



Key Points:

- Research and cultural backgrounds impact the success of co-production of knowledge projects
- Input and partnership development are critical stages in the research process
- There is a need to balance academic and Indigenous perspectives for credibility, legitimacy, and relevance

Correspondence to:

M. H. C. Rudolf,
mhrudolf@alaska.edu

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Factors in and Perspectives of Achieving Co-Production of Knowledge With Arctic Indigenous Peoples

M. H. C. Rudolf¹ , S. F. Trainor², J. O'Connor³, E. Figus⁴, and R. Hum⁵

¹International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA, ²Alaska Center for Climate Assessment and Policy, International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK, USA, ³Raven's Group, LLC, Colorado Springs, CO, USA, ⁴Figus Consulting Services, LLC, Coimbatore, India, ⁵School of Education, University of Alaska Fairbanks, Fairbanks, AK, USA

Abstract Co-production of knowledge (CPK) is a process of bringing together diverse perspectives from researchers, agency, and community partners to achieve a shared research goal. The main objective of this article is to provide tools for achieving CPK in research projects, especially with Alaska Native and Arctic Indigenous communities. Team members need to understand their positionality and be aware of assumptions and biases to come to jointly agreed upon project priorities. To assist researchers in reflecting on their positionality, we present research paradigm dispositions from commonly trained methodologies and academic norms. Differences across the dispositions are highlighted in decision-making, success metrics, evaluation, and validation of outputs. Factors of Success were synthesized from existing literature on CPK, boundary spanning, the science of team science, convergence, Indigenous methodologies, and best practices to understand the CPK process. These Factors of Success are presented in a typical project life cycle logic model, categorized into inputs, process, and outcomes. Given the limited time and resources of research projects and activities, some factors will be given stronger emphasis over others. This article provides tools for transparent communication between researchers and community or agency partners.

Plain Language Summary Co-production of knowledge is a collaborative research approach. This article presents two tools to support and achieve co-production of knowledge in research projects, with specific application to working with Indigenous communities. The first tool we present is a summary of different perspectives or approaches to research based on the literature. This summary can help research team members become aware of their individual perspectives in order to better work as a team to achieve equitable and mutually agreed upon approach to research goals, priorities, activities, and evaluation. The second tool provides and in-depth outline of a range of factors that can contribute to the success of a research project. These include the overall context of the project as well as the intrapersonal, interpersonal, and partnership inputs that form the groundwork upon which a research project is based. Project success also depend on multiple procedural aspects of the project, projects outcomes and impacts, and the team and community member's perceptions of success. Our hope is that the tools in this article assist researchers in becoming more self-reflexive about their own research approach, assumptions, and perceptions of success, which will lead to better communication and equitable partnerships.

1. Introduction

The process of co-production of knowledge (CPK) has the potential to achieve benefits of usable, actionable research outcomes, including direct benefits to communities (Figus et al., 2024). CPK requires a diverse team of researchers and community partners. It is especially important to include those intended to benefit from the project. CPK is centered around collaboration and requires shared decision-making at every step of the research process (Djenontin & Meadow, 2018; Mach et al., 2020; National Science Foundation, 2021; Norström et al., 2020; Wall et al., 2017; Yua et al., 2022). However, tensions can arise as a result of cultural or methodological differences, including between different disciplines. Inherent limitations of time and project resources can compound these tensions. For example, every project is constrained not only in the amount of funding available, but also by timeline and requirements for funding, the capacity of the research team, and the existence or lack of established relationships among team members. The dynamics and imbalances of power and politics within CPK projects need to be addressed (Daly & Dilling, 2019; Lemos et al., 2018), including those between researchers and community members, as well as those among different disciplines. As a result of the U.S. National Science Foundation's Navigating the New Arctic (NSF; NNA) funding program (National Science

Foundation, 2019), CPK has become an increasingly popular approach for researchers working with Arctic Indigenous communities. Best practices and ethics for Indigenous engagement, as well as Indigenous methodologies, are essential aspects of making CPK projects culturally inclusive.

The goal of this article is to provide tools for understanding the CPK approach in a cross-cultural context, in particular with Arctic Indigenous communities. The target audience for this article are researchers, including natural and physical scientists that may lack understanding of key social science terms and concepts. Within any research project, each researcher and research partner consciously or unconsciously prioritizes different aspects of the research process depending on their perspective (Section 4.1). Throughout this article, we call these different project priorities “Factors of Success.” These Factors of Success are rooted in the personal and professional backgrounds of CPK team members, creating multifaceted perspectives within a project. Multifaceted perspectives are also rooted in cultural and trained perceptions of credibility, relevance, and legitimacy (Section 4.2).

This article was developed from the co-authors’ personal experiences in combination with a review of CPK and other methodology literature. Personal experiences and self-reflection provided an iterative learning process and in-depth understanding of elements in the successful implementation of CPK research projects with Arctic Indigenous communities. The explicit and implicit tensions that arise from different methodological and cultural perspectives significantly impact the success or failure of achieving CPK and require transparent, intentional communication to create to a shared understanding that is required of a strong partnership. First, we explore how different research paradigms (the trained philosophical approaches to research) influence the values, assumptions, and priorities of research team members. We then synthesize the factors of creating a successful CPK project from the literature on CPK, boundary spanning, convergence, the science of team science, and Indigenous best practices and evaluation frameworks.

All research projects are inherently limited in resources, funding, and time. Participants in CPK research must be especially aware of how the assumptions, positionality, and power dynamics of research partners can influence how the work is conducted within the confines of these limitations. The purpose of this article is to facilitate transparent communication between researchers as well as among researchers and community partners about research processes and metrics of success. The authors envision readers using this article for educational purposes in teaching about CPK. In addition, Section 4 can be used for researcher self-reflection prior to doing a CPK project and Table 1 and Figure 2 can be used to support communication during the co-design phase of a project. The discussion section (Section 6) describes how use the tools within the article and presents case study examples highlighting alternative success metrics and potential methodological misunderstandings.

