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Insight

A framework for co-production of knowledge in the context of Arctic research

Negeqlikacaarni kangingnaulriani ayuqenrilnguut piyaraitgun kangingnauryararkat

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ABSTRACT. The Arctic has been home to Indigenous Peoples from time immemorial. Distinct Indigenous worldviews and complex knowledge systems have been passed on from generation to generation, evolving over time in a living process that continues to this day. Indigenous Peoples' knowledge systems hold methodologies and assessment processes that provide pathways for knowing and understanding the Arctic, which address all aspects of life, including the spiritual, cultural, and ecological, all in interlinked and supporting ways. For too long, Indigenous Peoples of the Arctic and their knowledges have not been equitably included in many research activities. We argue for systematic change in how research-related activities are conducted in the Arctic. Bringing together multiple knowledge systems, specifically Indigenous Peoples' knowledge systems and science, can lead to more equitable, inclusive, and useful outcomes. The co-production of knowledge framework that we forward is designed to assist researchers, decision makers, and communities in moving toward those goals. Given increased interest in the Arctic by the research community, the complex, rapid, and ongoing change in Arctic systems, and amidst renewed and urgent calls for equity globally and across all spheres of life, adoption of a co-production of knowledge framework for the conduct of Arctic research is timely as well as a moral and intellectual imperative. Further, solutions to challenges facing the Arctic and global community are enhanced by the combined understanding of Indigenous Peoples' knowledges and science.

Imukenirnek Negeq likacagaat [makuni igani "Arctic"] nutem tamakumiunek ciulialget nunaketuit. Ukanirpak nutem tamakumiunek ciulialget ukveruciteng ellameng-llu tungiinun elitelteng kinguvallrukait piinanermeggni man'a engelkarrluku cimirturluteng. Nutem Negeqlikacaarmiunek ciulialget elitellermegteggun nunameng tungiitnun nallunritlerkameggnun yuvrillerkameggnun-llu piyararluteng kangingnauryararluteng-llu, yuucimeggni tamalkuita cat yuita, piciryarameng, ellam-llu tungiinun atunem ilakluki. Ukanirpak nutem Negeqlikacaarmiunek ciulialget elitellrit tapeqluki ilangcinrilkurtessiyaagluki kangingnautuut. Negeqlikacaarni Kass'at kangingnauryaraita piciryarait cimiisqumaaput. Ayuqenrilnguut elitellritgun, arcaqerluki nutem Negeqlikacaarmiunek ciulialget Kass'at-llu kangingnauryarait tapeqluki, atunem pitallgutekluki kinkunun cangallrunrilngurnek, ilakuralrianek, atuunruarkaulrianek-llu kingungqerrarkauluteng. Yuullgutkenrilnguut Negeqlikacaarmiunek ciulialget Kass'at-llu elitellritgun atunem caliyaraq, makut igaqeput tamatum tungiinun ikayuutnguarkauluteng. Kangingnaurtet caungengatki Negeqlikacagaat, tamakumiuni-llu ayuqenrilngurteggun cukamek cimirturalriit, cali-llu ellam tamiini yuut tamalkuita pitalkelluki pisqeńgatki, ayuqenrilnguut elitellritgun atunem caliyaraq Negeqlikacaarni pinariluni, elluarluni, elitnaulrianun-llu nancunaunani. Cali-llu Negeqlikacagaat ellam-llu tamiini arenqiallugutaita kitugutkait, atunem nutem Negeqlikacaarmiunek ciulialget Kass'at-llu kangingnauryarateng aturluki elluanruut. Cali-llu Negeqlikacagaat ellam-llu tamiini arenqiallugutaita kitugutkait, atunem nutem Negeqlikacaarmiunek ciulialget Kass'at-llu kangingnauryarateng aturluki elluanruut.

Key Words: *Arctic; collaboration; co-production of knowledge; ellam yua; equity; Indigenous; Indigenous Peoples' knowledge; partnerships; research*

INTRODUCTION

We define co-production of knowledge (CPK) as a process that brings together Indigenous Peoples' knowledge systems and science to generate new knowledge and understandings of the world that would likely not be achieved through the application of only one knowledge system. Co-production of knowledge emphasizes the importance of attaining equity in research relationships. The value of a CPK approach, if done appropriately and respectfully, is that it allows people engaged in research to bring different ways of knowing, experiencing, and looking at the world together to gain a broader, deeper, and new understanding of topics and to generate new knowledge. A true CPK approach is urgently needed in the Arctic to enhance understanding and to inform adaptive and holistic decision making in research, resource management, and policy. The work we put forward builds upon the experiences of the co-authors, all that they have learned from Indigenous communities, the work of the many colleagues working within these and similar topics, and the decades of effort and work conducted by Indigenous Peoples, communities, and organizations. The co-production of knowledge framework presented includes tools and concepts designed to assist researchers, decision makers, and communities to move toward the goal of equitable research.

The Arctic is the homeland of over 1 million Indigenous Peoples across 40 different Indigenous cultural groups (Karvinen and Rantakallio 2019; Fig. 1). For thousands of years, Indigenous Peoples have maintained strong cultural ties to northern lands and waters. Over generations, they have systematically amassed knowledges with extraordinary and distinct information about their worldviews and the environments of which they are a part.

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Fig. 1. Map of Arctic Indigenous Peoples. The map broadly demonstrates Arctic Indigenous languages spoken by members of the Arctic Council Permanent Participant organizations. (Source: Indigenous Peoples' Secretariat and UiT The Arctic University of Norway, adapted from CAFF 2013).

These knowledge systems are living and continue to be built upon today. The application of these knowledges offers great value to those in and outside the Arctic for addressing pressing contemporary concerns.

The Arctic environment is rapidly changing (IPCC 2014, 2021) with many ongoing transformations in Arctic social, economic, and ecological systems (Marino and Ribot 2012, Chapin et al. 2014, IPCC 2014, Watson and Huntington 2014, Secretariat of the Convention on Biological Diversity 2017, Reidmiller et al. 2018, Carothers et al. 2019). These transformations have led to increased attention on the Arctic region from various interests including geopolitical, military, commercial, industrial, research, and from large-scale international institutes (e.g., Ellis and

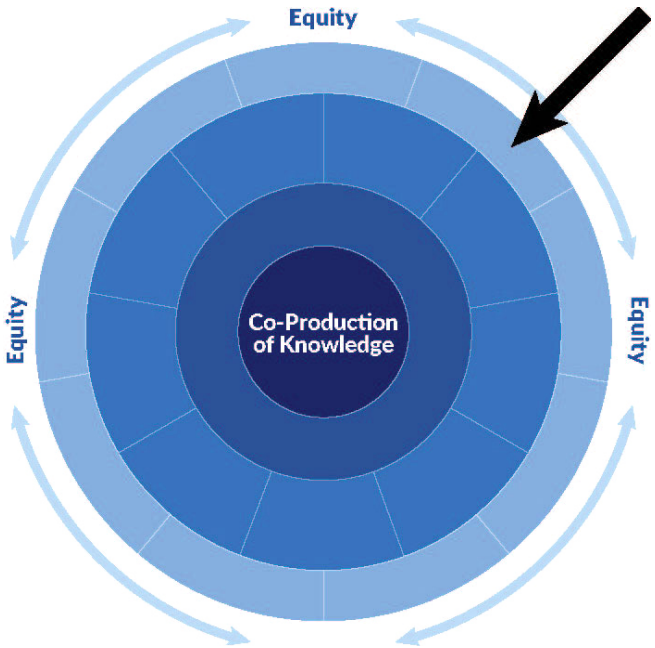
Brigham 2009, Ebinger et al. 2014, ADAC 2019, IPBES 2019, USCG 2019, IASC 2020, NSF 2020, Wilson Center 2020; United Nations Framework Convention on Climate Change https://unfccc.int/). Research activities in or about the Arctic tend to be directed toward efforts to better understand the transformations taking place and to plan for future adaptations through policy, management, or other decision making. Many of these efforts are directed by legislation or agency processes and priorities such as the Arctic Research and Policy Act that directs the development of a five-year research plan (APRA 1984). Not enough of this research is directed or guided by Indigenous communities, nor does it equitably include Indigenous Peoples' knowledge systems, nor adequately address the needs and concerns of communities.

It is important to recognize critical issues shaping contemporary Arctic Indigenous Peoples' rights, sovereignty, security, and self-determination to better understand the need for building equity that centers Indigenous Peoples' knowledges and systems (e.g., governance, social, political, etc.) across society. Building and attaining equity is foundational to a co-production of knowledge framework. Equity in this context refers to ensuring that space is fairly provided for all knowledge systems and knowledge holders in an agreed upon research process. The CPK framework we share includes a number of conceptual tools that we believe collectively build toward and create equity (see Figs. 2, 3, Table 1). The inequities experienced by Indigenous Peoples across Arctic societies, which are manifested in current research processes and relationships, are rooted in the broader history of colonialism.

Fig. 2. Figure 2: A framework for co-production of knowledge.

