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Key Points:

- Convergence across disciplines and nations is required to address the complex impacts of a changing Arctic on society and ecosystems
- Convergence research requires consensus-building, cross-disciplinary relationship building, and new institutional reward structures
- Challenges and benefits of purpose-driven, societally relevant research in the Arctic are discussed, and strategies for success are shared

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Is A Common Goal A False Hope in Convergence Research?: Opportunities and Challenges of International Convergence Research to Address Arctic Change

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Abstract The Arctic faces multiple pressures including climate change, shifting demographics, human health risks, social justice imbalances, governance issues, and expanding resource extraction. A convergence of academic disciplines—such as natural and social sciences, engineering and technology, health and medicine—and international perspectives is required to meaningfully contribute to solving the challenges of Arctic peoples and ecosystems. However, successfully carrying out convergent, international research and education remains a challenge. Here, lessons from the planning phase of a convergence research project concerned with the health of Arctic waters developed by the Arctic Science IntegrAtion Quest (ASIAQ) are discussed. We discuss our perspective on the challenges, as well as strategies for success, in convergence research as gained from the ASIAQ project which assembled an international consortium of researchers from disparate disciplines representing six universities from four countries (Sweden, Japan, Russia, and the United States) during 2018–2020.

Plain Language Summary Bringing together scientists from across multiple disciplines is required to solve societal and ecological issues resulting from a changing Arctic. However, working together across disciplinary, international, and cultural boundaries poses challenges. We describe our efforts to overcome these challenges to bring about meaningful understanding of the vulnerability of Arctic peoples and ecosystems, where we applied particular focus to Arctic waters. Over three years, we brought together researchers from six universities and four countries across many disciplines, from sociologists to human health specialists to oceanographers to permafrost microbiologists to engineers. Here, we chronicle our successes and hurdles, and outline strategies for successful future collaborations.

1. Introduction

The Arctic is globally recognized as the bellwether of anthropogenic climate change. With rapidly rising surface temperatures (Hartmann et al., 2013; Overland et al., 2019), dramatic sea ice declines (Maslanik et al., 2007; Onarheim et al., 2018), thawing permafrost (Grosse et al., 2016; Hugelius et al., 2020; Petrov et al., 2017), coastal erosion (Overduin et al., 2014), and substantial mass loss from the Greenland ice sheet (Briner et al., 2020; Mouginit et al., 2019), changes are already permeating globally through physical, biological, socio-economic, and geopolitical systems. The warming, melting, and thawing Arctic has created highly complex challenges for human communities including overlapping issues of governance, infrastructure, health, access to natural resources, commerce equity, and Indigenous rights (Durfee & Johnstone, 2019; Stephen, 2018). Most governments recognize that in order to address such vexing problems, success can be achieved through international collaboration and diplomatic transparency (e.g., The Arc-

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tic Council). Successful interdisciplinary initiatives include the International Geophysical Year, the International Geosphere/Biosphere Program, and the Intergovernmental Panel on Climate Change. Funding agencies also contribute to convergence through such programs as the US National Science Foundation's programs "Growing Convergence Research" (National Science Foundation, 2019) and "Navigating the New Arctic" (National Science Foundation, 2020), Nordforsk's Joint Nordic Initiative on "Responsible Development of the Arctic: Opportunities and Challenges – Pathways to Actions" (Nordforsk, 2015), the Japanese MEXT's "Arctic Challenge for Sustainability" (Ministry of Education Culture, Sports, Science and Technology (MEXT), 2015), and the Russian Foundation for Basic Research's request for proposals seeking international collaboration at the interface of natural sciences and socio-humanitarian areas (Russian Foundation for Basic Research, 2018).

While the Arctic Council has been a high-level political forum for governance issues since 1996, an international top-down agenda for the Arctic has been hard to develop (Nord, 2019). Top-down initiatives—if guided by clear governance and consensus among the concerned nations—allow scientists to more easily focus on structuring collaborations and conducting research. They render a clarity of goals and can be conducive to scientific progress (Lau et al., 2014; Wallenstein, 2009), while also providing a solid funding base. However, top-down initiatives may also be destructive to the freedoms of discovery, expression, and communication needed for meaningful scientific progress (Fähnrich, 2017; Sörlin, 2011) and are particularly harmful if they are based on outdated knowledge, which is particularly critical while trying to advance understanding of the rapidly changing Arctic. Due to the contentious and political nature of the Arctic, bottom-up convergence from scientific problem-solving and the resulting initiatives may hold more promise for addressing the complex linkages of society and ecosystems inherent in Arctic challenges.