2. Positionality

Positionality is a concept that stems from one’s identity, assumptions, and biases that influences research projects (Bourke, 2014; Rose, 1997). Researchers are often unaware of these assumptions and biases without self-reflection. Specifically, positionality is a process of reflexivity of one’s gender, race, socioeconomic status, education, etc. The lead author learned the concept through Indigenous critical methodologies, where, for centuries, western researchers have been defining other races and cultures as inferior (Smith, 2012). Academia is rooted in western methodologies and epistemologies (ways of knowing) (Brady et al., 2018; Smith, 2012). Awareness of their own positionality, including the dispositions presented below, can help academic researchers create equitable CPK research. Indigenous methodologies recognize that Indigenous Peoples have research methodologies that also have standards for credibility and legitimacy. While these may differ from those of western methodologies, they should be given equitable consideration and space in research (Kovach, 2009; Wilson, 2008). The term “positionality” might not be used in Indigenous methodologies. However, the concept of exploring one’s relationship to the research and its participants is central in the development of an Indigenous researcher’s personal methodology based on their ancestral knowledge and ways of doing research (Kovach, 2009; Neeganagwedgin, 2013; Sandoval et al., 2016). Indigenous methodologies are rooted in Indigenous self-determination, which includes significantly more in-depth reflective exploration than the concept of positionality. Part of developing one’s positionality in CPK research is gaining an understanding of the dominance of western methodologies and the western worldview in most research as well as an appreciation and respect for the rigor, depth of insight, and value of Indigenous methodologies (Brady et al., 2018; Smith, 2012). In this article, the authors invite readers to develop awareness of their own positionality, both culturally and disciplinarily as a way to advance their CPK work.

2.1. Positionality Statement

The lead author is an Inupiaq interdisciplinary Ph.D. student, at the time of writing, working within the context of Arctic research. The co-authors are her mentors and colleagues who have heavily influenced and contributed to this work. The lead author has worked on five CPK projects, advised on two, and participated in countless formal and informal discourses around CPK in the Arctic with the co-authors and others in the boundary spanning role. This paper was developed to capture how to achieve CPK with Arctic Indigenous communities. This work builds on the foundational work of Djenontin and Meadow (2018) CPK review paper, the CPK evaluation indicators of Wall et al. (2017), and the Yua et al. (2022) CPK conceptual model for working with Alaska Native communities.

With visible identities of being Indigenous and female, the first author also writes with lived experience of navigating the obstacles of academia (Berhe et al., 2022). The first author also recognizes her privilege of higher education, which is not accessible to many Indigenous individuals impacted by Arctic research. The concept of “multifaceted” mentioned throughout the article honors the multiple identities a person can hold, such as the first author being Indigenous and a scientist. We have written this article from this multifaceted lens and understand the different perspectives and priorities that can sometimes be at tension with each other. We believe that part of the CPK process in research is to facilitate awareness of the different approaches each team member brings to a project in order to negotiate a conscious and deliberate research process that can be successful for all participants.

3. Background

As stated in the introduction, CPK involves collaboration and shared decision-making at every step of the research process. Norström et al. (2020) outline four principles of CPK that differentiate it from other community engagement approaches. First, to achieve collaboration and shared-decision making, CPK is inherently interactive at every step of the research process. Second, CPK is pluralistic, with projects that respect and engage scientific and local/Indigenous knowledge systems. The third and fourth principles make a project relevant to community partners by being context-based and goal-oriented. The Yua et al. (2022) CPK conceptual model uses the term “partnerships,” which can be used as a non-jargon word with a similar conceptual meaning. In general, CPK is a flexible framework that allows community engagement strategies and convergence methods from other fields to be used to reach CPK.

Within the broader CPK literature, utilization (or creating usable, actionable outcomes) drives the process, while in Yua et al. (2022) CPK conceptual model equity is the overarching driving element. The Ellam Yua et al. is foundational for CPK in Arctic research and with Indigenous communities. The model takes the CPK methodological approach and layers on Indigenous ethics and values as conceptual tools, such as sovereignty, trust and respect, relationships, deliberate and intentional, and empowerment.

This article builds upon the work of Wall et al. (2017), who developed 45 indicators of CPK under a similar process of literature synthesis with a focus on CPK with resource managers and federal agencies. In addition, Djenontin and Meadow (2018) did a systematic literature review to understand “how to” design and implement CPK. Lemos et al. (2018) frame the extensive time and resources needed to do CPK and emphasize that researchers need to be intentional in utilizing the approach. Turnhout et al. (2020) detail how power dynamics and depoliticization within projects reaffirms inequality and can impair societal transformation. This foundational CPK literature lays the groundwork for this article, with many of the concepts found therein included in the tools we present. We also draw on literature related to research paradigms including books by Creswell and Creswell (2018) and Mertens and Wilson (2019). We further draw on Indigenous authors within the CPK literature, including two books on Indigenous methodologies by Kovach (2009) and Wilson (2008) and David-Chavez and Gavin (2018) who developed an analytical framework and indicators for responsible Indigenous community engagement.

4. Multifaceted Perspectives of Creating Success

4.1. Research Paradigms

Research paradigms are the philosophical framework for research methodology, which lead to models, standards, practices, processes, methods, and success metrics (Creswell & Creswell, 2018; Mertens & Wilson, 2019; Wilson, 2008). While research paradigms are not commonly taught to physical and natural scientists, they are one of the target audiences for this article. Research paradigms summarize perspectives about how to do research based on different ideas about relevance, credibility, and legitimacy (Section 4.2). The five paradigms included in

Table 1
Dispositions Developed From Research Paradigms Representing the Multifaceted Perspectives of Success

Research paradigm	Post-positivist	Constructivist	Pragmatic	Transformative	Indigenous
Research purpose	Hypothesis testing	Analyzing perspectives	Applied research	Social justice	Self-determination
Career path	Academia	Academia	Agency, NGOs, and academia	Community and nonprofit	Community
Priorities in the research process	Outputs	Interpersonal	Outputs and Outcomes	Impacts	Intrapersonal
Metric of Success	Peer-review publication	Peer-review publication	Outputs and utilization	Changes in community	Self-determination
Who validates outcomes?	Researchers	Researchers	Users and Researchers	Community	Community
Project decision-maker	Researchers	Researchers	Researchers	Community	Community
Methods of project evaluation	Experimental	Participatory	Usability	Culturally responsive	Indigenous

Note. Developed based on Creswell and Creswell (2018); Mertens and Wilson (2019); Wilson (2008); Kovach (2009).

this article are post-positivist, constructivist, pragmatic, transformative (Creswell & Creswell, 2018; Mertens & Wilson, 2019), and Indigenous research (Kovach, 2009; Wilson, 2008). Due to the pluralistic nature of the CPK approach (Norström et al., 2020), at least two paradigms would be representative within any CPK project. Descriptions of each paradigm are presented throughout this section, with Table 1 presenting the key concepts of each. From these paradigms, we developed dispositions as intellectual and normative models for how each would typically influence a person's approach to a research project and project evaluation, including assumptions and prioritizations. How a researcher would approach a research project is complex and dependent on many variables, with research paradigms being a driving influence. We present simplified versions of the paradigms in order to highlight key differences, and not with the intention of creating a sense of supremacy of one paradigm over another. It is expected that a researcher may not fit into one disposition, but the discourse presented in this article is meant to create reflexivity and awareness of positionality. Without awareness of other ways of doing research, a researcher may make assumptions and unintentionally create interpersonal tensions within a CPK project. In the partnership development stage, awareness of these different perspectives is needed to co-develop interdependent, shared goals that support convergence rather than divergence (Stokols et al., 2008). Our Factors of Success logic model depicts many possible different factors to support transparent communication in deciding which Factors of Success to prioritize within the limited time and resources of any CPK project.