The traumas and inequities Indigenous Peoples have endured directly as a result of colonialism continue to persist today. The history of colonialism within Indigenous Peoples' homelands has included land dispossession, epidemics, forced settlements, violent removal of children to boarding schools, racism, and cultural and spiritual suppression (Napoleon 1996). Past inequities persist in the form of inequitable research processes and relationships across the Arctic. These inequitable processes and relationships, which prioritize non-Indigenous ways of being and knowing, feed a structure of decision making that does not fully account for Indigenous Peoples' knowledge, perspectives, or needs. New approaches to research are needed to address past and current inequities that start with shared understandings of the historical and present trauma experienced by Indigenous Peoples as well as using Indigenous approaches to address systematic problems. Developing shared understandings and Indigenous approaches requires building a foundation of equity through change in the dominant systems that govern research and science activities today. We suggest that the CPK framework can guide us on a path to fostering this equity through constructive change.

Fig. 3. Figure 3. The co-production of knowledge framework highlighting the conceptual tools. The arrow points to the outer ring, which contains the conceptual tools.



Indigenous voices in the Arctic have emphasized their long-standing needs and demands for more inclusive and equitable research activities. Calls for collaborative approaches to research, including with Indigenous Peoples, are not new (Flaherty 1995, Smith 1999, UNDP 2001, Wilson 2008, ICC 2010, Raymond-Yakoubian and Raymond-Yakoubian 2017, ITK 2018, Daniel 2019, Heeringa et al. 2019, Miller and Wyborn 2020), though they have recently received more intensive attention and discussion by the Arctic research community (Armitage et al. 2011, Irlbacher-Fox 2014, Gadamus et al. 2015, Euskirchen et al. 2020). There are elevated numbers of requests and inquiries for Arctic communities to engage in research, often because many funding opportunities now require various levels of engagement with affected communities (e.g., Barnard et al. 2021, NSF 2021) Nevertheless, research continues to often be focused on the

Table 1. Definitions of the concepts used in the co-production of knowledge (CPK) framework.

CONCEPT	DEFINITION
Co-production of Knowledge	Co-production of knowledge, in the framework we present, is the process of bringing together two different knowledge systems in true partnership and equity, to enhance, learn, and create new understandings on a specific topic. In this context, it specifically refers to bringing Arctic Indigenous Peoples' knowledge systems and western science together.
Equity	Equity refers to ensuring that space is fairly provided for all knowledge systems and knowledge holders involved in an agreed-upon process.
Co-Production of Knowledge Tools: Outer Ring (i.e., tools that build equity)	
Deliberate and Intentional	Every part of the co-production process requires deliberate (thorough and careful) and intentional (by design) decision making to ensure that the principle of equity and other conceptual tools are being consistently applied.
Trust and Respect	Partners must respect each other's cultures including ways of communicating, values, philosophies, and cosmologies. Trust, developed through sharing and relationship building, goes hand-in-hand with respect.
Relationships	Cultivating strong relationships is an iterative process that takes time and requires the mutual participation and effort of all participants. Building a relationship requires learning about and understanding each other's knowledge systems, motivations, and goals.
Capacity	Capacity for researchers includes having appropriate education and training regarding Indigenous Peoples, including Indigenous rights, cosmologies, histories, values, methodologies, and concerns. Having capacity also means having the institutional support and funding to build and maintain relationships.
Means and Ability	Indigenous Peoples require the means and the ability to support equitable participation in research processes. "Means" refers to having the necessary resources, and "ability" speaks to having the appropriate tools and proficiencies.
Ethical	Research should be conducted in an ethical manner and include agreed-upon guidelines, principles, and values. Ethical frameworks and practices should be central to relationships between researchers and Indigenous communities.
Decolonization	Decolonization is the intentional and active process of recognizing and counteracting processes, structures, and institutions imposed on Indigenous Peoples. Decolonization requires actively making room for mechanisms that support Indigenous cultures and ways of knowing, and which provide Indigenous Peoples and organizations the opportunity to lead and direct research activities.
Sovereignty	Sovereignty is the inherent right of Indigenous Peoples to have self-determination over their political, legal, social, spiritual, and intellectual lives, as well as other aspects of a community or one's self.
Empowerment	Equitable research relationships empower all participants and create a balance of authority and responsibility in the process.
Action Circle: Inner Ring	
Practice Reciprocity	Reciprocity is a relationship of respectful and mutually beneficial exchange.
Communications	Transparent and open communication that recognizes the goals and needs of participants from different worldviews is vital throughout the process.
Control of Information	Guidelines for the equitable access and control of information generated in a co-production of knowledge process must be agreed upon by all participants.
Problem Definition	Experts from both knowledge systems, with substantial leadership from Indigenous Peoples living in communities, must be involved when defining issues and problems that serve as the basis for research.
Identify Question	Experts from both knowledge systems, with strong leadership from Indigenous Peoples living in communities, must work collaboratively in identifying research questions.
Develop Methods	Indigenous Peoples' knowledge systems include methods for seeking, analyzing, and validating information. When determining which methods to use, and when, both Indigenous methodologies and science methodologies should be considered, and there should be consensus on the suite of methods that will be used throughout a CPK research process.
Gather Information	Information should be collected following protocols and methods agreed upon by all participants.
Information Analysis	Information should be analyzed using methodologies agreed upon by all participants.
Review Results	All participants in the research process should be given the opportunity to review results.

interests, priorities, timelines, and needs of non-Indigenous actors, institutions, and societies. Some of these inquiries include an attention to partnerships, collaboration, or co-production, but typically only from the perspective of researchers' understanding of these terms. Our work provides the added perspective of what co-production means through an Indigenous perspective.

We importantly note that the "research community" includes many Indigenous organizations and peoples. For our purposes, when we use the term "research community," we are primarily referring to academic institutions and researchers, state and federal agencies and researchers, funding institutions, and other research-related institutions that are non-Indigenous, or mostly non-Indigenous. This is done heuristically to point to meaningful cultural distinctions.

Authorship and contributions

Ellam yua, the first author, is the Yup'ik name for "the spirit or person of the universe" that recognizes more than just the physical or living aspects of the environment. Our work developing the CPK framework and the writing of this paper has been significantly influenced and informed by, i.e., essentially created by, Ellam yua in many ways. By including Ellam yua in this way, we affirm the greater powers at work in these efforts, and in our work, specifically. Although we collectively work across the Indigenous Arctic, we associate most closely with this Yup'ik term for the spirit or person of the universe because it comes from the first language of one of the authors (Raychelle Aluaq Daniel). This term, and the concept it represents, is related to multiple similar concepts in other Arctic Indigenous languages and dialects (e.g., *Cillam Cua*, *Iñua*, *Eslam Yuga*, and *Sila*). By acknowledging the work of Ellam yua via inclusion as an author,

we illustrate both the importance of Indigenous lived experiences and respect for interconnections between everything that makes up the Arctic.

The authors also specifically note that many of our Indigenous and non-Indigenous colleagues have contributed to our thinking about the issues discussed. We recognize that ideas and concepts are rarely original and acknowledge the many formal (i.e., recognized by academia) and informal (i.e., non-academic) ways that our colleagues, friends, Elders, mentors, and others have contributed to the creation and refining of the concept of "co-production of knowledge" and all that entails. Many of these individuals are practicing, promoting, and polishing these ideas and concepts in regular and meaningful ways via the ways they conduct themselves, the ways they teach, and the ways they write, speak, and publish. Many of them embody the framework and concepts we describe. We would particularly like to remember and appreciate the work and life of recently departed colleague Lene Kielsen Holm. We are immensely grateful for the leadership, contributions, and work of Lene to the topics discussed. Lene's grace, patience, and generosity has brought an immeasurable contribution to these discussions across the globe and her work and efforts will live on through many of us.

We intentionally chose to highlight scholarship and writing from Indigenous scholars and organizations. The bodies of literature applicable to topics of research, ethics, equity, Indigenous Peoples and research, collaborations, and related topics are extremely broad. We assume a basic level of familiarity with those literatures by the reader. Our citational practice herein is meant to recognize Indigenous work and highlight some of it for readers that may not be as familiar with it. We take steps away from typical approaches that rely on what is often a white, male, western canon (Todd 2015, 2016, Mott and Cockayne 2017, CBC 2018, Hitomi and Loring 2018, Justice 2018, Wemigwase and Tuck 2019). This approach is not meant to discredit or ignore other literature.

Uses of the term co-production

Our understanding of "co-production of knowledge" sits within a larger intellectual history, which includes the work of Indigenous scholars and those within conventional scholarship who have attended to "strategic deletions" (Jasanof 2004), elisions, and neglect of non-normative thought and research approaches (for example). This larger history of more inclusive approaches to conventional science has been developed and implemented for a very long time. Within academia, some of these approaches, such as action and participatory research (Brown and Tandon 1983, Gibbons et al. 1994), mode 2 science (Nowotny et al. 2003, Hessels and van Lente 2010), and interactive research (Svensson et al. 2007), for example, have incorporated concepts and approaches that are similar to some co-production of knowledge concepts and approaches.

