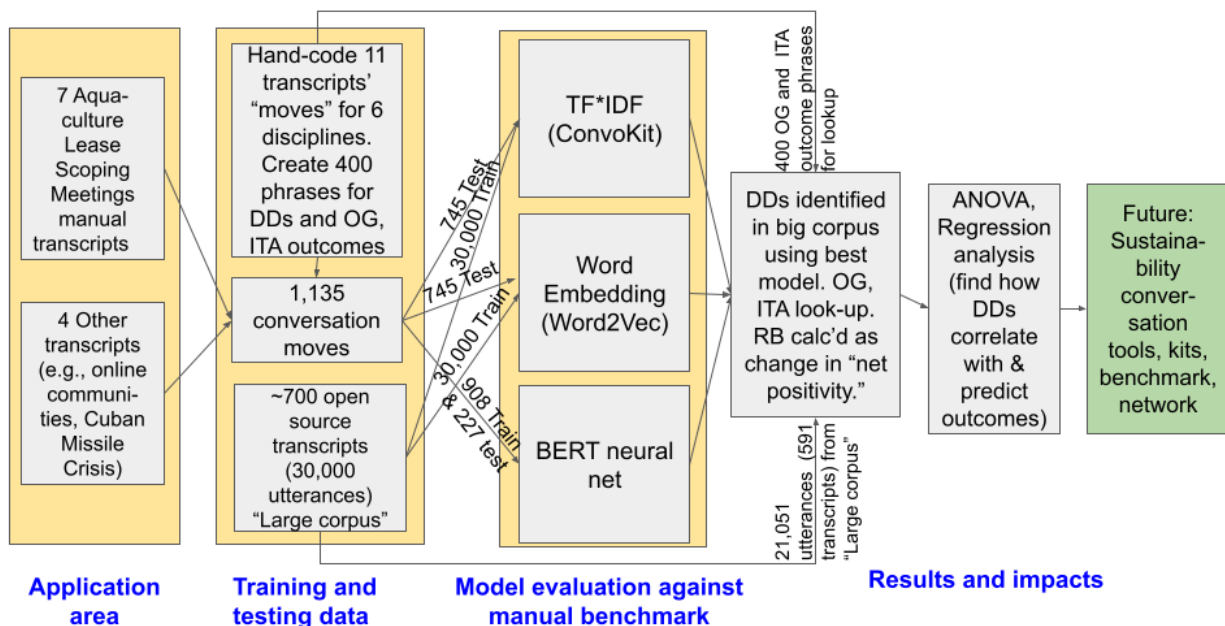
Figure 5.4: NLP methodology and data development process.

Note: DD=Discussion Discipline; RB=Relationship-Building; OG=Options Generation, ITA=Intent to Act outcomes. "Net positivity" is First half of transcript to second half percent change in Courtesy+Inclusion-10% of Anti/Snarky.

5.3.1 Observe, manually code, and validate on LSM training data:

a. Attended publicly available aquaculture lease scoping meetings (LSMs). Seven LSMs were attended on Zoom over the period October, 2020-May 2021. These were recorded and transcribed manually to respect participant privacy. Seven additional anonymized transcripts were coded and made available from aquaculture, online student discussions, a public semi-academic community's online discussion, the *Friends* pilot episode, and President John F. Kennedy's team Cuban Missile Crisis.

b. **Manually parsed LSM transcripts into moves, and inferred outcomes**. From the seven LSM transcripts, 746 total moves were coded for the presence of discussion disciplines. (728 contained named speakers, genders and discussion disciplines.) Discussion disciples were coded as described in Chapter 4. (Figure 4.1 is an illustration.) Multiple coders participated to validate the coding of the discussion disciplines in the transcripts, and to avert any coder bias. Pivotal juncture(s) in each conversation were

also identified, such as where truth-telling or high-emotional language (breakdown) led to new capacities for relationship-building or options-generation (Scharmer, 2018). Moves were coded for gender and role-type (e.g., environmental advocate, farmer, policy maker, riparian landowner, and regulator). From text meaning, conversation outcomes were manually identified and recorded (options-generation, intent-to-act, and relationship-building).

c. **Using Zoom or phone, conducted semi-structured interviews**. Interviews were conducted with people who have been either 1. Involved in the above conversations, or 2. Able to observe the outcomes of these types of conversations. Interviews inquired into the context of the conversation, the hidden meanings of moves, perceived outcomes, and potential for conversation skill-building.

d. **Generated a 400 phrase term-set for enriching (appending) training utterances**. From the seven lease scoping meetings phrases were generated that correspond to Integrity-Q, Courtesy, Inclusion, Translation, and Anti- (Snarky). (Integrity, which is a statement, was the default value.) This used lemmatization (expansion, such as play, plays, playing) rather than stemming, which regresses to the root and loses meaning (playing to play). Term-sets were also generated for the outcomes of options-generation and intent-to-act. (Relationship-building was labeled based on a change in net "kindness," as calculated to be percent change in the difference of Courtesy plus Inclusion less Anti/Snarky, by transcript.)

5.3.2 Train and compare NLP models' ability to detect discussion disciplines

a. Loaded and tested Cornell's ConvoKit, selected open source transcripts. ConvoKit offers a growing number of open source transcript libraries, including movie transcripts and Reddit's Coarse-Discourse transcripts (Zhang, Culbertson & Paritosh, 2017). A corpus similarity test was performed (Fothergill et al., 2016) against the seven transcripts and found that the ConvoKit transcripts were suitable. By contrast, the AMI corpus (Kilgour, 2021), which was based on technical project team

meetings, had insufficient similarity. From the ConvoKit transcripts we identified 30,000 utterances, across approximately 500 transcripts, to create an open source corpus.