Societal grand challenges—such as those posed by a changing Arctic—require broad, yet systematic approaches that integrate diverse knowledge and perspectives while being highly collaborative. Built from the bottom-up, these so-called convergence research approaches can contribute new knowledge at the confluence of separate disciplines by the cooperative work of individuals (National Research Council, 2014; National Science Foundation, 2019). Convergence research can be viewed as the next progression in the continuum of research thought, moving from intra-, to multi-, to cross-, to inter-, to trans-disciplinary (Klein, 2010; National Academies of Sciences and Engineering and Medicine, 2019). Scientific convergence thus requires that natural and social scientists and engineers participate in the design and implementation of need-driven scientific research, integrating qualitative and quantitative techniques into experiments, modeling, and inductive frameworks (Moses & Knutsen, 2019). Given the structures of scientific endeavors nationally as well as internationally, scientific convergence—even when constrained to the Arctic—represents a tall order.

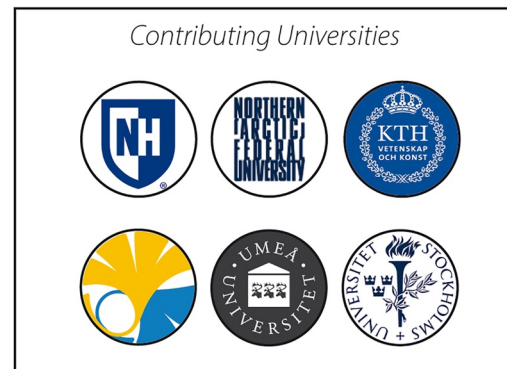
The aim of this article is twofold. We convey and discuss challenges in the formation of a small-scale, interdisciplinary and international convergence Arctic research project, the Arctic Science IntegrAtion Quest, ASIAQ. Further, based on lessons learned from this effort, we provide strategies to improve similar efforts. Our empirical source is four ASIAQ workshops and planning meetings, which brought researchers, both junior and senior, from six international universities together for a period of three years (Figure 1). We chronicle our experiences fostering collaboration across disparate disciplines in the internationally contentious Arctic setting, where we converged around the common theme of the well-being of the waters and peoples of the Arctic.

2. Challenge-Driven Strategies for Successful Convergent, International Arctic Research

Working in interdisciplinary, international teams presents unique challenges, ranging from team dynamics to logistics, balancing obligations of various career stages, cultural awareness, maintaining forward momentum, and funding. While the interdisciplinary and purpose-driven approach to problem-solving embodied by convergence research is meant to tackle the technical, organizational, and logistical challenges to collaboration from the outset (National Research Council, 2014), ASIAQ struggled with this objective; most scientists and engineers are not trained—and often not rewarded professionally—for maneuvering these types of interpersonal and team dynamics. Furthermore, translating natural scientific findings and engineering

The focus of ASIAQ is the well-being of Arctic waters—those on land and the Arctic Ocean—as Arctic waters are fundamentally important due to their impact on global climate, economics, politics, and on health and well-being of **INDIGENOUS** and local communities in the Arctic. The responsibility for a sustainable Arctic cannot be confined to people in the Arctic. Water does not recognize geographic, political or disciplinary boundaries.

The Arctic Science IntegrAtion Quest (ASIAQ, 2018–2020) brings together expert competence in typically non-collaborating disciplines across engineering and technology, natural science, medicine and health, and social science to address the fundamental challenges facing the Arctic ecosystem and its inhabitants through the common link of Arctic waters.



Creating an international, multi-academic forum to discuss and develop convergent solutions



Joint research, education and outreach activities to develop a holistic Arctic Science perspective and strengthen collaboration between Russian, Japanese, US and Swedish universities



Communication with stakeholders to enable fact-based decision making for a sustainable Arctic and its communities, with ramifications far beyond this region.