Research contexts across the globe have recently focused on the concepts and the uses of the terms co-production of knowledge or knowledge co-production (Voorberg et al. 2014, Bremer and Meisch 2017, Nature 2018, Norström et al. 2020 for co-production syntheses). There is a need for conceptual clarity in the application and use of co-production (Voorberg et al. 2014), but there are several contexts we emphasize regarding how co-production has been applied. Application of co-production in inter- and transdisciplinary work (e.g., Johnstone et al. 2008, Hidalgo 2016, Howarth and Monasterolo 2017, Melvin et al. 2017, Reed and Abernethy 2018, Harvey et al. 2019) has focused more on bringing together different disciplines within science to meet a common goal. Research-related efforts that seek to bring in policymakers (e.g., Meadow et al. 2015, Reed and Abernethy 2018, SEARCH 2019, Oliver et al. 2019, Miller and Wyborn 2020) are looking to produce information to address issues important for decision makers. Another area in which knowledge co-production concepts have been applied is in work seeking to be more hands-on with the general public to produce more stakeholder-driven research to address societal challenges (e.g., Enquist et al. 2017, Hickey et al. 2018, Nature 2018, Moore and Hauser 2019). The intent of some of this work is to produce meaningful or policy-relevant research that will support community needs rather than research for research's sake (e.g., Djenontin and Meadow 2018, Norström et al. 2020). The people and knowledge systems brought together with the above understandings of co-production may come from different backgrounds and experiences (often connecting academics and non-academics). Co-production knowledge tools can be useful in these approaches and can lead to greater social justice for those underserved in society (e.g., Tebes 2018). But, in these contexts of co-production, all of the participants are typically coming from a commonly shared society and culture (i.e., the same or similar ways of knowing). This is qualitatively different from work involving our CPK framework, which specifically seeks to equitably bring together people from different cultures and knowledge systems.

Another valuable concept that applies co-production principles, known as "two-eyed seeing," brings together different epistemologies in research. The concept was described in Bartlett et al. (2012:295) by Mi'kmaw elder Albert Marshall as, "to see from one eye with the strengths of Indigenous knowledges and ways of knowing and from the other eye with the strengths of Western knowledges and ways of knowing and to using both these eyes together, for the benefit of all." Applications of the two-eyed seeing approach have helped in advancing the fields of human health (Bartlett et al. 2015, Peltier 2018) and wildlife health (e.g., Kutz and Tomaselli 2019), among others. As with our CPK framework (Fig. 2), reciprocity is an important characteristic of the two-eyed seeing approach that embodies the mutual respect for the contributions of different knowledge systems and their respective importance in generating understandings of the world.

A variety of other work (e.g., Robards et al. 2018, Colavito et al. 2019, Kettle 2019, Brady and Leichenko 2020, Euskirchen et al. 2020) has been referred to as co-productive or as a co-production of knowledge but focused on bringing together different scientific disciplines and Indigenous participants through one cultural lens. These projects, processes, institutions, and bodies that are coming together under a co-production umbrella have not focused on ensuring equity nor do they fully embrace the conceptual tools we put forward (Fig. 2). Furthermore, in many of these cases equity is being defined by non-Indigenous people and perspectives (Friedman et al. 2018).

The growing application of the term co-production in research proposal titles and academic papers is often used as a badge of sorts, whereby often incomplete or troublesome approaches are re-branded. Additionally, co-production and collaboration are often used interchangeably, and there can also be a mistaking of collaboration for co-production. This is not to say that

collaborative work is not necessary and positive, but rather that in and of itself, collaboration is not a fully implemented CPK process. Collaboration is simply people working together jointly on an activity; collaboration does not mean that equity is forefronted, that reciprocity is valued, or that other conceptual tools of CPK are used. It is a common problem to mistake work that uses some CPK tools for CPK itself. For example, it is not uncommon for a project or proposal to engage communities in some way or share results after publication, but not engage communities in designing the project, yet still be labeled as a CPK project. Many of these projects and analyses are still based on western worldviews or do not address fundamental inequities in the research process. So, although research questions might be addressed in somewhat collaborative structures (e.g., in partnerships or through co-management), other challenges such as power imbalances and inequitable valuations of Indigenous knowledges are also often at play (Armitage et al. 2011, Bohensky and Maru 2011, Raymond-Yakoubian and Raymond-Yakoubian 2015, ICC AK 2016, 2018, Graugaard 2020, van Bavel et al. 2020). Many of these examples are bringing in only one worldview (i.e., a western worldview) to generate knowledge (Bryan 2009, Raymond-Yakoubian and Raymond-Yakoubian 2017, ICC AK 2019).

We are using CPK differently. We are describing a process that brings distinct cultures and knowledge systems together, in equity, to create new understandings of topics. Although we designed this framework based on experiences with, and for, Arctic research, we believe it is also applicable and useful elsewhere.

Approaches to the development and presentation of our co-production knowledge (CPK) framework

We introduce our framework for CPK in the context of Arctic research (Fig. 2). We have collectively developed, shared widely, and implemented our framework for CPK between 2016 and 2021 (e.g., see Behe et al. 2021 https://www.kawerak.org/CPKlist). Our work has also involved drawing on the previous work of many colleagues from around the Arctic. Our framework for CPK builds on existing co-production approaches and applies them specifically to research that has a focus on equity as an overarching principle and which brings Indigenous knowledges and science together. This framework is specifically presented from an Indigenous perspective; many of our descriptions of various components of the framework focus on Indigenous Peoples' experiences and guidance. Our focus on these perspectives is one way to redress the ways that Indigenous perspectives have often been elided in research.

Our CPK framework highlights concepts for how to structure the relationships and processes that are the necessary foundation for relationships between Indigenous Peoples and researchers. It is not a method for the technical aspects and challenges of various types of interfacing Indigenous Peoples' knowledges and science. This framework is not providing the technical aspects of what is often called integrating or incorporating Indigenous Peoples' knowledges with science, policy, or management (Agrawal 1995, Nadasdy 1999, Ellis 2005, Berkes 2008, Berkes and Kislalioglu Berkes 2008, Thornton and Maciejewski Scheer 2012). Rather, our framework provides preconditions, guiding relational principles, and meta-discourse that can structure that other technical work of integration or incorporation.

The CPK framework we present was designed through reflection on all that we have learned from the Indigenous Peoples we work with and for, in bringing together Indigenous Peoples' knowledge systems and science to create a holistic understanding of the Arctic. The framework includes our experiences with many partnerships and collaborations with the research community, spanning across successful to challenging experiences. It also incorporates the results of, and ongoing efforts to develop more equitable processes. Prior to and during the development of this framework, we participated in many collaborative projects and partnerships, community meetings, and spent thousands of hours meeting with, interviewing, and discussing research and related topics with Indigenous leaders, communities, and community members. Previous iterations of this framework have been presented, workshopped, and discussed at numerous events over the past several years. We have invited Indigenous colleagues to join us at many of these events, and engagements and discussions with them (including their reflections on their own experiences) have shaped the final design of this framework. Some of their voices are included here.

CO-PRODUCTION OF KNOWLEDGE FRAMEWORK

Co-production of knowledge is the process of bringing together two different knowledge systems, in true partnership and equity, to enhance, learn, and create new understandings on a specific topic. In this context, we specifically refer to bringing Arctic Indigenous Peoples' knowledge systems and science together. The CPK framework described (Fig. 2) illustrates all of the concepts (referred to as conceptual tools) needed to support the CPK process. The concept of equity is the cornerstone of CPK and is shown encircling the framework.

The center of the framework shows the goal: co-production of knowledge. Surrounding the goal are the two knowledge systems (Indigenous Peoples' knowledges and science) that will come together in this process. The inner ring surrounding the knowledge systems is what we refer to as the "action circle." This circle, or inner ring, contains various aspects of, or actions that are part of, a CPK research process. We emphasize that CPK is a process. The outer ring of the CPK framework holds all of the concepts, referred to as "conceptual tools," that all participants in this approach need to implement and be continuously mindful of. These tools are the concepts that, when implemented together, can bring about equity. Lack of equity is a systemic issue in many research relationships with Indigenous Peoples. Without equity, a CPK approach is not possible. Co-production of knowledge is an iterative and cyclical process, rather than a simplistically linear approach.

Defining concepts needed for co-production of knowledge

In the following sections, we define the concepts used in our CPK framework. We present the rings of the framework and the components of those rings using definitions and discussions of the conceptual tools and actions. Indigenous colleagues have been invited to share their thoughts on some of these concepts, and their perspectives are included throughout the paper. We illustrate how these concepts and components of the framework interact, connect, and fit together, and end with a discussion of applications of the framework and recommendations to the research community. These definitions are compiled together in Table 1.

Box 1:

Our Indigenous communities contain incredible knowledge. They are of their lands and waters. Their existence is an expression of the interconnectedness of all things. Reciprocity, humility, and respect for beings we coexist with and rely on are at the center of our Way of Life. Customary laws and unwritten protocols exist in each community around the sharing of knowledge. Relationship-building and recognition of parallel and equal knowledge systems is critical.