The two paradigms most prevalent within academia are post-positivist and constructivist. The post-positivist disposition approaches research with hypothesis testing, a reductionist mindset, and quantitative methods (Creswell & Creswell, 2018) and prioritizes scientific outputs. The majority of natural and physical scientists are trained in the post-positivist paradigm and typically approach the social elements of CPK in the same manner they approach studying the natural world (Mertens & Wilson, 2019). The strength of the post-positivist disposition is theory verification (Creswell & Creswell, 2018). Social scientists could be trained in any of the research paradigms and work within academia, agencies, NGOs, or communities. Constructivists, the other paradigm prevalent within academia, analyze social perspectives through qualitative methods (Mertens & Wilson, 2019). Therefore, the constructivist disposition will prioritize the interpersonal factors of a CPK project, especially how researcher and partner perspectives have impacts through the research process. The strength of the constructivist disposition is understanding the complexity of a situation (Bremer & Meisch, 2017; Creswell & Creswell, 2018). The reward system within academia prioritizes peer-reviewed publications, and therefore, validation of success is from other researchers. Within evaluation, the post-positivist disposition prefers experimental methods, while the constructivist disposition captures perspectives within a participatory method (Mertens & Wilson, 2019).

Within the pragmatic disposition (Creswell & Creswell, 2018; Mertens & Wilson, 2019), researchers provide scientific services, develop tools, and conduct applied research, which benefit agencies, NGOs, or academia. The purpose of this disposition's work is applied research through the development of tangible outputs that are used to achieve the goals related to their applied research. If this disposition were to evaluate success, it would be on the utilization of the outputs through mixed methods (Mertens & Wilson, 2019) to assess whether they achieved the applied research goal within the project's outcomes. Pragmatists working in research institutions would also prioritize peer-review publications, conforming to academic reward systems, with other scientists validating the success of the project.

The two community-centered paradigms are transformative and Indigenous. These dispositions are commonly trained with critical methodologies. The transformative disposition (Creswell & Creswell, 2018; Mertens & Wilson, 2019) generally includes community-based researchers with social justice motivations and goals for creating positive changes within the community. The transformative disposition will prioritize developing societal impacts in their projects. The transformative disposition commonly works within NGOs or directly for a community or Tribal government. Therefore, the community, NGO, or Tribe validate success and have decision-making authority. The transformative disposition will evaluate success through a culturally responsive lens using mixed methods and focused on marginalized viewpoints (Mertens & Wilson, 2019).

The Indigenous research paradigm differs from transformative in regard to the researcher's own cultural worldview and Indigenous methodologies. Indigenous methodologies (Kovach, 2009; Smith, 2012; Wilson, 2008) involve an Indigenous researcher looking toward their own Indigenous Knowledge Systems in approaching research design and development of research methods. Those performing Indigenous methodologies would ideally work within their own community, in their own language, for their own community needs. Therefore, the methods could look differently in different research settings due to cultural differences. For example, using Indigenous languages or building language revitalization is often a crucial part of Indigenous research methods. This article does make the assumption that the Indigenous research paradigm is analogous to the way Indigenous partners would approach CPK projects. Within the Indigenous research disposition, the basis for success is Indigenous self-determination. With the development of methods based on one's own Indigenous Knowledge Systems, this disposition would prioritize the intrapersonal stage of the research process, where the researcher ready themselves to approach a CPK project and participate in partnership. The concept of positionality, understanding one's own relationship with the research, is a practice that is considered culturally responsive in working with Indigenous Peoples (Kovach, 2009; Smith, 2012; Wilson, 2008). This disposition would utilize Indigenous evaluation, a growing field rooted in Indigenous methodologies (Bowman & Dodge-Francis, 2018).

Within CPK projects, each paradigm has roles and strengths in working together to create an overall successful project. Pragmatic, transformative, and Indigenous paradigms are better equipped to place projects within the context of the community partners (Norström et al., 2020) than are post-positivist or constructivist paradigms. Transformative and Indigenous researchers are generally community-based and, therefore, more aware of community-driven goals and priorities (Chambers et al., 2021; Norström et al., 2020). Constructivist and transformative paradigms support the pluralistic principle of CPK (Bremer & Meisch, 2017; Chambers et al., 2021; Norström et al., 2020). Post-positivist researchers are able to conduct theory verification within a subset of a CPK project (Chambers et al., 2021). Positionality supports understanding the roles and responsibilities of researchers in relation to community partners based on the ways of doing research that best fit the situation and goals (Haider et al., 2018), which should be structured within the inputs phase and revisited throughout the project.

4.2. Relevance, Credibility, and Legitimacy

Within the science-policy interface, there are three components that influence the utilization of research: (a) relevance, (b) credibility, and (c) legitimacy (Djenontin & Meadow, 2018; Norström et al., 2020; Sarkki et al., 2015; Wall et al., 2017). These three factors form the foundations for how researchers and CPK partners perceive success within the dispositions. Within a CPK project, the perspectives on relevance, credibility, and legitimacy must be balanced. Figure 1 depicts an example of a CPK project between an academic institution and an Indigenous community, where these factors must be balanced between the academic dispositions (post-positivist and constructivist) and Indigenous research disposition. For a project to be *relevant*, or salient, it must meet users' needs, which requires projects to be context-based and goal-oriented (Djenontin & Meadow, 2018; Norström et al., 2020; Sarkki et al., 2015). Relevance for an academic disposition is seen as applying research expertise and ideas that are innovative and competitive for funding opportunities (Arnott et al., 2020; Sarkki et al., 2015). For the Indigenous research disposition, relevance is seen as meeting community priorities (Wilson, 2008). Relating to the context factors of success, Indigenous communities exist within the context of systemic inequity, colonization, and racism. For the Indigenous disposition, Indigenous communities seek systemic societal impacts toward Indigenous self-determination and sovereignty (David-Chavez & Gavin, 2018; Ellam Yua et al., 2022). Scientific credibility is established by conforming to research paradigm standards on whether the knowledge produced is trustworthy and believable. Within the academic dispositions, this means conducting research within approved scientific methods and evaluating work within the peer-review process with scientists with relevant expertise. Indigenous credibility