b. Generated a model that cleans, parses, and clusters (discovers) utterances. The large corpus was used for training the TF*IDF model, and the LSM training data was used to train the BERT Neural network. Using the decision tree in Figure 5.4, six variants of the model were initially tested. Four used ConvoKit and Phrasing Motif tokens, with and without normalization,. Two used Word Embeddings (Word2Vec). Each was tested with and without appended metadata.
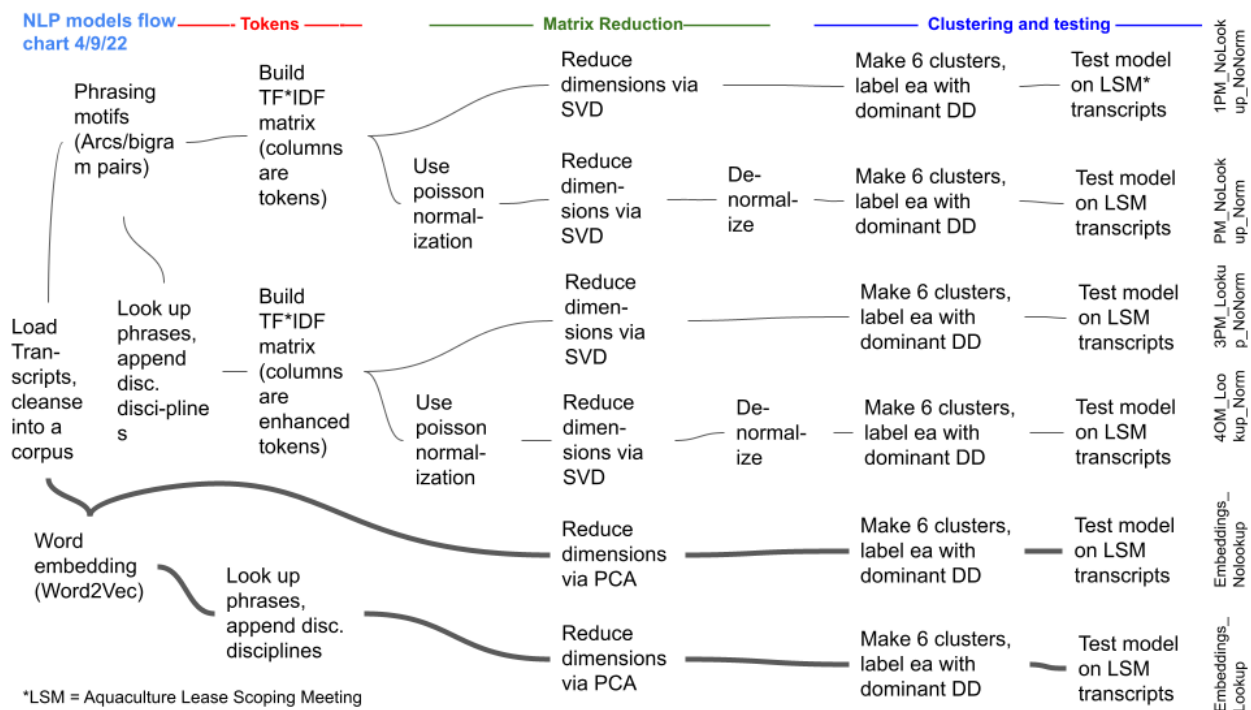
Figure 5.5: Decision tree for first six models, varying tokens, matrix reduction, and normalization, clustering and testing.
Note: Includes comparison of two tokenizations: Phrasing motifs and words in Word Embeddings.

After the first six comparisons, the successful TF*IDF models were compared to BERT neural networks using transfer learning, as shown in Figure 5.5. In all cases the clustering involved generating six clusters, corresponding to our five discussion disciplines and the Anti (snarky) discipline.
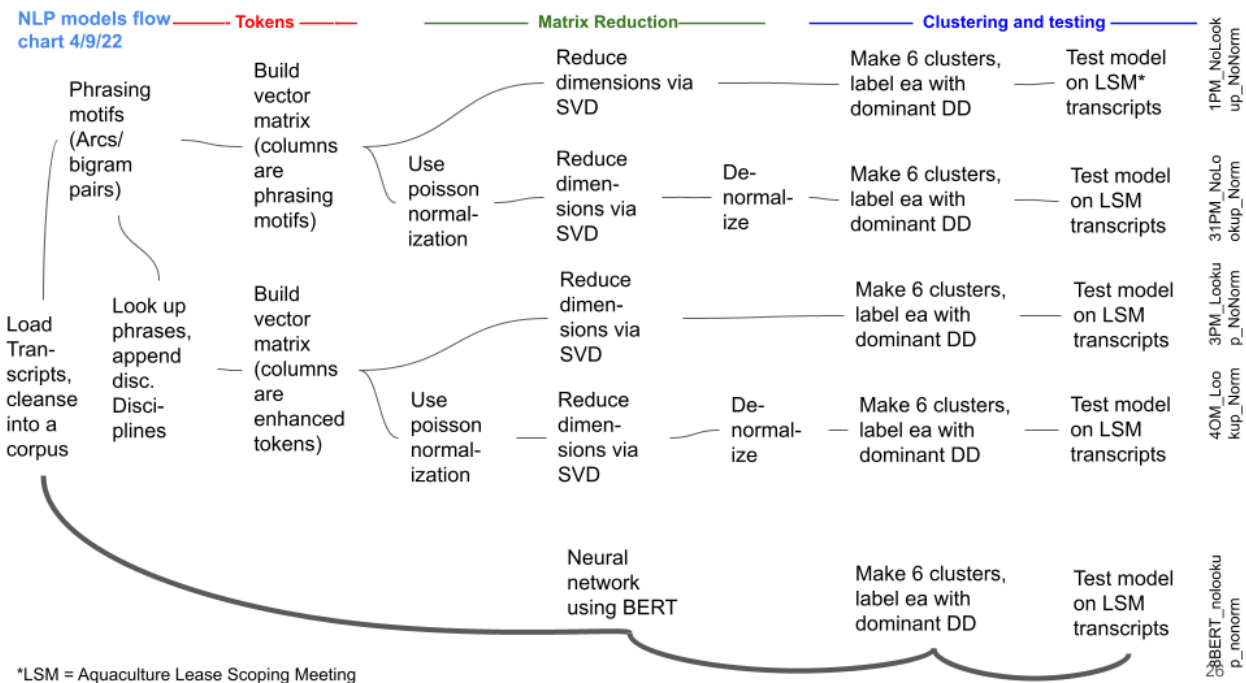
Figure 5.6: Decision tree swapping BERT into the last spot, varying tokens, matrix reduction, normalization, clustering.
Note: A comparison of two tokenizations: Phrasing motifs and word tokens used in Word Embedding and BERT. Neural Network pathway is in **bold**.

For the Phrasing Motifs token scenarios, a TF*IDF matrix was generated with approximately 700 columns in the mxn matrix, using the large corpus. ConvoKit transformers were parameterized, such as specifying numbers of minimum Phrasing Motifs in a vector, number of clusters, and inclusion or exclusion of prompt and response designation. In the append scenarios, discussion disciplines were appended using a lookup process that recognized the phrase variants and appended one of six discussion discipline tags. This used the 400 hand-crafted phrases. Integrity was considered to be the "default" value if there was no match. Where two or more discussion disciplines applied, the rule was to append the discussion discipline label based on the "rarest" value, as discerned during the manual coded LSM testing data in Figure 4.2. For the Word Embeddings scenario only, a frequency matrix with 768 columns (which is the length of a Google Word Embeddings Word2Vec model) was generated, each column representing words that are derived from a Facebook Corpus, with rows representing each utterance. Depending on the scenario, the data were normalized. A Poisson normalization involved taking the non-