Lisa Navraq Ellanna

(Katirvik Cultural Center Director; King Island Inupiaq)

Equity

Equity refers to ensuring that space is fairly provided for all knowledge systems and knowledge holders involved in an agreed-upon process.

Equity is the cornerstone of a CPK approach. Building equity begins with ensuring that both knowledge systems start from a level playing field. Throughout the CPK process, barriers to active participation need to be continuously identified and removed. Meaningful and active engagement should be supported for all parties throughout the entire process. Fairness in terms of means, capacity, decision-making authority, and rights (for example) are required if working within an equitable space.

Much of the structure of contemporary Arctic research is rooted in colonialism and has resulted in systemic inequities, often including the relationship between research and Indigenous Peoples. The processes, procedures, and funding mechanisms used to support research, policy development, and decision making were developed and continue to be used to predominantly address the questions, desires, and worldviews of a set of dominant cultures and scientific disciplines that are part of contemporary settler-colonial society (Smith 1999, Cochran et al. 2008, Ballantyne 2014, Simpson 2014, Raymond-Yakoubian and Raymond-Yakoubian 2017, Brattland and Mustonen 2018, ICC AK 2018, Pfeifer 2018, Büscher and Fletcher 2019). These processes, procedures, structures, and approaches most often have not considered resemblant ones that are used by Indigenous Peoples (Coombes et al. 2014, Larsen and Johnson 2016, Whyte 2019, Whyte et al. 2019). To truly bring together knowledge systems these systemic problems have to be addressed, recognizing that not all knowledge systems have been equally respected or assigned the same value (Berkes 1993, 2008, Nadasdy 1999, 2003a, 2003b, 2007, Usher 2000, David-Chavez and Gavin 2018, Latulippe and Klenk 2020; Behe and Angnaboogok 2018 https://doi.org/10.13140/RG.2.2.12598.57928/1). Equitable approaches to research can begin to address these systemic problems if they are inclusive of the needs, worldviews, knowledge systems, and cultural approaches of participants.

In the context of research, equity can be built in many ways and can take many forms. Equity can be built through the sharing of decision-making power or by ensuring that project budgets fairly compensate all participants. Equity can be built by ensuring that training or equipment needs are covered and through purposefully inclusive sharing and discussions of knowledge. These actions, and others described below, will contribute to equitable research practices.

Building equity requires a paradigm shift in thinking and methodology to create new, inclusive spaces. Focusing on equity will aid in building robust research and observing systems, adaptive decision making, and holistic policies. Equity can be created through the recognition and utilization of the conceptual tools in the outer ring of our framework (i.e., relationships, empowerment, capacity, means and ability, deliberate and intentional, ethics, decolonization, sovereignty, and trust and respect). Throughout the paper, we identify the conceptual tools using italics to further demonstrate their recursive nature and connectivity. Each ring has unique but inter-connecting conceptual tools and actions. These conceptual tools should be used when understanding research using a CPK approach.

The outer ring: tools for undertaking research using a co-production of knowledge framework

We identified a suite of concepts that build equity, called conceptual tools, which should be used when undertaking research using a CPK approach (Fig. 3).

Deliberate and Intentional

Every part of the co-production process requires *Deliberate* (thorough and careful) and *Intentional* (by design) decision making to ensure that the principle of equity and other conceptual tools are being consistently applied.

Everyone involved must make a deliberate choice to be part of an intentional CPK process. Co-production is a process that requires deliberate consideration and intentional action; it is not possible to do co-production "by accident." Researchers may use some of the tools needed for co-production in their work (like *Empowerment* or *Trust and Respect*), however using some of these tools is not the same as deliberately and intentionally collaboratively deciding to engage in CPK.

Co-production requires an iterative strategy in which all parties collaboratively discuss each decision in a deliberate way and come to a consensus on any necessary adjustments needed to support a continued equitable approach from the very beginning. When entering into a CPK research relationship, it is good practice to document decisions that the participants make regarding how the relationship and research processes will proceed. This documentation can be a terms of reference or similarly constructed document, which presents in clear, transparent, and culturally appropriate ways how the conceptual tools will be applied to research actions throughout the process. Such a document may also include decisions or discussion of topics such as how authorship on research products will be determined, what ethical guidelines have been agreed to, timelines for communication, and other topics that partners determine are important to document. It is important to have these discussions as early as possible, and chronicling them in a living document will help to minimize misunderstandings, lay out clear intent for all parties, and help with relationship building in the long-term.

Trust and Respect
Partners must respect each other's cultures including ways of communicating, values, philosophies, and cosmologies. Trust, developed through sharing and relationship building, goes hand-in-hand with respect.

Box 2:

Thinking of a lifetime of oral communications and our knowledge, the Inupiat have had to trust their hunting partners and respect each other to survive in the harsh unforgiving environment of the North Slope. We have to be reliant on each other, we have to trust and respect others for survival. This is our way of life.

Harry Brower, Jr.

(Mayor of the North Slope Borough, Utqiaġvik, Alaska)

All participants in a successful CPK process must feel mutually trusted and respected. Developing that mutual *Trust and Respect* takes time and is something that should be continuously revisited throughout the research process. Trustworthiness (i.e., a commitment to keeping one's word) and being a respectful person (i.e., being considerate and not diminishing others) are crucial to creating equitable relationships. Building *Trust and Respect* is an iterative process.

Each knowledge system should be respected on its own merits and as a whole system of knowledge. Trusting and respecting the knowledge and information that all parties bring to the process includes respecting the different ways we express our worldviews (e.g., communication styles, methodologies, values, cosmologies). Individuals should also be respected and recognized for the knowledge, skills, and abilities they bring to a partnership. Some people may value a degree from a western institution and academic publications, and others may value being a medicinal plant gatherer or being an Elder and hunter (Nickels et al. 2007, ICC 2016, ICC AK 2018, Pfeifer 2018; Indigenous knowledge and monitoring: applying a food security lens and co-production of knowledge approach March 2016 https://iccalaska.org/our-work/; Holm 2016 https://www.youtube.com/watch?v=92i8tpErSG0). When an Indigenous person brings forward their knowledge, it should be trusted and recognized for the expertise it is.

When operating from a place of *Trust and Respect*, scientists would trust that Indigenous experts bring real proficiency based in an Indigenous knowledge system, and the scientist or institution would show respect by supporting the space needed for that expertise. Reciprocally, the Indigenous Peoples would trust that the process and products are fully informed by both knowledge systems. For example, having an expert from a science perspective determine how and where Indigenous knowledges and perspectives are included in research is inadequate and not appropriate (Tengö et al. 2014, Brattland and Mustonen 2018; Behe 2017 https://doi.org/10.13140/RG.2.2.16373.45287). Space must be made for Indigenous expertise and worldviews to collaboratively inform this kind of decision making (Johnson 2008, Raymond-Yakoubian et al. 2014, ICC 2016).

Relationships
Cultivating strong *Relationships* is an iterative process that takes time and requires the mutual participation and effort of all participants. Building a relationship requires learning about and understanding each other's knowledge systems, motivations, and goals.

Box 3:

We're all the same, as people. We need to get to know each other better. Every day I'm looking for those opportunities.

George Noongwook

(Elder from Savoonga, Alaska)

Effective partnerships and research require strong *Relationships* consistently nurtured by all participants. Long-term commitments to relationship building with communities and individuals are more likely to lead to positive, mutually beneficial, and enriching interactions (Reo et al. 2017). Research is inherently a social activity. The social nature of research is amplified in a collaborative setting. There is a high value to being explicit and intentional in CPK work, which includes cultivating strong human relationships.

Relationships should be rooted in equity and integrate the other concepts we discuss, such as *Sovereignty* and *Trust and Respect* (Johnson 2008, Raymond-Yakoubian and Raymond-Yakoubian 2017). In research, as in life, developing meaningful *Relationships* with people requires being willing to take risks, to share, to have patience, to spend time, and to be open. We must also acknowledge that our relationships (and responsibilities) are not just to other humans, but also to the environment around us (Wilson 2008, Latuilppe 2015). The sharing of stories and of diverse cultural perspectives is a powerful way for collaborators to connect and build rapport (Tully 1995, Kovach 2009).

Capacity
Capacity for researchers includes having appropriate education and training regarding Indigenous Peoples, including Indigenous rights, cosmologies, histories, values, methodologies, and concerns. Having capacity also means having the institutional support and funding to build and maintain relationships.

The research community, in general, requires growth in its *capacity* to effectively take part in equitable and collaborative research relationships with Indigenous Peoples (Holm 2016 https://www.youtube.com/watch?v=92i8tpErSG0). *Capacity* for researchers includes understanding that "all" members of a research team, regardless of what role they will play in the research, need to take a *Deliberate and Intentional* approach to earnestly learn about their Indigenous partners and to develop active listening skills. Researchers need to recognize biases and assumptions about Indigenous Peoples and further their understanding about Indigenous Peoples' cosmologies, values, networks, governance systems, and concerns.