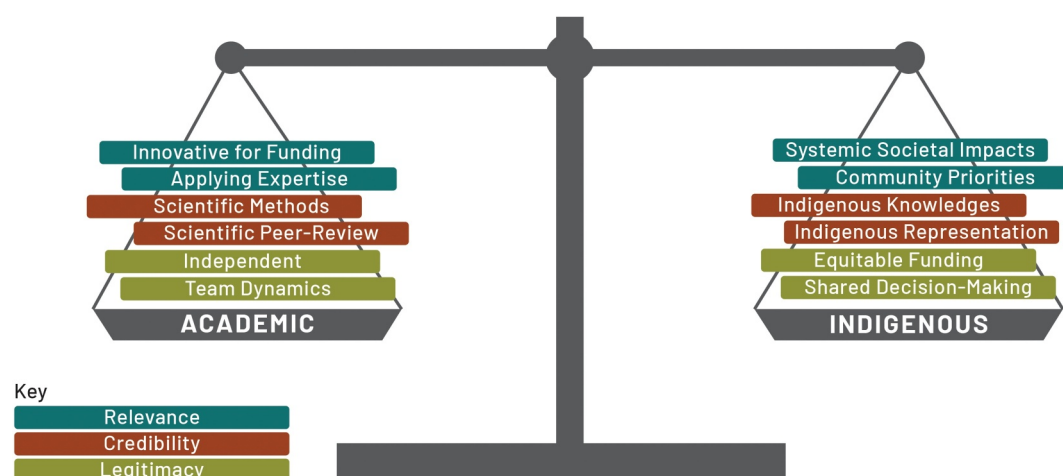


Figure 1. Balancing between the academic and Indigenous disposition perspectives on relevance, credibility, and legitimacy on a Co-production of knowledge project.

has an oral and experiential peer-review process within Indigenous Knowledge Systems. When evaluating credibility of a project, a metric would be Indigenous representation as researchers and/or advisory as it ensures accurate representation of the Indigenous worldview (Smith, 2012; Stephens et al., 2012; Wilson, 2008; Yua et al., 2022). Scientific uncertainty is another credibility metric. Uncertainty in lack of understanding also impacts the perception of credibility (Pielke, 2007), where the social learning within CPK projects increases understanding and therefore the perceived credibility. Legitimacy is whether the knowledge is judged to be fair and unbiased. Academia has worked on transparency and team dynamics within team science projects (Sarkki et al., 2015; Stokols et al., 2008). For Indigenous partners, legitimacy is based on being treated as an equal partner with shared decision-making and equitable distribution of funding (Yua et al., 2022). There is tension in the concept of unbiased, or objectivity, across worldviews. The post-positivist disposition will look for independent, non-biased teams and Indigenous methodologies explore subjectivity and positionality in order to reach objectivity (Smith, 2012; Wilson, 2008). Within Figure 1, what is relevant, credible, and legitimate for each side does not reduce the relevance, credibility, and legitimacy for the other side, but they do need to be balanced within a CPK project. If a CPK project was developed like a typical academic project, it would have limited relevance for the Indigenous partners and therefore limited utilization of the outcomes. While equity for Indigenous partners would be prioritizing their perspective, it could be counterproductive for the academic's career and that research topic may be better suited for a community-based participatory action research approach. The figure is not to create a value-judgment but to depict the complexity of a CPK project and support informed decision-making.

To achieve co-produced outcomes is to focus on the process of CPK, meaning that researchers and project leads need to think about and implement activities that support co-production throughout their research project (Norström et al., 2020; Sarkki et al., 2015). In practice, supporting CPK involves transparent dialog about which factors of success to prioritize in a research project and which activities can increase the project's relevance, credibility, and legitimacy for all team members. These CPK project considerations would happen in the interpersonal and partnership stages, and include awareness and practice of social learning within the Process stage. Sarkki et al. (2015) argue that focusing on “iterativity,” the continuous interactions that build on each other to foster partnership in order to achieve relevance, credibility, and legitimacy, will promote CPK to happen.

5. Factors of Success

“Factors of Success” are the variables that contribute to the success of a collaborative project, which have been theoretically or experimentally determined. Figure 2 below is a framework of how the factors build upon each other to lead to the outcomes of a CPK project. Figure 2 is the second tool to support communication between researchers and community partners. This tool can be used during the co-design phase of the project and additionally referenced during strategic planning and reflection points in the project. Building on the foundational CPK work of Djenontin and Meadow (2018), Wall et al. (2017), and Yua et al. (2022), this paper also draws from