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zero value cells in the TF*IDF matrix, dividing them by the square root of (the sum of the value of the cell plus 1), and then, for each cell, subtracting the mean of the column. We performed SVD matrix reduction (when using Phrasing Motifs) or the PCA matrix reduction (when using Word Embeddings). This took the phasing motif matrix (normalized or not, depending on the scenario) from approximately 700 columns to 25. In scenarios where normalization was used before the matrix reduction (SVD), the normalization steps were reversed before clustering.

c. Assigned utterances to discussion discipline clusters. For the TF*IDF and Word Embeddings (Word2Vec) models the reduced m^1xn (column x row) dimensional matrix (m^1 being 25) was used to collect the moves into six clusters: Using the LSM testing data, the discussion discipline was assigned to the cluster by looking at the largest percent of any discussion discipline that was co-located in a cluster. Then those cluster and discussion disciplines were set aside. The next largest percent of a discipline in a cluster was identified, and that cluster and that discussion discipline were set aside. This continued until all of the clusters were labeled with a discussion discipline. Where there were conflicts, the larger discussion disciplines were favored (e.g., if both integrity and courtesy had the majority of their utterances in Cluster 1, Integrity would be the assigned cluster). This maintained a conservative approach to the scorecard, as described below.

For the BERT model, discussion discipline predictions were performed directly by the model, and were illustrated in a "confusion matrix," that compared the predicted discussion disciplines to the actual discussion disciplines as assigned by hand coding. A ResNet model was used under BERT to reduce the possibility of overfitting. Nodes were randomly dropped out of ResNet during the process of running through epochs until accuracy peaked.

5.3.3 Tested the NLP models and populated the scorecard.

The hand-coded aquaculture LSM transcripts were used to test the models by running the LSM moves through the model and validating the coding match. (For the TF*IDF and Word Embeddings

[Word2Vec] models, this entailed starting with the reduced matrix and then re-running the k-means clustering.)

For the BERT model, this meant running 20% of the total LSM moves through the model and evaluating the "confusion matrix," where the value predicted by the model was compared to the actual value). Next, the share of accurately assigned modeled discussion disciplines was calculated and put into the scorecard. This included: 1. Performance for each discipline; 2.Performance for all discussion disciplines (accurately coded moves, as a share of total moves).

5.3.4 Determined the impact of conversation disciplines on outcomes

In this section we overview the steps to use the selected BERT neural network model to assign utterances with discussion disciplines, and transcripts with outcomes. Columns 1-3 in Table 5.1 profiles the large corpus used for this analysis. These sources were selected from the Cornell ConvoKit repository because they were available as open source, documented resources, and were sufficiently similar to the LSM transcripts from a syntactic and language perspective.

The following sections describe the steps used to classify the transcripts, correlate the discussion discipline frequencies, and regress the outcomes onto the discussion disciplines. Table 5.2 summarizes, at a source level, the profile of the transcripts.

a. Calculated "signatures" of conversations. Using the winning model, the percent of each discussion disciplines within a transcript was calculated.

b. Tagged outcomes to transcripts. Lookup data were used for the intent-to-act and options-generation outcomes. Relationship-building was found as an increase in net positive moves (Courtesy plus Inclusion, less Snarky) from first half to second half of the transcript. This is based on Scharmer's (2018) presencing model, as described in Chapter 4, which suggests that groups evolve to a greater sense of mutuality through politeness, to breakdown, to inquiry, and then to flow. This pattern was also discussed in Chapter

4, where early pivots (breakdowns) were more likely to be associated with relationship-building, and later pivots were more likely to be associated with intent-to-act.

c. Regressed outcomes on explanatory variables. After generating a correlation matrix to test for multicollinearity, a regression analysis was performed, showing the impact on the outcomes, by transcript, of the discussion discipline shares for 591 transcripts. Table 5.1 describes the intended explanatory variables. (As we shall see in the Results section, Gender was not included in the regression analysis because of lack of female data. Region [corpus source] was not included because it did not have a statistically-significant correlation with Outcomes.)

Table 5.1: Proposed Linear Regression Model

Explanatory Variables (Transcript Signature)	Dependent variables (Outcome)

X_{1-6} Discussion Disciplines (determined by percent of discussion disciplines) relative to our LSM testing data: e.g.,
 	
     Integrity %
 	
     Integrity-Q %
 	
     Courtesy %
 	
     Inclusion %
 	
     Translation %
 	
     Snarky %
 	
 X_7 Gender* (percent of moves contributed by females)
 	
 X_8 Region* (proxy for costly signals, as described in Chapter 4).
	Options generation (innovation)*
	
	 Intent to act (accountability)*
	
	 Relationship building (mutuality)*

Note: *Categorical variables.

5.3.5 Inform designs for productive sustainability conversation capacity-building.

In Chapter 4 I described a design phase for community roll-out with aquaculture industry stakeholders. For example, a group could have their anonymized transcripts analyzed for the discussion disciplines and outcomes. This could help them focus their conversational practice. Capacity-building design could

involve learning modes, such as self-paced, classroom, town meeting, and boundary objects, such as reference cards, data read-outs and videos. As conversation requires social engagement, roll-out could feature a knowledge network, using Pugh and Prusak's Knowledge Network Effectiveness Framework (Pugh & Prusak, 2013). This would entail designing structures, such as the operating model, tools, facilitation, and measurement, in alignment with specific network outcomes, a "theory of change" (intent-design logic) shared by network leaders, and goals for designing psychological safety into network activities.

5.4. Results

In this section we discuss the performance of the three models (ConvoKit TF*IDF, Word Embedding, and BERT NeuralNet). Following the results is a discussion of the predictive performance of the transcript "signatures" (discussion discipline distributions) and other explanatory variables.

5.4.1 Comparison to hand coded discussion discipline data

To ground the results, it is instructive to look at the overall distribution of the discussion disciplines in the LSM testing data (the seven lease scoping meeting transcripts that were hand coded). Figure 4.2 in Chapter 4 showed the weighted average discussion disciplines, calculated as the total number of moves coded as each discipline across the entire corpus, as a percentage of total moves. Integrity (statement) dominated over the other discussion disciplines for moves within conversations. Next was Integrity-Q, followed by roughly equal courtesy and inclusion. Translation, and anti (snarky) moves were considerably less. Integrity's domination is considerable, and could distort the data where the level of granularity for looking at Integrity activity in our data could be coarser, than the level granularity for other discussion disciplines. The Poisson normalization variant in our model evaluations was chosen to explore the impact of correcting for this.

This domination by Integrity, and the broad variety of forms of Integrity (statements), also led us to use Integrity as the "default" label when our discussion discipline lookup process (in the TF*IDF and Word Embeddings [Word2Vec] scenarios) did not find a match or an utterance.