Figure 1. The guiding mission and principles of ASIAQ and contributing universities. ASIAQ is the name of the weather goddess in Inuit mythology, cf. <https://en.wikipedia.org/wiki/Asiaq> (accessed March 06, 2021). The ASIAQ planning project had a short and finite runtime (3 years), and funded mainly network activities, researcher mobility, and student projects to develop sustained collaborations and build future leaders.

technological advances to societally relevant impacts requires unique training to formulate narratives for a broad audience. Viable research opportunities have to be explored and assessed depending on geopolitical contexts, stakeholder and community needs, and resources. We discuss challenges we faced below and suggest strategies for successful international, convergence collaboration (Table 1).

2.1. Common Mission and Goals

We found that the most crucial feature of successful convergence was a shared mission, rigid enough to provide boundary conditions for ongoing and future work (Petrov et al., 2017) but adaptive enough to flex and change as relationships between participants and interdisciplinary understanding grows. In the opening workshop at Stockholm University in 2018, ASIAQ participants identified compelling, collaborative research questions and set clear goals to prioritize actions resulting in tangible outcomes motivated by specific United Nations Sustainable Development Goals (SDG's). This participatory activity was guided by experienced workshop facilitators, to whom we, in large part, attribute the success of the first workshop. Facilitation was as follows. Participants, regardless of academic background, were tasked with breaking down SDG's (previously selected for their relevance to water) to researchable questions. Smaller groups (6–10 participants) were formed and given time to elaborate on their sense of immediacy for certain research questions (after some activities to get to know each other). As the workshop unfolded, the facilitators carefully mapped and summarized conclusions and outstanding issues. In the event that workshop facilitators are

Table 1

Emergent Challenges During the ASIAQ Project and Suggested Actions to Meeting These Challenges, Towards Fostering Successful International, Convergence Research

Challenge	Suggested actions
Common mission and goals	- Co-develop a shared mission using consensus-building and participation-driven collaboration techniques (e.g., dot voting, mind mapping, boundary objects, and break-out groups). - Collect biographies and research slides in advance of the workshop to engage participants and identify themes and objectives. - Compile learning packets, identify potential collaborative funding opportunities, and establish social media hashtags. - Select speakers and panelists from among workshop participants to represent the diversity of nations, institutions, demographics, and disciplines.
Group dynamics and participation	- Rotate hosting responsibilities between participating institutions to enable the network to expand its membership within host nations. - Consider, encourage and support travel-free, virtual meetings (especially important during the COVID-19 pandemic and with the carbon costs of travel). - Host workshops at shared field sites or coincident with popular international gatherings to increase attendance, engagement, and community building. - Integrate casual social outings like visits to laboratories or to sites relevant to the culture of the host nation.
Balancing obligations of different career stages	- Empower early career researchers to engage in peer mentoring and research and provide access to input from senior mentors. - Retain graduate students who moved to other institutions during the course of the project. - Recognize the value of postdoctoral scholars to serve as participants, because of their flexibility and tendency to transition to independent research projects.
Silos and interdisciplinary work	- Educate university reward structures (e.g., promotion and tenure committees) about the importance and relevance of convergence research and suggest that laying the foundations of convergence research should be rewarded. - Utilize feedback-mechanisms (e.g., halftime and final reports) to inform funding agencies about successes and timelines of convergence research relative to disciplinary research.
Cultural and disciplinary awareness	- Maintain transparency and increase inclusivity beyond disciplinary boundaries using techniques such as “vocabulary wall,” banning acronyms, collaborative online note-taking, and shared editable online documents. - Share collaborative tools in pre-conference communications and during introductory logistics discussions to familiarize participants with the objectives of transparency, collaboration, and trust-building. - At the project initiation, discuss how to facilitate engagement with government stakeholders and resident communities, as well as how to develop strong, authentic relationships. - Promote open access to preliminary products (e.g., datasets, maps, or models).
Forward momentum	- Provide opportunities to build and maintain relationships among institutions and individual researchers. - Provide funding for mobility of researchers (especially early career) to engage in research and extended visits to partner institutions. - Once relationships are established, researchers are well-positioned to take advantage of external funding opportunities to support sustained collaboration.

inaccessible, extensive literature on inter-organizational collaboration (e.g., Daniels & Walker, 2001; Heath & Isbell, 2017; Kania & Kramer, 2011) and participatory conferences (e.g., Chambers, 2002; Segar, 2017) can help self-guided workshops stay on task and break through the tensions that can inhibit international and interdisciplinary interactions.