Many Indigenous organizations have documented a wealth of knowledge about their respective cultures, governance, histories, and cosmologies (e.g., regional organizations such as Kawerak, Inc., Association of Village Council Presidents, Maniilaq Association, Inuvialuit Game Council; national organizations such as Inuit Tapiriit Kanatami; and international organizations such as the ICC). Researchers should look to this material as a starting place for building their knowledge (effectively increasing their own capacity). Institutions and funding agencies should provide funding to support capacity and relationship building. The research community should also recognize the value of capacity building as equal to other activities such as publishing and getting proposals funded (Daniel et al. 2016). Indigenous communities have a large role to play in facilitating the growth of capacity by researchers. As Pitseolak Pfeifer has argued: "We don't need Northerners to become better researchers, we need researchers to become better Northerners" (2018:34).

The impact of COVID-19 on research activities has highlighted important equity gaps for Arctic Indigenous communities in research participation and has further illuminated the need to build capacity (AOS 2020, de Vos 2020). The COVID-19 pandemic offers an opportunity for inward thinking on the part of the research community in identifying their own needs (e.g., knowledge about Indigenous Peoples) as well as providing opportunities to start conversations with communities about their *Means and Ability*.

Means and Ability

Indigenous Peoples require the *Means and Ability* to support equitable participation in research processes. "Means" refers to having the necessary resources, and "ability" speaks to having the appropriate tools and proficiencies.

Indigenous Peoples require the *Means and Ability* to participate and meaningfully engage throughout a CPK process. For example, having the means, such as funding, to support staff and community members, and to support communication; understanding and addressing these needs will enhance co-leadership and equitable engagement. The capability of Indigenous Peoples to participate alongside researchers builds the *Empowerment* of Indigenous communities by changing the power differential from what has typically and historically been the case in research relationships. Enhancing the ability of communities to participate in research means that they are identifying the appropriate tools, training, and skills that they determine are important (Kawerak Marine Program 2015, Daniel et al. 2016, Pfeifer 2020), such as the need to hire additional people, to receive specific training, or for long-term funding to support the use of Indigenous methodologies in a particular project.

Leveraging existing Indigenous networks, institutions, and organizations may be preferable to creating new and competing entities. Indigenous organizations will understand how they want to grow and where the *Means and Ability* are needed to address issues. It is very common that many Indigenous organizations and Tribal governments in Alaska lack the *Means and Ability*, like funding, to adequately address research requests or to initiate their own research. The National Science Foundation, rather than directly addressing the systemic challenges of increasing *Means and Ability* for Indigenous communities, used a "request for proposals" process for research institutions to create a Community Office to, in part, facilitate these conversations in relation to some of their funding activities (NSF 2020). The Community Office may be a positive step for building research capacity for academic institutions in working with communities; however, additional support is needed for communities to take a leading role. Indigenous communities should be supported and trusted to identify their needs before research activities start. Developing *Means and Ability* can be a long-term process and requires collaborative *Relationships* to identify and address gaps for true co-leadership (Daniel et al. 2016).

Ethical

Research should be conducted in an *Ethical* manner and include agreed-upon guidelines, principles, and values. *Ethical* frameworks and practices should be central to relationships between researchers and Indigenous communities.

Box 4:

Our knowledge provides a basis for one's activities; to make sure one can travel, hunt safely and successfully, and also as a basis for living one's life in an appropriate way. In this sense, our knowledge often incorporates an ethical component, setting out the values of a community. For scientists, our knowledge can be a valuable source of information that may not be obtainable any other way.

George Noongwook

(Elder from Savoonga, Alaska)

Ethical practices should be at the center of relationships between Indigenous Peoples and the research community (Trimble and Mohatt 2005, Trimble 2008, Holm et al. 2011). Discussing and collaboratively determining what practices and values will guide a research relationship is also an important part of building *Trust and Respect* and in strengthening *Relationships*. Ethical practices require respect for Indigenous Peoples, their values, cultures, sovereignty, and right to self-determination. Instituting ethical practices requires shared leadership with Indigenous partners, and for partners to adjust behavior as necessary to ensure that ethical principles are upheld. Ethical practices should be agreed upon by all participants before work begins as an initial step in collaboration.

For many Indigenous Peoples, ethical practices extend beyond humans and include the totality of the world including the environment (i.e., animals, plants, water, ice, the cosmos). Ethical practices embedded in practices and beliefs pertaining to *Reciprocity* are important for many Indigenous Peoples. Attention needs to be placed on how partners interact within that linked environment (Cruikshank 2005, Napoleon 1996, Fienup-Riordan 1983, 1990, ICC AK 2016, Raymond-Yakoubian and Angnaboogok 2017, Raymond-Yakoubian and Daniel 2018, Raymond-Yakoubian 2019). Indigenous communities may require the inclusion of specific guidelines or practices that regulate proper human-animal and human-environment relationships and behaviors, which should be followed during the conduct of research activities (e.g., Fienup-Riordan 1999; Fienup-Riordan 1997, *unpublished manuscript*).

Decolonization

Decolonization is the intentional and active process of recognizing and counteracting processes, structures, and institutions imposed on Indigenous Peoples. *Decolonization* requires actively making room for mechanisms that support Indigenous cultures and ways of knowing, and which provide Indigenous Peoples and organizations the opportunity to lead and direct research activities.

Indigenous Peoples have ways of knowing and understanding the world that often differ from dominant western worldviews (Smith 1999, Bishop 2005, Smith et al. 2016). Frameworks and processes (e.g., education, resource management) have been imposed on Indigenous communities without including, or by purposefully excluding, Indigenous ways of being and knowing (Sahlins 2002, Stevenson 2004, Tuck and Wang 2012, Wildcat et al. 2014). Many of these systems may have originated or were implemented in the past, but the lived experiences of Indigenous Peoples today are still rooted in these systems. Some governments recognize these past injustices and are working toward building equity through decolonization actions. For example, in Canada decolonization action was initiated after Truth and Reconciliation (TRCC 2015, Government of Canada [date unknown]).

Decolonization in Arctic research means making the space to include Indigenous Peoples' worldviews in ways that can direct and guide research. Indigenous frameworks and processes are not archaic but evolve over time and are alive today. Many myths about Indigenous Peoples persist in large part due to academia (Younging 2018), but Indigenous Peoples are increasingly putting forward their own narratives and voice. Indigenous Peoples have the right to freely choose how decolonization manifests, including revitalization. In a CPK process, Indigenous methodologies and processes will need to be equitably included along with western practices, norms, and scientific methods (Kovach 2009). Additionally, funding processes and university and agency research protocols will need to be addressed, possibly through policy and regulation, in the long term.

Sovereignty

Sovereignty is the inherent right of Indigenous Peoples to have self-determination over their political, legal, social, spiritual, and intellectual lives, as well as other aspects of a community or one's self.

Box 5:

For me, a true co-production of knowledge approach to research uses free, prior, and informed consent. Free, since the community has always the right to say no. Prior, in that the plans for the research have to be announced to the right institutions of the communities, prior to the initiation of such a research project. Last but not least, it has to be an informed consent approach; meaning that the community has all the information they need in order for them to make a decision. This includes how information gathered will be used, stored, and what it will be used for.

Lene Kielsen Holm

(Indigenous Knowledge holder, scholar, leader, and at the time of drafting this paper was the Research Scientist and Project Leader with the Greenland Climate Research Centre)

Arctic Indigenous Peoples live on and are connected to ancestral homelands and hold inherent sovereign rights and self-determination (i.e., the right to choose freely). Researchers must understand, recognize, and respect that Indigenous Peoples hold sovereignty over their homelands and have spiritual connections to land, ice, and water. Often the information derived from science is used to make decisions concerning Indigenous homelands. Poorly conducted science can threaten sovereignty for Indigenous Peoples. Aside from legal requirements, there are moral and societal obligations to respect, recognize, and support self-determination including in decision making (supporting Indigenous sovereignty) by Indigenous Peoples about research activities in or having an impact on Indigenous homelands.

Indigenous protocols, ethical codes, and spiritual and traditional practices should be respected in Indigenous Peoples' homelands. Free, prior, and informed consent guidance is included in the *UN Declaration on the Rights of Indigenous Peoples* (UN 2007) and can help researchers better understand and support Indigenous sovereignty (ICC AK 2020). Indigenous Peoples are free to decide if, how, and when they will be involved in any research activities. Indigenous Peoples must be engaged in discussions and decision making prior to the start of any activities, from the very beginning (UN 2005). We refer to "the beginning" as the first discussions about a proposed project or a researcher's interest in a particular region. Initial conversations should include a mutual understanding of needs related to *Capacity* and *Means and Ability*. Indigenous Peoples need to be adequately informed of all potential risks and opportunities, and costs and benefits associated with engaging in any research activities, including the sharing of their knowledge (UN 2005). It is essential that researchers understand that Indigenous Peoples' perceptions of risk may be different from how risk is assessed from a western worldview. Indigenous partner's views should be included in discussions to identify potential ways of addressing and mitigating risk. Indigenous Peoples need to consent to all activities and processes occurring and this should include the full and effective participation of all Indigenous partners through the Indigenous communities' or partners' own decision-making processes (UN 2005, Whyte 2019).