5.4.2 Evaluating the models for their ability to find discussion disciplines

Table 5.2 contains the scorecard of the model results. Rows 1 and 2 use ConvoKit's Phrasing Motifs tokens (frequently-occurring pairs of Arc, or bi-grams, as described in 5.2.5 above). Phrasing motifs performed better than the Arc tokens (not shown). Rows 4 and 5 use words as tokens inside of Word Embeddings (Word2Vec), which are represented semantically, according to the Word Embeddings transfer learning reference. Row 2 and 4 also have discussion discipline terms looked up and appended before the matrix reduction (SVD for TF*IDF, PCA for Word Embeddings). The "/" in the numeric cells represents non-normalized and normalized matrix data, respectively.

The appending of the discussion disciplines marginally improved the overall TF*IDF model performance, mostly by lifting Integrity and Inclusion, but not other discussion disciplines. Normalization marginally improved the overall results, notably, Integrity, Inclusion and Snarky for the TF*IDF with the appended discussion discipline metadata. On net, normalization did not improve the overall results.

Table 5.2: Scorecard for testing TF*IDF v. Word Embeddings (Word2Vec) v. BERT.

NLP Model	Lookup/ Append Discussion Disciplines?	Poisson Normaliza-tion? [1]	Percent of all moves correctly categorized	Integrity	Integrity-Q	Courtesy	Inclu-sion	Transla-tion	"Anti" (Snarky)
TF*IDF	No	No / Yes	42.0%/ 39.3%	74.8%/ 73.5%	9.3%/ 9.1%	12.9% /-%	-%/ 6.2%	9.1%/ 8.1%	5.4%/ -%
	Yes	No / Yes	**45.2%/ 44.5%**	**84.9%/ 85.1%**	6.5%/ 5.1%	4.3%/ -%	-%/ 7.3%	-%/ -%	5.4%/ 7.1%
Word Embeddings (Word2Vec)	No	No / NA	25.6%	**76%**	22.1%	-%	-%	27.3%	35%
	Yes	No / NA	22%	22%	**36.4%**	19.8%	7.3%	**22.7%**	34.3%
BERT [2]	No	No / NA	**95.2%**	**98.4%**	**100.0%**	**91.7%**	**95.8%**	**100.0%**	**95.2%**

Note: Blue, bold figures were notable, progressing from the initial TF*IDF, through the word embeddings to BERT. [1] SVD decomposition is used with Phrasing Motifs. PCA decomposition is used with Word embedding. Poisson normalization involves: All non-zero values in the TF*IDF matrix cell are divided by (square root of cell value (count)+1) and the mean of the column is subtracted. Then SVD or PCA is performed, and the Poisson/mean are repeated in reverse before K-Means clustering. [2] BERT was used with a ResNet layer with random node exclusion during iterations to reduced overfitting risk.

For Word Embeddings, appending metadata helped improve the performance of Integrity, Courtesy, and Anti, but did not create an overall performance superior to the TF*IDF model. We advanced the initial best performer (TF*IDF using the Phrasing Motifs token, with appended metadata and no normalization, the second row in Table 5.2), at an overall performance of 45.2% compared to Word Embeddings' overall performance of 25.6%.

The BERT neural network was the best performer on all discussion discipline. After several trials which led to over-fitting, we successfully used the ResNet layer below BERT, randomly dropping out nodes. Table 5.3 illustrates some differences between the LSM transcripts and the open corpuses, notably LSMs' higher share of integrity and courtesy (dominant in the LSM, which was dominated by presentation with question and answer), and lower share of Anti/Snarky.

Table 5.3: Large corpus sources used for running the BERT NLP model, and discussion discipline results

Source	Trans-cripts	Utter-ances	Female utter-ances	Integrity count in Corpus	Percent in Corpus	Integrity Q count in Corpus	Percent in Corpus	Courtesy count in Corpus	Percent in Corpus	Inclusion count in Corpus	Percent in Corpus	Translation count in Corpus	Percent in Corpus	Anti/Snarky count in Corpus	Percent in Corpus
Coarse Discourse Corpus	122	4,373	0	819	**19%**	204	**5%**	819	**19%**	1,327	**30%**	379	**9%**	825	**19%**
Friends Corpus	49	1,439	0	171	**12%**	74	**5%**	320	**22%**	531	**37%**	99	**7%**	244	**17%**
GAP corpus	28	8,009	0	2,004	**25%**	557	**7%**	80	**1%**	1,301	**16%**	1,117	**14%**	2,950	**37%**
Movie Corpus	103	3,475	960	652	**19%**	229	**7%**	374	**11%**	1,318	**38%**	260	**7%**	642	**18%**
Persuasion Corpus	135	2,793	1,388	253	**9%**	110	**4%**	938	**34%**	908	**33%**	218	**8%**	366	**13%**
Tennis Corpus	80	160	0	30	**19%**	40	**25%**	9	**6%**	25	**16%**	35	**22%**	21	**13%**
The Argument Podcast	74	802	0	98	**12%**	33	**4%**	143	**18%**	230	**29%**	90	**11%**	208	**26%**
Total	591	21,051	2,348	4,027	**19%**	1,247	**6%**	2,683	**13%**	5,640	**27%**	2,198	**10%**	5,256	**25%**
			11%												
LSM profile	**7**	**728**	**152**	**377**	**52%**	**108**	**15%**	**85**	**12%**	**74**	**11%**	**44**	**6%**	**40**	**5%**
			21%												

Note: Large corpus transcripts were sourced from Cornell ConvoKit https://convokit.cornell.edu/documentation/datasets.html. Large corpus transcripts are divided into utterances. LSM utterances are further divided into moves

Outcomes were hand-coded in the LSM data based on correlations between conversation profiles and outcomes expressed by interviewees or found directly in transcript language (See Chapter 4, Figure 4.3). Finding the outcomes variables (Relationship-Building, Options-Generation, and Intent-to-Act) used two processes. For Options-Generation and Intent-to-Act, the lookup process using the manually-generated term set resulted in 167 and 430 occurrences out of the 591 transcripts, respectively, for 28% and 73%, as shown in Table 5.4. This is similar to the LSMs, comparing to 29% and 71% for the LSMs, respectively. A test lookup and append of the options-generation and intent to act on the original LSM transcript data was accurate 80% of the time, predicting accurate instances of these two outcomes in 11 out of 14 LSM transcripts. Relationship-building, which was calculated as the net "positivity" difference from first to second half of the Inclusion + Courtesy – 10% of the Snarky discussion disciplines (divided by total utterances). This showed a lower relationship-building share for the large corpus overall, at 11% compared to the LSM of 21%.

Table 5.4: Outcomes comparisons between large corpus sources and LSM data

Source	Number of Transcripts	Number of utterances	Female utterances	Transcripts with Relationship-Building	Transcripts with Options-Generation	Transcripts with Intent-to-Act
Coarse Discourse Corpus	122	4,373	NA	42	39	113
Friends Corpus	49	1,439	NA	24	9	44
GAP corpus	28	8,009	NA	10	5	19
Movie Corpus	103	3,475	960	42	48	87
Persuasion Corpus	135	2,793	1,388	86	49	91
Tennis Corpus	80	160	NA	51	1	6
The Argument Podcast	74	802	0	22	16	70
Total	591	21,051	2,348	277	167	430
			11%	47%	28%	73%
LSM profile	7	728	152	5	2	5
			21%	71%	29%	71%

Note: Large corpus transcripts are divided into utterances. LSM utterances are further divided into moves.