Factors of Success

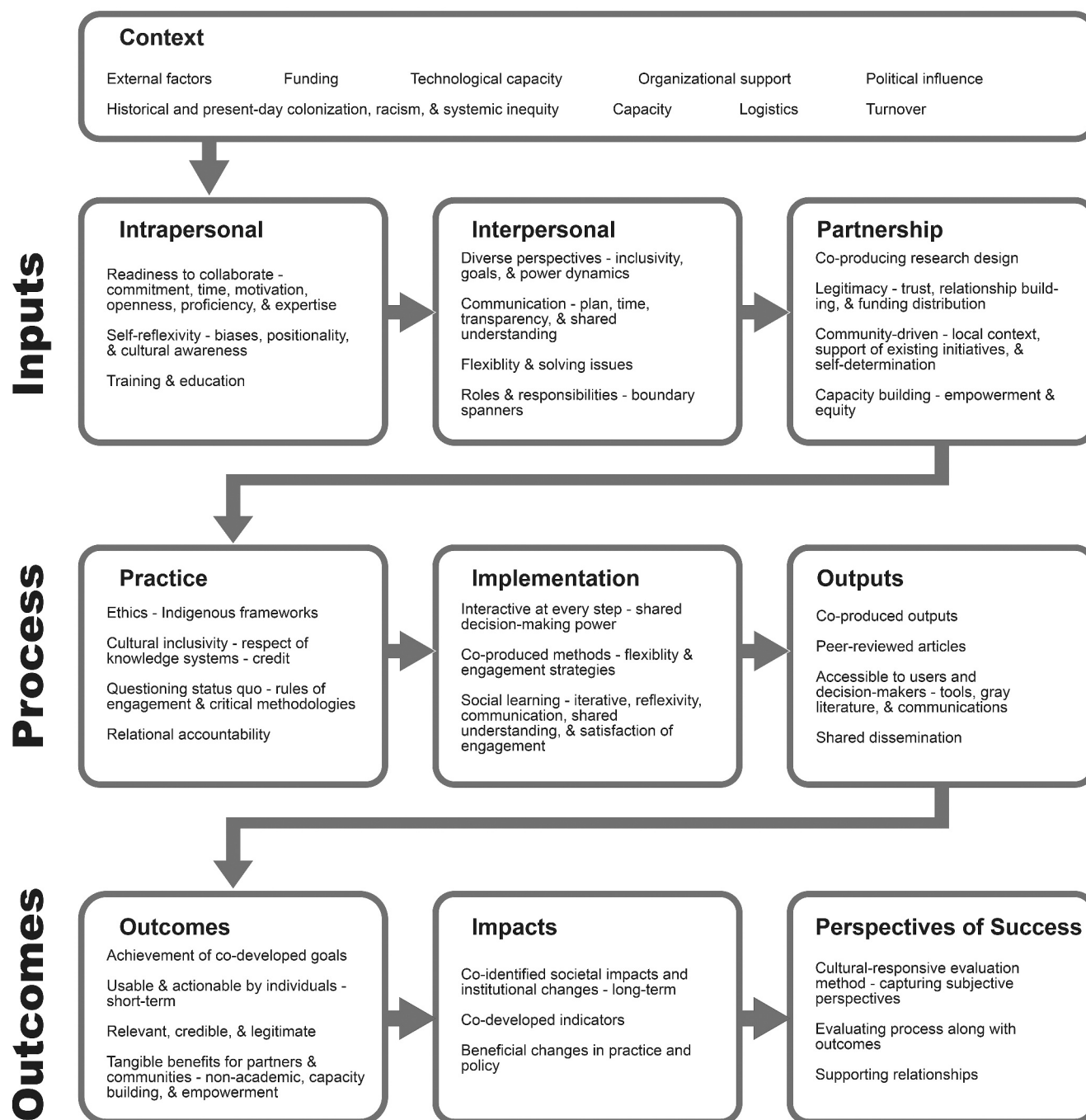


Figure 2. Factors of Success to achieve Co-production of knowledge outcomes, presented in a logic model framework.

literature in the science of team science, convergence, boundary spanning, and Indigenous methodologies. With the limited time and resources inherent in every research project, it is unreasonable to expect that all of the Factors of Success identified below (Figure 2) could be accomplished in one project. These Factors of Success are concepts where metrics could be co-developed for any given project, with examples shown throughout the article.

The goal of creating this synthesized list of Factors of Success is to facilitate transparent communication and decision-making between and among researchers and community partners in order to mutually agree upon which factors should be prioritized over others. Following Djenontin and Meadow (2018) and Wall et al. (2017), presenting the factors in the linear life cycle of a typical research project highlights how factors set the stage as precursors to successful outcomes.

The logic model (Djenontin & Meadow, 2018; Mertens & Wilson, 2019) in Figure 2 represents the typical research project life cycle with three phases (inputs, process, and outcomes) as well as the context in which the project is situated. The figure was developed to be printed out to use a tool to support discussions and negotiations. Presenting these factors of success in a linear process is more representative of the western scientific worldview, while Indigenous evaluation would be more holistic, cyclical, and culturally rooted (Kovach, 2009; Wilson, 2008). The linear model is used because most funding structures that drive research derive from the western scientific worldview. In practice, however, using an Indigenous framework may be more appropriate, such as the Yua et al. (2022) CPK conceptual model.

The dispositions of diverse team members (Table 1) set the stage for these Factors of Success (Figure 2). The more each team member is aware of their own disposition(s) and those of the other members of the team, the more able they will be to navigate and intentionally design and implement a project that leads to benefits for all partners (Figure 2) (See also Figus et al., 2024). Moreover, as each team member gains this awareness and epistemological agility (Haider et al., 2018), the team as a whole will build capacity to work collaboratively as equal partners in order to achieve a successful CPK project. Similarly, balancing the actions that create relevance, credibility and legitimacy for diverse research partners (Figure 1) is an on-going process for CPK leaders and team members. This balancing occurs continually as the team proceeds through the planning, decision-making, research activities, research outcomes, and evaluation phases of the project, all of which contribute to the project's success (Figure 2).

5.1. Context

Every project exists within a broader context that impacts its success, often described as external factors (Djenontin & Meadow, 2018; Wall et al., 2017). The funding source is a dominant factor driving research design and implementation, as funding agencies and organizations have their own priorities, requirements, and limitations. Both the amount of funding available and the requirements for receiving funding impact the ability of researchers to implement CPK projects and effectively engage communities. The capacity and available resources for both researchers and their partners are also key factors (Arnott et al., 2020; David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Doering et al., 2022; Lemos et al., 2018; Norström et al., 2020; Sarkki et al., 2015; Yua et al., 2022). CPK takes time and resources that require organizational support as well as a reward system within research institutions, agencies, NGOs, and Indigenous Tribes and organizations (Djenontin & Meadow, 2018; Sarkki et al., 2015; Wall et al., 2017). For example, inflexible resource management agencies may not allow time or information sharing necessary for their staff to meaningfully participate in CPK research projects (Djenontin & Meadow, 2018). Special consideration is needed for the capacity at the community level to meaningfully participate in achieving CPK, where turnover, technological capacity, political influences, and logistics could prevent progress (Djenontin & Meadow, 2018; Norström et al., 2020; Sarkki et al., 2015; Turnhout et al., 2020; Wall et al., 2017; Yua et al., 2022). When working with Indigenous communities, there is the historical and present-day colonization, racism, and systemic inequity that must be addressed within the project (David-Chavez & Gavin, 2018; Doering et al., 2022; Turnhout et al., 2020; Yua et al., 2022; Zanotti et al., 2020). An example of the influence of context is the rise of the popularity of CPK in Arctic research due to NSF's NNA (National Science Foundation, 2018), raising awareness of CPK and providing funding for it. However, in building the NNA program NSF failed to fully recognize the influence of colonization and systemic inequity of research as well as the current political movement in recognizing Indigenous sovereignty. Indigenous leaders from western Alaska wrote two open letters criticizing NNA (Bahnke et al., 2020, 2021), which cite capacity issues stemming from remote logistical issues, lack of connectivity within communities, and personnel within communities to participate within individual research projects and applying for NNA funding. With the NNA example, context challenges within the communities prevented participation in CPK projects as well as the funding structure possessing barriers for not considering the communities' context.

5.2. Inputs

Inputs are factors that are in place before the official start of the project. Inputs relate to intrapersonal or individual readiness to collaborate, interpersonal or team dynamics, and partnership development in the proposal writing.