Indigenous Peoples are often left out of the decision-making process of identifying what kinds of research have "human impacts" (e.g., the "Common Rule" in the U.S., 45 CFR Part 46) or relevance and interest to Indigenous Peoples. For example, vessel-based marine fisheries research in the Bering Sea would not typically be considered a type of research that has impacts on humans or that falls under the Common Rule. However, the Indigenous Peoples of the Bering Strait region believe that, in addition to taking place in their traditional waters, this research certainly has impacts on their communities and they want to be part of decision making with regard to such research (e.g., Kawerak Marine Program 2015, Raymond-Yakoubian and Daniel 2018). Conceptualizations of research and research impacts are closely connected to consent and sovereignty issues, but frequently do not include Indigenous communities (Bielawski 1984, 1992, 1996, Fienup-Riordan 1999, Raymond-Yakoubian and Raymond-Yakoubian 2017, Whyte 2019).

Empowerment
Equitable research relationships empower all participants and create a balance of authority and responsibility in the process.

Empowerment means creating and supporting political and intellectual space for Indigenous Peoples to have authority and responsibility. It is necessary to recognize and name the power dynamics at play in a relationship and actively work to create balance through the empowerment of Indigenous Peoples. A truly equitable research relationship empowers all participants in their work. This balance increases the authority of the knowledge produced in a CPK process, because it is inclusive, more robust, and representative of multiple knowledges.

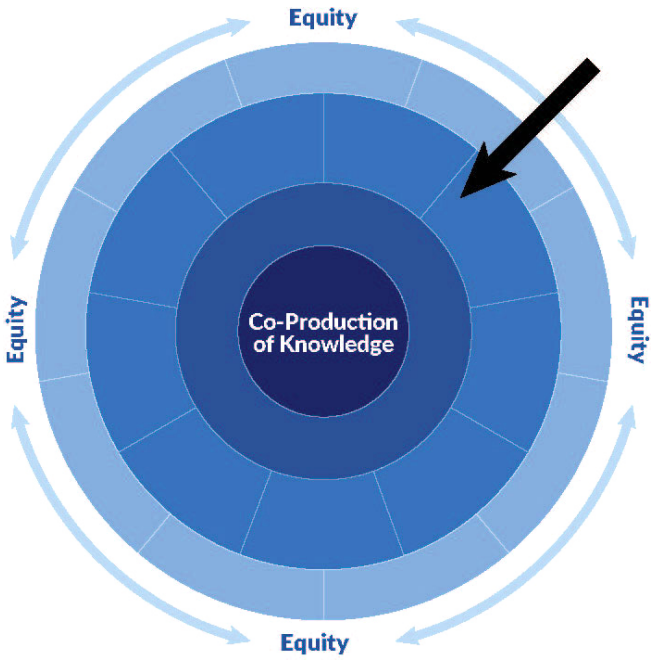
The equitable inclusion of Indigenous communities in research has been a challenge, in some part due to the unequal power dynamics at play in typical research relationships (Nadasdy 1999, Schreiber and Newell 2006, Raymond-Yakoubian and Raymond-Yakoubian 2015) and the history of colonization (Huntington et al. 2020). Funders, policymakers, and society in general, more commonly place a higher value on information derived from science than information coming from Indigenous Peoples. Recognizing that many science-based approaches to research are predicated on a western worldview (Smith et al. 2016) means that we should seek to take deliberate action to include other perspectives in CPK (ICC AK 2020). Supporting equitable processes, and valuing and including Indigenous Peoples' knowledges, requires intentionally working to change existing systems.

Coda: the interconnected nature of the outer ring concepts
The conceptual tools of the CPK framework are interconnected and collectively build upon each other to establish *Equity* in research relationships. *Equity* is supported through the understanding, acknowledgment, and utilization of these concepts. We emphasize that *Equity* is crucial to this process, but it is not always easy to see how to achieve it. Our hope is that this framework provides guidance and tools for those looking to engage in CPK processes.

For example, building a *Relationship* rooted in *Equity* means recognizing Indigenous Peoples' *Sovereignty* and the need for mutual *Trust and Respect* between Indigenous partners and researchers. Engaging in ethical research requires that we must be *Deliberate and Intentional* about the approaches, methods, and ideas we are using. Increasing the *Means and Ability* of Indigenous Peoples related to research, policy, and decision-making requires *Decolonization* efforts in the realms of funding, research leadership, and access to decision makers (among other things). The importance of the interconnected nature of the conceptual tools, and how they work together to build equity, becomes clearer when looking at CPK in action and applied to research.

The action circle (inner ring)
The inner ring or "action circle" of our CPK framework (Fig. 4) represents different parts of the research process. We challenge the reader to think about research and research projects not as linear, but rather as cyclical and iterative processes. Research should not be seen as being simply conducted sequentially. Rather, it is important during the research process to continually revisit both the conceptual tools in the outer ring as well as the various actions of the research process. Both the inner and outer rings of the framework are intertwined, with the components intersecting with each other. For example, at the stage of analysis it is important to revisit the concepts of *Empowerment* and *Sovereignty*; are these tools being applied to the analysis of results? Additionally, the team may be analyzing results, but may want to revisit the methods previously agreed upon to re-evaluate if they are still appropriate. Each action in the research process should build upon work already done and decisions already made, continue to use the framework components to guide the process, and should also be highly iterative, in that the concepts and tools (e.g., *Equity*) presented in the framework are regularly being revisited and (re)implemented to guide or strengthen the evolution of a project or relationship.

Fig. 4. Figure 4. Figure 4. The co-production of knowledge framework highlighting the action circle. The arrow points to the inner ring which contains different parts of the research process (the actions).



Practice Reciprocity
Reciprocity is a relationship of respectful and mutually beneficial exchange.

Box 6:

Reciprocity is our Indigenous value of taking care of one another and all that provides for us, i.e., the land, waters, fish, and wildlife. Reciprocity is practiced through action and cultivates reverence. It takes place in multiple ways: through large cultural events like potlatches or feasts; when hosting a visitor; in traditional beliefs like how and where you dispose of animal bones or parts; and in contemporary relations when trading work in the community or food across the regions. Practicing reciprocity helps sustain a balance, to not take more than needed; to give, receive and have regard for our mutual relations; and to recognize the life force that connects all that is created.

Malinda Chase

(Deg Hit'an Dene' (Athabascan), from Anvik, Alaska and Tribal Liaison at the Alaska Climate Adaptation Science Center and Aleutian Pribilof Islands Association)

Reciprocity is an everyday practice of many Indigenous Peoples that is rooted in and guided by traditional values and the sharing and exchange of knowledge and experiences (Hallowell 1960, Brightman 2002, Nadasdy 2003*a*, *b*, Cruikshank 2004, Johnson 2008, Whyte 2013, Gadamus and Raymond-Yakoubian 2015*a*). Reciprocity is not only practiced in relationships between people, but in how people relate to kin, including the surrounding environment, plants, animals, and their spirits (Kirkness and Barnhardt 2001, Harris and Wasileweski 2004, Wilson 2008). Research designs should be mindful of the relationships between Indigenous People and the lands and waters.

Relationships between participants in CPK must be reciprocal. For many Indigenous communities, research has historically been primarily an extractive activity. Extractive research has taken place in figurative and literal forms. Indigenous Peoples' knowledges have been gathered, taken away, and interpreted through non-Indigenous lenses, and often put to use in non-Indigenous contexts (and often to the disadvantage of Indigenous communities). Additionally, research has played a key role in the use and extraction of natural resources that Indigenous Peoples have relied upon and stewarded for millennia. The inequitable research relationships in past activities must be thoughtfully addressed within a CPK framework, including the need to adequately address *Reciprocity*. Effectively including *Reciprocity* includes the recognition of relational accountability between humans and each other and between humans and the rest of the environment. Indigenous Peoples and communities should receive tangible benefits from any research that is about, or which occurs on, Indigenous homelands. Research topics should satisfy the questions put forward by Indigenous Peoples and communities in addition to those put forward by science.

Communications

Transparent and open *Communication* that recognizes the goals and needs of participants from different worldviews is vital throughout the process.

Box 7:

Most Arctic researchers are born, raised, and live far from the Arctic. Although the geographical divide between Arctic researchers and residents is great, the cultural divide can be greater. A one-time solution will not work. To bridge these divides, it is going to take serious attention by each and every researcher who plans to step foot on our land.

Kaare Sikuaq Erickson

(Principal, Ikaagun Engagement; enrolled Tribal member of the Native Village of Unalakleet; shareholder of Arctic Slope Regional Corporation; descendent of Ukpeaġvik Iñupiat Corporation)

Communication refers to how we express ourselves and share knowledge and information, as well as how research products convey research information and results. Ensuring open and transparent *communication* among all participants throughout a CPK endeavor is imperative. *Communications* should be culturally appropriate and understandable, i.e., reflecting the needs of participants from different worldviews throughout the process. The format within which information is shared and discussed should include oral traditions and the use of Indigenous languages (UN 2005). All participants need to be open to different discussion formats such as meeting for longer periods of time and participating in story-based discussion and problem solving.