5.4.3 Regressing outcomes on "signatures" of transcripts

Table 5.5 contains the Pearson correlations for a BERT model which has been run on 591 open source transcripts. In green is the predicted relationship between the Intent to Act outcome and Inclusion, at the 1% confidence level. However, Relationship-Building outcome and Courtesy (brown) seem to be inversely correlated, which was not what we saw with the LSM data. Some interesting results also appear: In brown we indicated the negative relationships between both Integrity Q and Translation and options-generation, the opposite of what appeared in the LSMs. In addition, Inclusion appears to be strongly negatively correlated at the 1% confidence level with Translation (a fact that will influence the regression model variables), and both Integrity Q and Integrity are correlated with Courtesy. One also sees statistically-significant (at the 1% level) correlations between Inclusion and Integrity Q, and strong negative correlations at the 1% level between Snarky and almost all of the outcomes and other discussion disciplines, with only the exception of Intent to Act, for which Snarky has an relationship that was not statistically-significant. These correlations influenced our regression model specifications.

That manual analysis of the LSM data showed that higher than average Courtesy and Integrity-Q tended to correlate with relationship-building and options-generation, respectively. Higher than average Inclusion correlated with intent-to-act, and higher than average Translation tended to correlate with higher options-generation (though this was a weak relationship due to few observations of options-generation).

Table 5.5: Pearson correlation matrix for transcripts' discussion disciplines and outcomes

		Relationship-Building	Options Generation	Intent to Act	Integrity percent	Integrity Q percent	Courtesy percent	Inclusion percent	Translation percent	Anti/Snarky percent
Relationship-Building	Pearson Corr.	--								
	N	591								
Options Generation	Pearson Corr.	.058	--							
	Sig. (2-tailed)	.158								
	N	591	591							
Intent to Act	Pearson Corr.	-.210**	-.038	--						
	Sig. (2-tailed)	<.001	.356							
	N	591	591	591						
Integrity percent	Pearson Corr.	-.008	.035	-.026	--					
	Sig. (2-tailed)	.855	.390	.536						
	N	591	591	591	591					
Integrity Q percent	Pearson Corr.	.196**	-.113**	-.297**	-.107**	--				
	Sig. (2-tailed)	<.001	.006	<.001	.009					
	N	591	591	591	591	591				
Courtesy percent	Pearson Corr.	-.056	.056	.133**	-.416**	-.307**	--			
	Sig. (2-tailed)	.174	.174	.001	<.001	<.001				
	N	591	591	591	591	591	591			
Inclusion percent	Pearson Corr.	-.237**	.097*	.250**	-.182**	-.341**	.015	--		
	Sig. (2-tailed)	<.001	.018	<.001	<.001	<.001	.710			
	N	591	591	591	591	591	591	591		
Translation percent in full transcript	Pearson Corr.	.184**	-.087*	-.216**	-.075	.076	-.202**	-.449**	--	
	Sig. (2-tailed)	<.001	.035	<.001	.069	.064	<.001	<.001		
	N	591	591	591	591	591	591	591	591	
Anti/Snarky percent	Pearson Corr.	-.012	-.020	.073	-.132**	-.206**	-.211**	-.268**	-.159**	--
	Sig. (2-tailed)	.769	.634	.076	.001	<.001	<.001	<.001	<.001	
	N	591	591	591	591	591	591	591	591	591

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Green and orange represent outcomes consistent with or inconsistent with the LSM analysis, respectively. Pink are strong correlations.

Dependent variables (outcomes) were regressed on the discussion disciplines only, as the gender variable was available for an insufficient number of transcripts, and we did not find statistically-significant correlations between the outcomes and the transcript sources.

Table 5.6 shows the regressions. Regression A shows **Intent-to-Act** being regressed on all the discussion disciplines except Translation (which is collinear with Inclusion, as designated in pink in table 5.5). This resulted in an F statistic (test of the overall significance of the regression) of 22.2, which is statistically-significant at the 0.1% level (see the ANOVA). Inclusion had the largest statistically-significant impact of the discussion disciplines. Other variables that were statistically-significant, but had smaller influence, were Courtesy, Inclusion and Snarky. (Snarky was negatively correlated with most discussion disciplines, so this is likely due to co-linearity). The Adjusted R-square, the share of variance in Intent to Act explained by the discussion disciplines was 13%, meaning that other explanatory variables are needed.

Regression B for **options-generation** had considerably less explanatory power. Balancing the F statistic and Adjusted R-Square, I performed eight regressions, varying the explanatory variables by including and excluding various discussion disciplines. The model with Integrity Q, Translation and Anti/Snarky had an F statistic of 4.4 (statistically-significant at the 0.4% level), but only a .016 adjusted R-Square. Additionally, both Integrity Q and Translation had small, negative coefficients, statistically-significant at the 0.5% and 3% level, respectively. Anti/Snarky was not statistically-significant, but including it in the regression model increased the Adjusted R-Square.

Regression C for **relationship-building** had more explanatory power than the Options-Generation regression model, but has less explanatory power than Intent-to-Act. Balancing the F statistic and Adjusted R-Square, I performed eight regressions, again, varying the explanatory variables by including and excluding various discussion disciplines. The model with Integrity Q, Inclusion and Anti/Snarky had the highest F statistic of 15.4 (statistically-significant at the 0.1% level), and the highest adjusted R-Square of .068. Integrity Q and Inclusion were both statistically-significant, with inclusion having a more statistically-significant impact, but that being a negative impact on relationship-building.

Table 5.7 is a summary, by outcome, showing discussion disciplines with statistically-significant impacts, performance of the top regression models for each of the outcomes variables, and a comparison to the expected explanatory discussion disciplines based on the lease scoping meetings in Chapter 4.

Table 5.6: Statistical significance of discussion disciplines' impacts

A. Regression of **Intent-to-Act Outcome** on all variables excluding Integrity Q and Translation

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363	.132	.126	.417

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.409	4	3.852	22.190	<.001
	Residual	101.732	586	.174		
	Total	117.140	590			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.136	.071		1.914	.056
	Integrity percent in full transcript	.005	.001	.172	3.789	<.001
	Courtesy percent in full transcript	.007	.001	.250	5.562	<.001
	Inclusion percent in full transcript	.009	.001	.341	8.196	<.001
	Anti/Snarky percent in full transcript	.007	.001	.240	5.563	<.001

a. Dependent Variable: Intent-to-Act

B. Regression of **Options-Generation Outcome** on Integrity Q, Inclusion and Translation

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.149[a]	.022	.017	.447

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.652	3	.884	4.429	.004[b]
	Residual	117.159	587	.200		
	Total	119.810	590			

Table 5.6 Continued.