Intrapersonal—Individuals within a CPK project can influence the success of projects, especially the project leadership (Stokols et al., 2008). To lead CPK projects, adequate education and training of the CPK process, community engagement approaches, and Indigenous engagement and best practices are needed and should be a metric for granting funding for CPK projects (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018). An individual's readiness to collaborate (Stokols et al., 2008) relates to many other concepts of expertise, proficiency, time, commitment, motivation, and openness (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Lemos et al., 2018; Sarkki et al., 2015; Stokols et al., 2008; Turnhout et al., 2020; Wall et al., 2017; Yua et al., 2022). It is common practice within grant funding to evaluate the professional readiness of researchers by reviewing CVs and existing projects. Similar metrics could be developed for agency and community partners in expertise, funded time, capacity in workload, and adequate training (prior and as part of the project). Making professional readiness an evaluation metric for grant proposals would raise more awareness of the capacity and resource support needed on the non-academic side. For socio-emotional readiness, self-reflexivity is important in regard to positionality, cultural awareness, and biases as described in the above Section 2 (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Doering et al., 2022; Pennington, 2016; Turnhout et al., 2020; Zanolli et al., 2020).

Interpersonal—With CPK projects requiring a diverse team of researchers along with community partners, the between-people dynamics influence the success of a project (Stokols et al., 2008). The diverse perspectives on methods, purpose, goals, and success metrics will require inclusivity, flexibility, addressing of power dynamics, and the ability to solve issues (Djenontin & Meadow, 2018; Doering et al., 2022; Norström et al., 2020; Pennington, 2016; Sarkki et al., 2015; Turnhout et al., 2020; Wall et al., 2017). Communication is crucial for transparency and developing a shared understanding, which requires dedicated time and often a communication plan (Djenontin & Meadow, 2018; Doering et al., 2022; Norström et al., 2020; Pennington, 2016; Sarkki et al., 2015; Turnhout et al., 2020; Wall et al., 2017; Yua et al., 2022). Also contributing to transparency are clear roles and responsibilities in leadership over parts of the project, communications, ethics, and expectations (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Doering et al., 2022; Lemos et al., 2018; Norström et al., 2020; Sarkki et al., 2015; Wall et al., 2017). Boundary spanners can support communication and knowledge exchanges between organizations involved with knowledge of the different perspectives (Bednarek et al., 2018), such as a Tribal employee facilitating work with an Indigenous community. Considering these interpersonal factors and developing plans at the inputs phase will ensure these factors do not negatively impact the project at later stages. Evaluation of interpersonal factors could be the sufficient participation (e.g., frequency and intensity) of researchers and community partners to support shared understanding, as well as surveys of the perceived satisfaction of communication and engagement (Ferguson et al., 2022; Posner & Cvitanovic, 2019; Wall et al., 2017).

Partnership—The formulation of the formal partnership during the proposal phase (Doering et al., 2022; Ellam Yua et al., 2022) has several factors, but the most important is co-producing the research design (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Doering et al., 2022; Norström et al., 2020; Wall et al., 2017). Legitimacy, or the sense of fairness, must be built through trust and relationship building, as well as equitable funding distribution (Djenontin & Meadow, 2018; Ferguson et al., 2022; Lemos et al., 2018; Sarkki et al., 2015; Zanolli et al., 2020). A community-driven project will be relevant by being in the local context, which in practice is often supporting existing initiatives and relationships (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Lemos et al., 2018; Norström et al., 2020; Sarkki et al., 2015; Wall et al., 2017). For Indigenous Peoples, community-driven research also follows an equity model that respects sovereignty and self-determination (Doering et al., 2022; Meadow et al., 2015; Yua et al., 2022), with capacity building and empowerment supporting communities to conduct their own research. Evaluation metrics could be a formal letter of collaboration as part of a proposal, a memorandum of understanding or agreement (MOU/MOA), community partners as principal or co-investigators, and informed consent. The Kake Climate Partnership, the topic of the companion paper by Figus et al. (2024), sets a good example of partnership development among Indigenous and non-Indigenous partners based in trust. This trust required Figus spending several months on relationship building after pitching the partnership idea to three leadership entities in Kake, Alaska. The Kake Climate Partnership sets an example of transparency with not only having an MOA but also a two-page Principles and Expectations document highlighting the agreed upon roles and research practices (Figus et al., 2022).

5.3. Process

Process Factors of Success within the project activities include the research practice, implementation, and tangible outputs or products.

Practice—The extensive literature on Indigenous engagement calls for better research practices from the broader research community as well as provides guidance on more ethical and equitable engagement. Education and training on ethics varies greatly depending on discipline, especially for natural and physical scientists who are not trained in human subject research. Indigenous ethical frameworks are developed to consider the context of colonization and systemic inequity, as well as culturally responsive of Indigenous Knowledges and intellectual property (David-Chavez & Gavin, 2018). Examples of Indigenous ethical frameworks are the UN's Free, Prior and Informed Consent (Food and Agriculture Organization of the United Nations, 2016), CARE Principles for data governance (Carroll et al., 2020), and the Inuit Circumpolar Council's Ethical and Equitable Engagement (Inuit Circumpolar Council, 2021), as well as regional and community-specific ethical frameworks. Identifying and implementing an ethical framework can be an evaluation metric of projects with Indigenous communities as it supports transparency and shared understanding. When working with Indigenous Peoples, a crucial factor is being culturally inclusive and respect of other knowledge systems, including giving credit to contributions from Indigenous Knowledge-Holders (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Ellam Yua et al., 2022; Latulippe & Klenk, 2020; Norström et al., 2020; Turnhout et al., 2020; Zanolli et al., 2020). With the CPK approach, Indigenous partners can co-analyze and co-author papers, rather than be anonymous participants. Critical methodologies push research communities to be more equitable and ethical through questioning the status quo and rules of engagement (Doering et al., 2022; Latulippe & Klenk, 2020; Yua et al., 2022; Zanolli et al., 2020). An Indigenous methodologies concept is relational accountability, which means prioritizing relationships in a project (David-Chavez & Gavin, 2018; Yua et al., 2022), which includes many factors within the Inputs stage (Section 4.2).