Language (verbal and non-verbal) is important. Inuit, for example, may have conversations entirely using non-verbal communication. Language can be a barrier, but it can also help in working toward reaching a common understanding (Herman 2017), which is needed in CPK. Communication styles may differ across participants and will require attention to power dynamics. Scientific discourse can be perceived as aggressive, offensive, or confrontational to some Indigenous cultures that hold different conflict resolution and communication styles.

Research communication products (e.g., reports, videos, photos) and their audiences (e.g, agencies, youth, hunters) should be thoughtfully planned for in advance. Any support (*capacity* and *means and ability*) needed to address communication issues should be included in budgets.

Control of Information

Guidelines for the equitable access and *Control of Information* generated in a co-production of knowledge process must be agreed to by all participants.

Equitable *Control of Information* in a CPK process requires addressing key dimensions of information management early in the process. Information in this context includes all knowledge derived from CPK. All participants need to collectively decide how information will be collected, how it will be maintained, where it will be stored, how and where it will be used, who will own the information, and who will give and have access to project information. The risks and benefits of decisions regarding the access and control of information should be clearly identified and carefully weighed.

Indigenous Peoples and the research community often have different perspectives about and guidance related to the access and *Control of Information* (Chambers 2006, Oceana and Kawerak 2014, Gadamus and Raymond-Yakoubian 2015*b*, Carroll et al. 2019, Raymond-Yakoubian et al. 2019). Communities often have their own culturally appropriate guidance for how knowledge is shared (this guidance may not be easily accessible; Holm 2016 https://www.youtube.com/watch?v=92i8tpErSG0). This guidance might be reflected in unwritten values shared by a community (e.g., Alaska Native values). Some

Indigenous communities and organizations have developed specific guidelines for research processes (e.g., the Native Village of Kotzebue (NVK [date unknown]), Bristol Bay Native Association (BBNA [date unknown]), Arviat Aajiiqatigiingniq Wellness Society (AAS [date unknown]), and the Inuvialuit Regional Corporation (IRC [date unknown]). Additional aspects of research directives are supported by legal agreements, such as directives within the Inuvialuit Final Agreement (INAC 2005).

The sovereign rights of Indigenous Peoples over their own knowledge includes information that may be generated through a CPK process. Agreements regarding knowledge and information management should be made in advance, with considerations for culturally appropriate approaches and with respect for Indigenous data (information) *Sovereignty* (Nagy 2011; Behe 2016 https://doi.org/10.13140/RG.2.2.34828.39045; Holm 2016 https://www.youtube.com/watch?v=92i8tpErSG0). These efforts may require specific funding requirements that will need to be incorporated into proposals.

Though separate actions, and with discrete definitions, the action circle terms below are discussed together for ease of discussion and because they share similar approaches in their implementation.

Problem Definition and Identify Question
Problem Definition: Experts from both knowledge systems, with substantial leadership from Indigenous Peoples living in communities, must be involved when defining issues and problems that serve as the basis for research.

Identify Question: Experts from both knowledge systems, with strong leadership from Indigenous Peoples living in communities, must work collaboratively in identifying research questions.

Indigenous Peoples' worldviews recognize the responsibility imbued in being part of a system (natural/physical/social/spiritual) and include values associated with how humans appropriately relate to and interact with other parts of the system, including kinship-based relationships. Indigenous Peoples (e.g., community leaders, Tribal members, knowledge holders) who live in the places where research is taking place need to be directly engaged in these steps. They need to lead in *Problem Definition*, which is an important step in identifying issues of concern that research will address. Often issues and problems are determined by policies, agencies, and/or academic researchers on their own or after broad input (e.g., the public scoping process for requests for proposals). Early and foundational conversations also help grow *Relationships* and contribute to ensuring meaningful and timely participation of Indigenous Peoples throughout the research process, from the very earliest possible point.

The *Identify Question* actions will include developing the hypotheses from which research methods will be determined. It is important to have experts from both knowledge systems collaborate on determining appropriate research questions. Respecting different knowledge systems and different ways of asking questions can result in stronger research questions rather than using scientific modes of inquiry alone. For example, Indigenous Peoples' knowledges may shed light on connections within a system that may not otherwise be readily apparent.

Develop Methods, Gather Information, Information Analysis, and Review Results
Develop Methods: Indigenous Peoples' knowledge systems include methods for seeking, analyzing, and validating information. When determining which methods to use and for what, both Indigenous methodologies and science methodologies should be considered, and there should be consensus on the suite of methods that will be used throughout a CPK research process.

Gather Information: Information should be collected following protocols and methods agreed upon by all participants.

Information Analysis: Information should be analyzed using methodologies agreed upon by all participants.

Review Results: All participants in the research process should be given the opportunity to review results.

The research team (scientists and Indigenous Peoples) should be involved in developing the methods for gathering information, information analysis, and reviewing results prior to commencement of work (Smith 1999, Wilson 2000, 2008). Before research begins, everyone will need to agree on the roles of all participants throughout the process. These steps emphasize the importance of ensuring there is appropriate *Capacity* and *Means and Ability* for all involved (e.g., identifying the appropriate tools, training, and resources) in CPK. Language is an important consideration because languages hold and reflect our perspectives, knowledge, and understanding of connections with the world around us (ICC AK 2020; Holm 2016 https://www.youtube.com/watch?v=92i8tpErSG0). A research team may, for example, decide to hold discussions in Indigenous languages, providing Indigenous Peoples an opportunity to freely share complex concepts that are difficult to translate. Whether discussions are held in English or an Indigenous language, translators may be needed. Additionally, it is important that all participants understand the terminology and definitions being used.

Co-production of knowledge requires evaluation criteria from both science and Indigenous Peoples' knowledges, therefore the research team will need to collectively agree upon appropriate methodologies. Methodologies will need to address the questions coming from different knowledge systems. Co-production of knowledge processes need to accommodate the different ways that knowledge systems categorize information (Smith 2015; Behe 2017 https://doi.org/10.13140/RG.2.2.16373.45287). The categorization of information from Indigenous Peoples' knowledges may include different variables, relationships, and purpose of use. The gathering of information will need to be conducted collaboratively to ensure that it follows the appropriate *Ethical* practices. Specific care must be placed on how information coming from Indigenous Peoples' knowledge systems is handled throughout all actions in the process (Nadasdy 1999, Schreiber and Newell 2006; Holm 2016 https://www.youtube.com/watch?v=92i8tpErSG0).

Creating new knowledge requires the involvement of all partners in the analysis of information. This will result in more creative, more robust, and often more applicable results that address real-world issues. Draft results should be available to all team members from both knowledge systems, as well as all project participants

(e.g., if the project included the participation of knowledge holders who are not formally part of the research team). It is vital for everyone engaged in a CPK project or relationship (e.g., scientists, knowledge holders, community members) to have access to research results. Everyone engaged in a CPK project or relationship should have an opportunity to review, provide feedback, and make final decisions about the interpretation and presentation of results.

MOVING FORWARD

Moving forward there are challenges and many opportunities. Indigenous Peoples and communities have been long advocated for research that is Indigenous and community-led and that focuses on Indigenous Peoples knowledge systems. With this recognition of the importance and need for Indigenous Peoples knowledges, there arBehe 2017e increasingly more opportunities for funding built on taking a co-production of knowledge approach (e.g., NSF 2020). There have been many challenges coming out of some of these efforts (e.g., Barnard et al. 2021; Kawerak et al. 2020 http://www.kawerak.org/NNA2020) and opportunities to address some of these challenges (e.g., the Community Office https://nna-co.org/). Because so many of these conversations are fluid and changing, we can't generalize about these funding opportunities. Instead, we briefly discuss some of the challenges moving forward and opportunities for applying CPK within Arctic research, the management of natural resources, and Arctic policy.

Challenges of implementing co-production of knowledge

There are many approaches that can be used to conduct research, some of which are more accurately described as collaborative rather than CPK. A major challenge with implementing CPK is mischaracterization (i.e., referring to collaborative work as CPK). For example, a researcher may identify a problem, develop research questions, and then invite Indigenous participation in the project. The project may result in Indigenous participation through collaboration on information collection or other aspects of the research process, or there may be a capacity building aspect to the work. This theoretical type of relationship, through the lens of our framework, would not be considered co-production because equity at all stages of the process was not the aim, methodology, or the outcome. The mischaracterization of CPK does not advance equity for Indigenous Peoples and their communities in research relationships and limits a fuller understanding of the world. Ensuring equity throughout the process requires a critical view toward how processes, procedures, and policies are being applied. The research community, at large, must be willing to adjust and change existing processes, procedures, and policies to support bringing together different knowledge systems.

A key problem with some research projects aiming to be co-productive can be a confusion of "the parts with the whole." The use of some of the conceptual tools of co-production should not be, though increasingly is, confused with employing a wholly co-productive approach. That is not to say that we discourage the use of a subset of the conceptual tools presented, but rather that a true CPK approach requires equity throughout the entire research process, from the very beginning. Additionally, it is far more important to do co-production than it is to talk about it or label things as it.