		Coefficients[a]				
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.371	.036		10.196	<.001
	Integrity Q percent	-.004	.001	-.119	-2.845	.005
	Translation percent	-.003	.001	-.087	-2.097	.036
	Anti/Snarky percent	-.002	.001	-.058	-1.373	.170

a. Dependent Variable: Options Generation

C. Regression of **Relationship-Building Outcome** on Integrity Q, Inclusion and Anti/Snarky

		Model Summary[b]		
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.270[a]	.073	.068	.482

		ANOVA[a]				
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.739	3	3.580	15.401	<.001[b]
	Residual	136.432	587	.232		
	Total	147.171	590			

		Coefficients[a]				
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.642	.063		10.179	<.001
	Integrity Q percent	.004	.002	.115	2.575	.010
	Inclusion percent	-.006	.001	-.210	-4.620	<.001
	Anti/Snarky percent	-.001	.001	-.045	-1.022	.307

a. Dependent Variable: Relationship-Building

Table 5.7 Summary of strongest regression models

	Intent to Act	Options Generation	Relationship-Building
Regression model performance	Adjusted R Square=.126 F=22.2 (0.1% significance) (Include: Integrity, Courtesy, Inclusion, Anti/Snarky)	Adjusted R Square=.016 F=4.4 (0.4% significance) (Include: Integrity Q, Translation, Anti/Snarky)	Adjusted R Square=.065 F=14.8 (0.1% significance) (Include: Integrity-Q, Inclusion, Anti/Snarky)
Lease Scoping Meeting, manually tagged	**Inclusion**	Integrity-Q and Translation	Courtesy
Large corpus, tagged with BERT neural network model (for Discussion Disciplines), tagged with Lookup (for options generation, intent-to-act). "net positive" calculated for relationship-building.	**Positive: Inclusion (strongest), Courtesy, Anti/Snarky, Integrity**	Negative: Integrity-Q, Translation	Positive: Integrity Q Negative: Inclusion

5.5. Discussion

In this section I discuss the results of the NLP model specification, testing, selection and application, especially as it brings into empirical domain the work of Chapter 4. I also consider opportunities for future sustainability conversation research. This discussion is structured into four parts: the NLP model, the regression model, the data variety, and the sustainability application.

a. The NLP Model. It is now possible to discuss the pros and cons of the different models. My objective was to understand dialogue acts (conversational interaction), not just phrase meanings or sentiment within utterances. Chang et al.'s (2020) Cornell ConvoKit PromptTypesWrapper (TF*IDF), was helpful as a pipeline and set of transformers, and clustering provided an angle into the relative rhetorical intent of utterances. In my analysis, it appeared that Arc tokens and Phrasing Motifs used with the ConvoKit TF*IDF process did not contain sufficient information to signal rhetorical intent, as Jurafsky and Martin (2021) warned. ConvoKit's Prompt-Response designation, as an additional means to detect rhetorical intent, appeared to not substantially change the performance. In my case, it appeared that weaknesses in both the TF*IDF model, based on arc- or phrasing motif tokens, and the Prompt-Response specification may be due to the fact that the LSM training data used "moves," and the large corpus used utterances (utterances potentially containing several moves, and, correspondingly, prompt-response components inside of each).

Tokenization experiments were highly educational for our team. With Zelasko (2021) I found tremendous value in treating moves as distinct dialogue acts (as I did in the LSM corpus), and not being confined to utterances. However, generating "moves" (as a decomposition of each utterance) with the large corpus was prohibitively expensive.

The enrichment (discussion discipline lookup and append, and normalization) improved the model performance in the semi-supervised TF*IDF process, with the appending adding more accuracy than the normalization. Without a doubt, the supervised multi-layered neural network performed substantially better, doubling the accuracy of the TF*IDF. This is due to three advantages of the BERT

neural network: 1. The head-start provided by BERT's transfer learning from its development on large multi-million-record corpuses like Google and Wikipedia. (While both Word2Vec and BERT use transfer learning, transfer learning is considerably more extensive with BERT); 2. The iterative, back-propagation learning cycles of a neural network, layered on top of the Word Embeddings (Word2Ved) model; and 3. The bi-directional learning (self-attention layer) specification, an advancement over our Word Embeddings model.

b. The Regression Model. The regression analysis corroborated both some of our important aquaculture LSM conclusions from Chapter 4, and also Zhang et al.'s (2020) conclusions on conversation outcomes. Using the large corpus, I regressed the outcomes of intent-to-act, options-generation, and relationship-building on the discussion discipline percentages. I found a positive, statistically-significant explanatory relationship between Inclusion and intent-to-act. As Inclusion is highly similar to the "coordination" conversation feature, which Zhang et al. (2021) found to correlate with conversation closure for a crisis hotline conversation, my findings on Inclusion may add to the understanding of similar high-stakes conversations. (Notably, Zhang et al.'s likelihood of an intent-to-act outcome was the same as both the LSM transcripts and the large corpus, at approximately 72%. Intent-to-act was also the most abundant outcome in the large corpus.) Courtesy also had a positive, statistically-significant impact on intent-to-act for our large corpus. This may correspond to Zhang et al.'s impact of (positive) sentiment.

I have provided a more extensive specification for Inclusion and other discussion disciplines, which may broaden the practical applications of the findings around the intent-to-act + Inclusion/Courtesy relationships. Specifically, my termset that was used for the Inclusion, Courtesy, intent-to-act lookups may expand on Danescu-Niculescu-Mizil et al.'s (2012) description of inclusion ("coordination") language, and Zhang et al.'s (2020) description of intent-to-act ("conversation closure").

My other regression models may have been hamstrung due to issues with the explanatory variables: 1. Non-independence (co-linearity) of the discussion disciplines (explanatory variables); and 2.

Mis-labeling sarcasm or snarkiness as Integrity or Courtesy discussion disciplines, and thereby misinterpreting Snarky's negative explanatory effects as Courtesy or Integrity.

I found strong co-linearity between several discussion disciplines, potentially masking Inclusion (being correlated with Translation and Integrity-Q) and Courtesy (being correlated with Integrity-Q and Integrity).

Finally, while I tested corpus similarity using a model similar to Fothergill et al (2016), there may have been some undetectable sarcastic statements in the large corpus. For example, Snarky, sarcastic questions ("It's raining again. Isn't it a nice day?") may have been mis-labeled as Integrity and Integrity-Q. That may explain why Integrity-Q was inversely correlated with Courtesy at a statistically-significant level in the Pearson Correlation.