Implementation—The definition of CPK includes being interactive at every step, including data collection and analysis. To co-produce a project requires shared decision-making, where research partners have decision-making power and authority (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Norström et al., 2020; Wall et al., 2017; Yua et al., 2022). Building off factors of success within the practice section, to co-produce the methods requires flexibility by researchers in adapting methods, funding, communications, and outputs to be culturally inclusive (Djenontin & Meadow, 2018; Doering et al., 2022; Yua et al., 2022). There are numerous engagement strategies, for example, research activities, data management, ethical frameworks, and facilitation and communication plans, to support achieving CPK from Indigenous methodologies, convergence, and team science literature (Djenontin & Meadow, 2018; Kovach, 2009; Norström et al., 2020; Pennington, 2016; Smith, 2012; Yua et al., 2022; Wilson, 2008). Successful CPK projects include co-learning and social learning (learning from each other) to understand the different worldviews and decision contexts (Bremer & Meisch, 2017; David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Euskirchen et al., 2020; Norström et al., 2020; Pennington, 2016; Sarkki et al., 2015). Social learning requires iterative, frequent interactions to develop a shared understanding with effective communication, including facilitated activities (Djenontin & Meadow, 2018; Norström et al., 2020; Pennington, 2016; Sarkki et al., 2015; Wall et al., 2017). The reflexivity concept within intrapersonal section is also important during the implementation for course correction, which can be achieved through conducting formative evaluation on the process and activities to measure the satisfaction of engagement (Djenontin & Meadow, 2018; Doering et al., 2022; Norström et al., 2020; Pennington, 2016; Wall et al., 2017).

Outputs—The outputs are the tangible products of a project, which should be co-produced to achieve the usable, actionable outcomes (Djenontin & Meadow, 2018; Doering et al., 2022; Norström et al., 2020; Sarkki et al., 2015; Yua et al., 2022). Peer-reviewed articles are a typical research project output. However, other types of outputs are generally required in order to be accessible and useful to the community partners, such as gray literature, tools, or other communications for the community as well as for other decision-makers (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Lemos et al., 2018; Norström et al., 2020; Sarkki et al., 2015; Wall et al., 2017). Ideas for gray literature could be policy reports, white papers targeting different audiences, science communication and graphics, Environmental Impact Statements, and workshop reports. To ensure the outputs reach their intended audience, there should be shared dissemination (Djenontin & Meadow, 2018; Yua et al., 2022). Using the Kake Climate Partnership (Figus et al., 2022) as an example, climate service outputs relate not only to data collection/publication, but also workforce development and healing from intergenerational trauma (Figus et al., 2024). Data

for baseline monitoring in Kake are collected by local people who are paid to complete training and paid to carry out field work (with projects defined by local leaders). Local high school and college students are mentored in internships and part-time work, including support to present at regional and national conferences. Peer-reviewed publications from the Kake Climate Partnership include co-authorship with local partners (including two mid-career professionals and two undergraduate students, at the time of this publication). Perhaps most important, Kake Climate Partnership work is approached from a healing standpoint, where team members are invited and supported, not pressured or judged (e.g., if they need to cancel attending a fieldwork event at the last minute). The actions of trust and relationship building are a constant part of the work and key for every output.

5.4. Outcomes

The outcomes of the project that happen during and after the project ends include the achievement of goals, impacts with co-developed indicators, and participants' perspective on success.

Outcomes—Outcomes are the measure individual uses and actions in the short-term as a direct result of the project (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Mertens & Wilson, 2019; Norström et al., 2020; Wall et al., 2017). Outcomes also include assessing the achievement of the co-developed goals (Djenontin & Meadow, 2018; Norström et al., 2020; Yua et al., 2022). CPK project goals typically include tangible benefits for the partners and the community, including non-academic outcomes of building capacity and empowerment of partners (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Norström et al., 2020; Sarkki et al., 2015; Turnhout et al., 2020; Wall et al., 2017). The perceived relevance, legitimacy, and credibility of the outcomes impact their application and utilization co-produced knowledge, as discussed in Section 5.2 (David-Chavez & Gavin, 2018; Djenontin & Meadow, 2018; Lemos et al., 2018; Norström et al., 2020; Sarkki et al., 2015; Turnhout et al., 2020; Wall et al., 2017).

Impacts—In comparison to outcomes, impacts are the societal and institutional changes that are a direct or indirect result of the project in the short-, medium-, and long-term (Chambers et al., 2021; Djenontin & Meadow, 2018; Lemos et al., 2018; Meadow & Owen, 2021; Norström et al., 2020; Wall et al., 2017). Impacts can be beneficial changes within the practice and policy (e.g., land/water management or local/state/federal policies) (Djenontin & Meadow, 2018; Lemos et al., 2018; Norström et al., 2020; Pennington, 2016; Turnhout et al., 2020). Institutional changes include new partnerships, diversified networks, built trust, utilization of information, greater understanding of an issue, and increased capacity and motivation (Posner & Cvitanovic, 2019; Wall et al., 2017). For example, if a project provided funds for a Tribe to hire a local research professional to work for the project, this would be an outcome. If that became a permanent position and became a sustained built capacity, it would be an institutional change and therefore an impact. Examples of societal impacts include more resilient ecosystems, environmental justice, adaptation and mitigation implementation, and increased food and water security. Following CPK, the impacts should be co-identified with co-developed indicators, such as co-defining food and water security that is culturally responsive and within the context of the partner community that can be used to measure both direct and indirect societal impacts (Djenontin & Meadow, 2018; Meadow & Owen, 2021; Norström et al., 2020; Yua et al., 2022).

Perspectives of Success—There is an element of subjectivity in viewing a project as successful, which is rooted in having different priorities for interacting with the project (Norström et al., 2020; Wall et al., 2017). The co-produced evaluation method should be participatory, with co-developed success metrics, and culturally responsive to solicit effective feedback (Doering et al., 2022; Lemos et al., 2018; Norström et al., 2020; Turnhout et al., 2020; Wall et al., 2017; Yua et al., 2022). A culturally responsive success metric would be supporting relationships and networks (Djenontin & Meadow, 2018; Norström et al., 2020; Wall et al., 2017). With CPK, it is the process that creates success. Therefore, the research process should be evaluated along with the outcomes (David-Chavez & Gavin, 2018; Norström et al., 2020; Sarkki et al., 2015; Wall et al., 2017).

6. Discussion

In using the tools and models presented in this article, the Factors of Success (Section 4) for CPK show the overall research project life cycle for strategizing. In order to use our Factors of Success logic model (Figure 2), project team members need to understand their own positionality as well as the inherent assumptions, needs, and goals of the research project. The multifaceted perspectives of dispositions and discussions of relevance, credibility, and legitimacy bring awareness to positionality (Section 5). With finite time and resources, researchers will need to

prioritize certain Factors of Success over others with consideration of balancing the perspectives as shown in Figure 1. There is no “checklist” for CPK but rather a process that supports shared decision-making with research partners over every stage of the research. With each project being contextually different depending on the partnering community and topical area, researchers cannot simply take what worked within one project and apply it to another project. For each project, the process of co-designing every step of the process detailed in Section 5 must be completed anew. Understanding the positionality of the team and its individual members will help in negotiating these priorities.