Over the three years, ASIAQ provided an opportunity for engagement with colleagues from a wide range of disciplines and perspectives (Figure 1) and was focused on finding commonalities and differences in our individual research programs that could be exploited to advance understanding the rapidly changing Arctic. This approach created the momentum for an intense learning experience for the participants with

respect to interdisciplinarity and convergence research. From this process, ideas converged around several compelling, societally relevant research questions related to the well-being of Arctic waters and people that would require not just representation from multiple disciplines, but the deep integration across disciplines. Two examples include, identifying and mapping natural and anthropogenic sources of local and regional Arctic water-pollution by measuring and modeling the fate of biological and environmental contaminants in response to thawing conditions, and investigating the impact of regulation and protection on human and ecosystem health and well-being in the face of increased cruise tourism. Furthermore, the series of ASIAQ workshops led to broadened dialogs and reflections on the relationships between disciplinary and integrative research, ranging from descriptions of the difficulties experienced in defining a common goal to maintaining a convergence-based approach that does not conflict with the everyday research, teaching, and administrative demands of participant institutions and programs.

Our experience in ASIAQ is that it can take far longer than anticipated to jointly formulate convergence research objectives and to take actionable steps on problems with the complexity to require convergence research methods. This may lead to occasional frustration among researchers accustomed to pursuing solutions to known questions within their disciplinary expertise. This mirrors the top-down/bottom-up predicament discussed previously regarding whether research agendas should be set by governments or scientists. In ASIAQ, the international agenda was intentionally set through bottom-up scientific convergence, but maintaining momentum was difficult without continued strategic, mid-to-long term organizational (i.e., top-down) project support. In other words, we found that we could successfully formulate convergence research objectives using bottom-up approaches, but progress towards achieving tangible research results was difficult without top-down organization, momentum, and goal setting. At the same time, a less structured management style allowed flexibility to pursue discussions in the form of new bottom-up approaches, and hence to deviate from the main agenda, resulting in new valuable collaborations. For example, Messori et al. (2020) successfully initiated a new interdisciplinary collaboration working with Arctic temperatures extremes building on sharing technical products (e.g., datasets and statistical tools) after trust had been built between ASIAQ partners.

2.2. Group Dynamics and Participation

Building trust amongst participants is especially important in convergence research, and a considerable challenge with international participants from disparate disciplines. For example, across participants from different nations, there can be a lack of familiarity with the institutions in which people trained and uncertainty about metrics of advancement and promotion success. Across disciplines, it is challenging to measure whether a person is well-regarded in their field and the collegiality of the potential colleague. We found that rotating the hosting responsibilities allowed different institutions the opportunity to showcase their expertise and leadership, leading to deeper relationships among researchers.

Another challenge to our group dynamics and ability to build trust was a rotating participant list. We expected the same attendees across several ASIAQ meetings and planned to organize at least two meetings per year. Unfortunately, this was not possible for reasons including travel issues (e.g., visas), academic schedules, participant teaching loads, job mobility, and time constraints. This resulted in a shifting participant list and arguably limited the ability of the participants to build the trust required to deeply integrate with one another to a certain degree. However, keystone participants, mostly senior scientists and other faculty (but also a postdoc with the strong institutional support of Umeå University) were able to keep momentum in tackling Arctic socio-ecological issues. Continual participation from students and most postdocs was not possible, however ASIAQ maintained impact on younger researchers through Arctic-focused mentoring and course opportunities at ASIAQ institutions, mobility grants enabling visits at partner universities, and joint, small-scale field work at Arctic sites. Over time, we learned that virtual gatherings and meetings alongside or in lieu of in-person events enable cross-institute communication, even when travel is not possible due to visa issues or other obligations. Further, organizing in-person events to coincide with field courses or cultural events ease travel burdens for participants. ASIAQ aims to host a field course on communication of science with Arctic residents at Stockholm University's Tarfala Research Station in the Kebnekaise Mountains (northern Sweden), which has been delayed twice due to COVID-19.