Dependent (outcomes) variable specification can also improve. While I saw roughly parallel shares of options-generation and intent-to-act outcomes in the large corpus, compared to the LSM corpus, such outcomes may be incorrectly or insufficiently tagged: Options-generation was found using a lookup based on a relatively small manually-created term-set (our options-generation term-set was expanded from only two LSM transcripts). Meanwhile, relationship-building in the large corpus was considerably less frequent that in the LSM corpus, raising questions about the suitability of the specification of relationship-building as an improvement in net-positivity (second half change over first half of the conversation). This "improvement" conceptualization has a robust theoretical basis (Scharmer, 2018), but it did not pinpoint Scharmer's specific tension from which collective resolution could result in group relatedness or bonding. Mine was a compensation for limited resources: outcomes-discovery sufficient to train a neural net would have required we code 10,000 utterances (200, 50-utterance conversations) to obtain sufficient samples for our analysis. (It is also notable that processing the 21,000 records through the neural net model took approximately five hours using Google Collab Pro. Additional model variables would add to that.)

c. Adding Data Variety. Our context data for the regression analysis was limited, given the lack of statistical significance of the transcript source, and insufficient gender data (only 238 transcripts). In the future one could obtain more context and gender data. It will be particularly useful to obtain unique features of of sustainability-related conversations, such as local town meetings across the United States. Future transcripts could add more diversity (cognitive and identity diversity), and training another neural network could result in more models suited to different sustainability contexts.

There are limitations inherent in written transcriptions. While these are more information-rich than online discussion threads, they omit pitch, cadence, body language, and costly signals, such as investments in the relationships. (Socio-physics [e.g., turn-taking], costly signals, and intensity have been shown to create or disrupt performance in groups [Buchanan & Pentland, 2007; Woolley et al., 2010, 2015. See also Chapter 4.]. On the other hand, there is some emerging evidence that signaling can be effective in virtual, synchronous contexts even without video (Tomprou et al., 2021). Other additions could include special treatments for indirect speech (Pinker et al., 2008), and gender, as discussed in Chapter 4.

Data quality and variety may be improved with a shared, open corpus for benchmarking NLP models, similar to SQuAD, Stanford Question and Answering Dataset. An open corpus and benchmark could be used for training models on discussion disciplines, context variables, sequence, and a better specification of outcomes.

d. **The Sustainability Application**. The goal with this Chapter was to bring statistical credibility and reliability to difficult conversations for sustainability topics. A model could simplify conversation complexity, e.g., by clarifying that certain moves build relationships, innovation, or accountability (or some combination thereof), by providing salient, neutral examples; and by removing some of the guess-work in conversation facilitation. I have made a contribution by showing empirically that there are

positive, statistically-significant relationships between Inclusion and Courtesy with intent-to-act, and by providing term-sets to kick-start conversation learning.

As Inclusion is based on the act of interpersonal acknowledgement, my findings raise the ante for investing in incorporating different ways of knowing during transdisciplinary programs. In addition, with a better large-corpus specification, one can continue to probe into the differences between the LSM findings and large-corpus findings related to Integrity Q, Courtesy and options-generation. Continued quantitative and qualitative experiments addressing co-linearity can further test the Courtesy-relationship-building correlation (per our LSM finding), and may also generate enduring relationships among sustainability teams.

In the end, the better the data and model, the more likely we will reduce the gaps between those with and without facilitation or rhetorical training (Druschke & McGreavy, 2016). A tool could inform conversation participants and leaders, asynchronously or in real time, about gaps between emergent conversation outcomes and goals. For example, using the natural language understanding of our discussion disciplines could marry effectively with programs like Cortico.ai (from MIT Media Lab) which transcribe speech and perform meaning-representation using highly intuitive graphical interfaces.

In conclusion, NLP models that can inform groups about the likelihood of their creating productive outcomes can be instructional and neutral, and can be less costly than facilitation and guesswork. Data may be combined with training, a focus on fair process and productive outcomes may reduce polarization, and help to scale up productive conversation (Bleijenberg, 2021). Nonetheless, NLP is not the leading, but the supporting actor in this study. An empirical conversation model must be used to in combination with learning around difference, empathy, respect and inclusion. When NLP can be used to reduce polarization – to "nudge" practice, increase credibility, and promote engagement -- stakeholders become both beneficiaries and enablers.

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APPENDIX A: INTERVIEW GUIDE FOR LEASE SCOPING MEETING FARMER

Below is the interview guide used with three aquaculture farmers after their LSM in Spring, 2021. Interviews lasted approximately one hour. Two were recorded on Zoom and transcribed. One was manually recorded at the request of interviewee.

Introductions

Discussion about the LSM and the conversation impact

1. What did you hope would happen in the conversation in which you participated?

2. What outcomes of the conversation did you see? (After open-ended response from the interviewee, prompt for outcomes of closure, rapport-building, idea/options-generation.)

3. (Team to describe the four discussion disciplines, integrity, courtesy, inclusion and translation.) What are your perceptions of the discussion disciplines (familiar, practical, challenging, etc.)

4. How do you think that the context contributed to the flow of the conversation in which you participated, to who contributed, and to whether the outcomes materialized?

5. Would the four discussion disciplines have helped? How might you bring them up in the future?

6. Would you like to share other thoughts on the conversation or on the conversation disciplines as a practice?

7. Would you agree to talk again as the research continues?

APPENDIX B: CONVOKIT "PROMPTTYPESWRAPPER" TRANSFORMER

This is the flow of ConvoKit steps and transformers (Chang et al., 2020), using the example of the aquaculture hand-coded lease scoping meeting as LSM testing data, and the 30,000 utterance in the large corpus corpus as training data.

Workflow step with <inputs> and [outputs]	Tool	Description
<live conversation> ***Produce digital transcripts*** [Moves coded with speaker, gender, discipline, rationale]	Zoom, MS Word (as parser), Google Sheets	Attend LSM, transcribe written notes into digital transcript, and break into moves, code manually for discussion disciplines in Google sheet.
↓		
<above + normalized columns> ***Append Google sheets into one corpus*** [Workbook]	Google Sheets, Python	Load sheets onto a single temporary workbook, and assign a unique numeric ID to each move.
↓		
<above + cleansing parameters> ***Create ConvoKit corpus, withholding one or two manually-coded transcripts*** [n-2 cleansed transcript corpus with IDs]	ConvoKit TextCleaner	Corpus is read by a number of transformers, including TextCleaner which fixes Unicode errors, lower cases text, removes some line breaths, URLs, brackets, etc. We load utterances and all metadata into the ConvoKit Corpus.
↓		
<above + tokenization parameters> ***Tokenize data into arcs inside of each move*** [arcs, by move]	ConvoKit TextToArc	TextToArc decomposes the text into dependent "bi-grams", which are bi-grams (2 word) tokens which show dependencies like noun-verb, and follow a simple patterned syntax showing dependencies between words. Berwick (2021) describes these dependency pairs with this example, "Book that flight," includes book_that and book_flight, where x_y means x is the parent, and y is the child.
↓		