The tools presented in this article can be applied in a variety of ways, with their main purpose during the co-design phase of a project. For example, a team that has never worked together before might use this article as a guide during time spent building relationships, solidifying trust, and supporting mutual learning. When following guidelines from this article throughout a research project, social learning should be prioritized to support convergence around a topic and goal, rather than non-integrated parallel efforts. Communication, transparency, shared decision-making, and the practice of Factors of Success will build legitimacy, which takes time and intentionality (Lemos et al., 2018; Sarkki et al., 2015; Yua et al., 2022). Building legitimacy can be achieved through reviewing our Factors of Success to support shared decision-making about which aspects to prioritize within a project. Through building legitimacy, a research team can build cohesion and become more productive, especially over continued and ongoing collaboration with each other (Ferguson et al., 2014; Stokols et al., 2008).

Looking again at the Kake Climate Partnership in Southeast Alaska (Figus et al., 2022) the tools described in this article have been used in multiple ways. Figus et al. (2022) detail the joint decision-making processes during the first 2 years of the partnership, which align with this paper. Additionally, in evaluating the Kake Climate Partnership (Figus et al., 2024), the Yua et al. (2022) CPK model influenced the evaluation themes, which aligns with the Practice and other Indigenous elements within the Factors of Success presented in this article. The Kake Climate Partnership's resultant concepts of success included intergenerational healing, engaging in work using Indigenous priorities and values, supporting future generations and workforce development. With those priorities, the Kake Climate Partnership focused on activities such as developing paid work, educational and mentorship opportunities for local adults, undergraduates and high school students in the rural, remote community of Kake within a research project that included ocean and stream field monitoring program as well as an interview project (Figus et al., 2022, 2024). As described in Section 5.3, academic priorities like peer-reviewed publications were balanced with community priorities by taking time to bring in co-authors from Kake. Project topics were determined by local leaders in Kake, while academic partners used their capacity to design and carry out project objectives. Overall, the scientific outputs became less of a priority than capacity building and supporting self-determination of Indigenous partners, but through support for self-determination scientific outputs followed.

Another example that has unfolded differently is the NSF NNA program. In the example of NSF NNA, applying the information from this article is useful for analyzing existing research funding mechanisms. The NSF NNA program encouraged practicing CPK with Arctic Indigenous communities (National Science Foundation, 2018) yet has been met with criticisms from Indigenous leaders from western Alaska (Bahnke et al., 2020, 2021). One of the main criticisms is the misuse of the term, “CPK,” for projects not co-produced at every step of the research process, specifically researchers who wait to approach communities until close to a funding proposal deadline with fully developed proposals and budgets. This behavior reduces opportunities for community or Indigenous partners to co-create project ideas and budgets, effectively relegating them to supportive rather than leadership roles on a project team. When placing this example in the context of our Factors of Success and the multifaceted perspectives presented above, it becomes clear that the prevalence of a post-positivist disposition (Creswell & Creswell, 2018; Mertens & Wilson, 2019) in the original design of the NSF NNA program prioritized scientific outputs over Indigenous self-determination.

The post-positivist disposition typically does not prioritize the input stage of the process. A post-positivist disposition's focus on outputs creates tension with the Indigenous research disposition, in which the input aspects are prioritized. The priority on intrapersonal aspects in the Indigenous paradigm means Indigenous partners want to know who the researchers are and build trust *prior* to committing to a partnership (Kovach, 2009; Wilson, 2008; Yua et al., 2022). There is a long history of unethical research that reinforces colonization and colonial systems and structures, creating a general distrust of research and researchers (Smith, 2012). While the post-positivist dispositions are practicing research according to the paradigm in which they were trained, in the example of the NSF NNA, this unintentionally offended potential Indigenous partners and caused unintentional harm.

While this article helps provide context and understanding of issues surrounding CPK research with Arctic Indigenous Peoples, the fundamental structure of most research funding, including short turnaround time on proposals, can create systematic barriers to achieving CPK projects by inhibiting societal benefits of research. To avoid this problem, some CPK teams have side-stepped larger-scale funding to leverage multiple smaller sources of funding from a mix of public and private funders (e.g., Figus et al., 2022, 2024). But this is a workaround and not a solution. We recommend that NSF and other large-scale funding sources consider new approaches to supporting CPK research teams, including: announcing calls for proposals at least 12 months before the submission deadline; requiring that principal investigators and project leads from academia have demonstrated success conducting CPK for smaller-budget projects (e.g., in the hundreds of thousands of US dollars) prior to awarding them large-scale funding (e.g., in the millions of US dollars); and weighting portions of proposals that describe planned CPK processes as heavily as the portions describing plans for data collection, analysis, and expected outcomes. To support Indigenous self-determination in research funding, it is also important to include Indigenous leaders on every committee/board/task force that develops CPK funding opportunities and conduct government-to-government consultation with Tribes to inform long-term strategic planning for government funding opportunities like those offered through NSF and Federal agencies.

It is crucial to support Indigenous self-determination through equitable decision-making, funding, and representation, as well as to follow Indigenous ethics and ways of doing research to achieve cultural inclusivity. We hope the reader comes away with increased awareness of different elements in the CPK research processes and different paradigms of research, as well as their own positionality(ies) within those processes and paradigms. We also hope the reader recognizes the need for equitable decision-making and dialog within the context of every CPK project.

7. Conclusion

The goal of this article is to provide tools for transparent communication within CPK projects, with the ultimate aim of improving the success of these projects - including success as defined by the Indigenous partners. We have synthesized concepts across several research fields to help the reader understand different approaches to creating success within CPK projects that include partnerships with Indigenous communities. The first part (Section 4) presented a logic model for understanding the different factors that contribute to successful collaborative projects. The second part (Section 5) outlined how different trained research paradigms prioritize different research stages, factors, and success metrics, including perceptions of relevance, credibility, and legitimacy. The authors hope the reader comes away with increased awareness of different elements in the CPK research process and different paradigms of research. The authors also hope the reader recognizes the need for co-decision-making dialog within the context of every CPK project.

The framing of this article is based on the lead author's own worldview as an Indigenous scientist and builds upon similar prior work (Djenontin & Meadow, 2018; Ellam Yua et al., 2022; Wall et al., 2017). Further work is expected from other positionalities as the CPK field continues to advance. From the lead author's positionality, it is crucial to support Indigenous self-determination through equitable decision-making, funding, and representation, as well as following Indigenous ethics and ways of doing research to achieve cultural inclusivity.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

No data was collected or created as part of this work.

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