We believe that CPK is the right approach to research in the Arctic, but we also acknowledge that there are limits to this kind of research. These limits are the result of many factors. A key limitation to CPK research is the necessity of respecting Indigenous Peoples' right to say "no," "maybe," or "yes" to any activities proposed within their homelands that will, or may, impact their communities or way of life. This is a form of respecting Indigenous sovereignty. In addition to their own research activities, Indigenous Arctic communities and organizations are experiencing a rising tide of requests to participate in research (at various levels of engagement). The research community must recognize that not all researcher-initiated timelines are feasible, not all research activities may be able to occur, and that not everyone who wants to work in the Arctic necessarily can. These are difficult sentiments to hear. But just as there are limits on ecosystems, funding, time, and other resources, there are also limits on how many researchers can possibly be effectively and satisfactorily engaging in research with, and partnering with, Arctic Indigenous communities.

Indigenous Peoples often share frustration about research questions being addressed, describing how they often know the answer to a question being asked and would be able to save a lot of time and resources if they had been involved in the development of the questions, methodology, and overall research from the beginning (e.g., Flaherty 1995, ICC AK 2020). A strong example of this is the bowhead census conducted between 1976 and 1979 by the National Marine and Fisheries Service in the waters off of Utqiaġvik. The census resulted in a drastically low number of bowheads because of the assumptions made by scientists about whale behavior and where the animals could be seen to be able to count them. After the formation of the Alaska Eskimo Whaling Commission, whalers were able to conduct a new census using their knowledge of whale behavior and movements. The new count demonstrated that the population of bowhead whales was much higher than previously reported (Albert 2001).

Indigenous Peoples' schedules, interests, needs, and *Means and Ability* all have to be addressed and considered. Challenges arise when research activities are valued more than Indigenous Peoples' ways of life and values (for example, conducting research activities that disrupt hunting and a community's food security, or research activities that are disrespectful to animals).

Opportunities for implementing co-production of knowledge in Arctic research

Indigenous-driven efforts should be supported, whether they are taking an approach based on Indigenous knowledges, a western science approach, or a CPK approach. Indigenous Peoples have lived in the Arctic since time immemorial (connected to Arctic places) and will continue to do so. They know and understand the challenges and changes happening in their homelands, as well as the information needed to address these challenges. Indigenous Peoples need to be driving the decision making surrounding their communities, livelihoods, and futures, whether it is through research, management, or policy-setting actions (e.g., Kawerak Marine Program 2015, Raymond-Yakoubian et al. 2017, Raymond-Yakoubian and Daniel 2018, ITK 2018, ICC AK 2020). Support is especially needed to build Indigenous frameworks that operate at community and regional scales. A few examples include the Inuit Food Security Conceptual Framework

(ICC AK 2016), the Tanana Chiefs Conference food security project (Heerenga et al. 2019), and the Ikaarvik project in which Indigenous youth developed guidelines for the engagement of Indigenous Knowledge within research activities (Ikaarvik 2019).

We developed the CPK framework to address inequities between Indigenous Peoples' knowledge systems and western science in research and to further advance understanding of the Arctic through bringing together these knowledges. Conducting research that uses the CPK process is not "easy" but has valuable benefits. Co-production of knowledge processes provide equitable spaces and help create holistic understanding of topics. Co-production of knowledge requires a commitment of time and financial resources, the genuine sharing of power, and the participation of our authentic selves. This type of work can often involve tensions (between knowledge systems, between individuals, between institutions) that cannot and should not be ignored. These tensions arise from deep and painful histories, ongoing systemic racism, knowledge exploitation, and the domination within research of colonial institutions. The purpose of the framework is to provide a set of conceptual tools to address, navigate, and resolve those tensions so that collaborations can be successful and equitable.

Application of co-production of knowledge tools in management of natural resources

A promising application of the principles within CPK could be the context of natural resource management practices and approaches. Many of the tools used to manage natural resources were built-into legislation from western frameworks based in science (e.g., Marine Mammal Protection Act 2019 and definitions of populations and models of population growth) rather than from Indigenous worldviews (Stevenson 2004, Metcalf and Robards 2008, Daniel 2019, Graugaard 2020). The management (both science and decision making) of land animals (e.g., moose and caribou), birds (e.g., migratory fowl), fish (e.g., salmon), and marine mammals relies on inequitable spaces created by agencies prioritizing or solely utilizing western scientific concepts such as population estimates, mortality, and reproduction rates (Iain Davidson-Hunt and O'Flaherty 2007, Raymond-Yakoubian 2012, McCarthy et al. 2014, Raymond-Yakoubian et al. 2014, Snook et al. 2018, Mustonen et al. 2018, MMC 2019, ICC AK 2020). For example, the value of Indigenous Peoples' knowledge about marine mammals or fish in the larger ecosystem system could better inform a more holistic understanding of cumulative impacts and interconnecting systems, a true ecosystem approach (e.g., Raymond-Yakoubian and Daniel 2018). Taking a holistic approach, with focus on *Relationships* and *Reciprocity* will strengthen marine mammal, fisheries, and other natural resources management (Maxwell 2019). Applying CPK to management will benefit the health of the entire ecosystem, inclusive of Indigenous Peoples and agency managers and may build *Trust and Respect* (which is often lacking) between managers and Indigenous Peoples (Armitage 2005, ELI 2015). Furthermore, it could better address the inequitable inclusion of Indigenous Peoples' knowledges, which is often not valued by researchers or trusted by managers and policymakers. The tools in the outer ring that work to build equity should be continually considered and should be applied throughout the management process. By revisiting the identification of problems and issues (*Problem Identification*) we could work toward better addressing concerns that communities are dealing with in a varying climate (e.g., changes in sea-ice extent and researchers tagging animals for management activities).

Box 8:

For a long time, our knowledge has been talked about, but not included by western science in research and in management. Their inability to include our knowledge is because they question the credibility. The researchers need to spend time in preparation with us and to have approval by our leadership; they need to follow protocols. Our knowledge needs to be adequately included to make sure our way of life is respected and honored while maintaining the health of our peoples, fish, and wildlife.

Chief Mike Williams, Sr.

(Akiak Native Community)

Applying co-production of knowledge tools to Arctic policy

Applying the CPK conceptual tools to establish more equitable policy would be beneficial for Indigenous Peoples. The concepts of *Decolonization* and *Sovereignty* are especially relevant in thinking about policy development. Policy is important in defining and driving governance systems. Systems (e.g., natural resource management, education, legal, health) have been imposed, throughout history, on Indigenous Peoples without their consent and often without their direct engagement in the systems' development. Decisions impacting Indigenous Peoples are often conceived and formalized far from the Arctic (e.g., in Washington, D.C.) and are based on western approaches to governance that do not recognize Indigenous values (e.g., holistic approaches and food security) and ways of governance, including the importance of *Sovereignty* (e.g., Stevenson 2004, CATG 2016, Black 2017, ICC AK 2020). Establishing policy through application of CPK tools could lead to more meaningful decisions. One example of this was the establishment of the Northern Bering Sea Climate Resilience Area that created a space to emphasize the value of Indigenous Peoples' knowledges and included the role of Indigenous Peoples in decision making along with federal agencies (Federal Register 2016, Raymond-Yakoubian and Daniel 2018). The area was subsequently withdrawn in 2017 (due to political changes resulting in different views about Indigenous Peoples' sovereignty) and then reinstated in 2020, but remains a good example, from an Indigenous perspective. Collaborative policy development is more urgently needed because Indigenous Peoples should be deciding how to adapt to the challenges of an abruptly transforming environment due to climate change.

CONCLUSION

Co-production of knowledge provides a framework to bring different ways of knowing and experiencing together to gain new and unique understandings of the world. It provides an equitable pathway for science and Indigenous Peoples' knowledge about Arctic systems. By using the CPK framework and its key concepts

(i.e., *Relationships*, *Empowerment*, *Capacity*, *Means and Ability*, *Deliberate and Intentional, Ethics*, *Decolonization*, *Sovereignty,* and *Trust and Respect*) equity can be built. Promising avenues for the application of the principles of CPK include natural resource management practices and approaches, such as fisheries management (e.g., Raymond-Yakoubian et al. 2017, Maxwell 2019). Applying the CPK conceptual tools to establish more equitable policy would be beneficial for Indigenous Peoples by better accounting for Indigenous values (Black 2017, ICC AK 2020).

A paradigm shift in thought and practice to create inclusive spaces will be required to develop equitable relationships. The old concept of "do no harm" that many researchers adhere to requires much deeper interrogation (Borofsky 2015 http://ethics.americananthro.org/maybe-doing-no-harm-is-not-the-best-way-to-help-those-who-helped-you/). Ultimately, "do no harm" is no longer an adequate cornerstone for research by itself. Rather, to respect our collaborators (be they Indigenous Peoples or others), we must strive to do good. What exactly "good" looks like may take many forms, but it should be determined by all partners committing to a co-productive process.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12960

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Data/code sharing is not applicable to this article because no data/code were analyzed in this study.

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