Workflow step with <inputs> and [outputs]	Tool	Description
<above + phrasing motif parameters> ***Collect Phrasing Motifs (arc-pairs) for each move*** [Phrasing Motifs, by move] ↓	ConvoKit PhrasingMotifs	The system looks across the arcs in the moves, and designates frequently-occurring arc-pairs as Phrasing Motifs, based on a frequency threshold, e.g., "Keep if 2 instances of a phrasing motif." Min_support is a parameter that is set for determining how many arc-pairs are required to include a phrasing motif.
<above + PromptTypes parameters> **TF*IDF process 1: generate phrasing motif matrix** [mxn matrix] ↓	ConvoKit PromptTypes "prompt embedding" model	Calculate phrasing motif frequency, by move, and vectorize moves as rows in a mxn matrix where each of the n rows contains the moves, and where each cells contains counts, by each of m Phrasing Motifs for the corpus. Below is the ConvoKit code that allows you to complete this step. The transformer is provided in the last line below. The initialization of the input and output fields, with parameters, such as the type of dependency token, is provided in the aux_input command. def __init__(self, output_field, input_field='parsed', use_start=True, root_only=False, follow_deps=('conj',), filter_fn=_use_text, input_filter=lambda utt, aux: True, verbosity=0): aux_input = {'root_only': root_only, 'use_start': use_start, 'follow_deps': follow_deps, 'filter_fn': filter_fn} get_arcs = TextToArcs('arcs',root_only=True, verbosity=100)
<above + SVD parameters> **TF*IDF process 2: generate clusters from matrix** [assignment of move to 8 Prompt clusters and 8 Response clusters] ↓	ConvoKit PromptTypes "prompt type" model	Using singular value decomposition and K Means clustering calculate the proximity to the centroid (low value = high proximity), for different moves in the corpus. PromptTypes also adds a prompt and respond model, and it assigns each utterance (except for first and last in each transcript) with both a prompt or response designation.

Workflow step with <inputs> and [outputs]	Tool	Description
<above + graphing parameters> **Graph the discussion disciplines to clusters and inspect.** [Scatter plot containing preliminary model.] ↓	ConvoKit graph generator, Google Sheets	Each move is assigned to either one of the Prompt or Response clusters, based on which cluster assignment is closer to the centroid (lower number is closer).
<trained model> **Use the model on the "virgin" transcripts and score** [scored model based on correct assignment of moves to disciplines]	Python, Google Sheets	Feeding the "virgin," manually-coded transcripts into the model can help us see if our model would correctly assign disciplines to them. A scoring process will let us see. Aggregate performance across all discussion disciplines; 2. Relative performance for discussion disciplines within models.

APPENDIX C: GENERAL TERMS AND ACRONYMS

Aquaculture Advisory Council (AAC), also "DMR Aquaculture Advisory Council": Group of aquaculturists (farmers and others in the supply chain) and researchers who advise the Department of Marine Resources (DMR).

Aquaculture Shared Waters (AQSW): Education program on aquaculture (science, business, social systems) administered by the Maine Aquaculture Hub.

Department of Marine Resources (DMR): Maine's regulator responsible for aquaculture leases.

E-NGO: Represents an ecologically or environmentally focused NGO. (See NGO.)

Lease is the term for a paid, approved access to a region on the water. There are three types: Limited Purpose Aquaculture lease (LPA) (1 year, renewable, for research), Experimental (3 year, non renewable, except for research purposes), and Standard (up to 20 year, renewable). The LSMs are generally required for Standard leases, and are optional for other leases.

Lease Hearings (hearings) are the public, legally binding quasi-judicial process where the public can formally comment on the lease application. *Hearings are generally not the subject of the research to date.* This is convened by the Maine Department of Marine Resources (DMR). Regulatory agencies (such as the Coast Guard, Department of Environmental Protection, Department of Wildlife and Game) may participate. DMR testifies on attributes they found in the area under and around the lease using scuba or monitoring equipment. The public can comment and generally has to register testimony ahead of time. Opinions generated by the DMR after the hearing are binding.

Lease Scoping Meeting (LSM) is a public, non-legally-binding gathering of citizens convened by the aquaculture farmer after the farmer's lease has been drafted and provisionally approved by the DMR. Topics generally include lease siting, impacts to the surrounding area and navigation, type of organism,

noise, craft and surrounding features. The seven conversations I have coded and summarized are LSMs.

This is not recorded and is non-binding.

APPENDIX D: ARTIFICIAL INTELLIGENCE/MACHINE LEARNING/ NATURAL LANGUAGE PROCESSING TERMS

Arc = mathematically generated dependency pair of words in a language. Arcs are similar to grammatical forms, but may not rely on word sequence.

BERT = (Bi-Directional Encoder Representations from Transformers) Google's open sourced NLP modeling tool using neural network layering and transfer learning to compute word meaning in context.

ConvoKit PromptTypes Wrapper ("ConvoKit") = a set of transformers (programs) and conversation text corpuses open sourced by Cornell University in 2020 to enable conversation-based NLP processing.

Corpus = Collection of transcripts containing utterances, which, in turn, may each contain multiple moves. Corpus in ConvoKit may also be formatted and cleansed for transformations.

Moves = sub-utterances with a single rhetorical purpose. For example, "I am going to the store for you. Do you have your wallet on you?" Is two moves, Integrity (statement) and Integrity-Q (question).

Phrasing Motif = commonly occurring arcs.

PCA = Principal Component Analysis

SVD = Singular value decomposition

TF*IDF = Term Frequency, Indirect Document Frequency

Transformer = Program that manipulates (e.g., parses, combines, counts) text and applies metadata.

Token= smallest fragment of conversation used for computing the NLP model.

Utterances = single-speaker statements in transcripts.

BIOGRAPHY OF THE AUTHOR

Katrina (Kate) Pugh is an Adjunct Faculty member and the former Academic Director of Columbia University's Information and Knowledge Strategy (IKNS) Master of Science program. As President or AlignConsulting, she specializes in business strategy, inclusion, collaboration, social network analysis, and knowledge-driven transformation. Kate has over twenty years of consulting and industry experience in the financial services, health sciences, energy, information technology, and international development sectors.

Kate was general editor and co-author of *Smarter Innovation: How Interactive Processes Drive Better Business Results* (Ark Group, 2014), author of *Sharing Hidden Know-How: How Managers Solve Thorny Problems with the Knowledge Jam* (Jossey-Bass/Wiley, April 2011), and has published in the *Harvard Business Review, Sloan Management Review, Ivey Business Journal, Journal of Digital Media Management,* and *Review of Economics and Statistic*s. Kate has an SM/MBA from the MIT Sloan School of Management, a BA in Economics from Williams College, and is a candidate for the Doctor of Philosophy degree in Ecology and Environmental Sciences from the University of Maine in May, 2022.