2.3. Balancing Obligations of Different Career Stages

ASIAQ was designed to provide opportunities for early career researchers to take leadership roles on team efforts and products in order to position them to affect change. In practice, we found these leadership opportunities to be inaccessible for early career researchers, presumably because they have many outside obligations to balance. The fluctuating participant list may be an indicator of this. Graduate students are working against short timelines and may find it untenable to balance convergence research obligations against their own, disciplinary research responsibilities, especially if they do not have direct intellectual support from their supervisor. On the other end of the “early career” spectrum, junior faculty members can decide to take on more responsibilities; the rewards may be transformative to one’s career (e.g., writing grants and manuscripts in a much broader context), but depending on the funding structure at their institution, picking up additional research duties may be unpaid. Despite these challenges, one junior faculty member was able to develop curriculum to engage students with Arctic issues relevant to ASIAQ; this coursework—and the diligent work of graduate and undergraduate students—resulted in a peer-reviewed publication about heavy metals and Arctic change (Perryman and Wirsing et al., 2020). The same junior faculty member has also stepped into a leadership role on this manuscript, a process which has led to deeper collaborations and relationship-building with researchers across disciplines and with whom there was considerably less exchange and engagement previously. The potential future benefits are unrealized, but great.

2.4. Silos and Interdisciplinary Work

Institutions of higher education are often siloed by discipline which can significantly limit the success of cross- and transdisciplinary collaboration (Goring et al., 2014). Traditional metrics for success—such as the reliance on publications and disciplinary expertise during promotion of researchers and faculty—are often misaligned with the type and longevity of the effort it takes to do sustained convergence research, especially in an international context. ASIAQ participants broadly agree that due to current structural limitations of our institutions, it is nearly impossible to participate fully in convergence research. Many researchers are also concerned that the quest for convergence funding could limit efforts to simultaneously advance within traditional disciplines. However, an example of the inverse resulted from ASIAQ; one University of New Hampshire (UNH) faculty member is currently funded by The Swedish Research Council as a Visiting professor at Stockholm University (SU). Finding sustained funding for international convergence work may need to come from non-governmental sources or scarce partnerships between governments geared toward funding large-scale international projects (e.g., the Belmont Forum, US NSF-UK NERC).

2.5. Cultural and Disciplinary Awareness

While ASIAQ participants uniformly agree in the value of the diversity of international and integrated perspectives to address ASIAQ questions, working within cultural differences among nations, demographics, and disciplines remains a challenge. Therefore, at every ASIAQ workshop, we strived to create and maintain cultural awareness. This had implications on the structure of discussions, where we focused on conceptualizing questions versus proposing solutions, which is particularly important in forging collaborations between biophysical and social scientists (National Research Council, 2014). This focus on questions rather than solutions has farther reaching potential, though we feel this was underexploited, a shortcoming that could have been remedied if professional facilitators had been engaged in all ASIAQ workshops, not just the first.

One aim of the ASIAQ network was to create opportunities for research and education participants to co-produce understanding with stakeholders and Arctic residents, particularly Indigenous and non-Indigenous local communities, to ensure that the scientific findings have societally relevant outcomes (Figure 1). We discussed when to bring stakeholders and communities into the conversation and whether representatives of these groups (e.g., consortia, non-profit and boundary spanning organizations) are adequate. One shortcoming we have identified is that we did not engage stakeholders and Arctic communities directly in the development of research questions related to the ASIAQ goals—rather focusing on outreach—which likely would have made our research more participatory and more meaningful for solving real-world issues (English et al., 2018). Indigenous voices—and even non-Indigenous northern

voices—are often lost in the conversation about the Arctic once the interests of the Arctic nations are involved (Nilsson & Christensen, 2019), a problem a growing number of Arctic Early Career Researchers is aware of (Sjöberg et al., 2018). Involving stakeholders and communities ensures that solutions to what constitutes a real-world issue in the Arctic come from the interest of Arctic peoples. Before the initiation of ASIAQ, the majority of the researchers were unknown to each other, and early efforts were placed on building these interdisciplinary relationships. However, in retrospect, involving Arctic residents and decision makers from the outset could have created a context for authentic relationship building coincident with the expansion of understanding across the expertise of participants from different backgrounds. It is challenging to consider how to involve non-academics prior to the initial organization of the academic participants, however this may be the place for more senior leaders to lay groundwork prior to the start of a convergent effort such as ASIAQ.

3. Conclusions

There is a growing understanding that scientific priorities cannot be separated from societal issues, particularly when it comes to considerations like the well-being of Arctic waters which cut across far reaching areas, such as global change, human and ecosystem health, and policy. Despite this, social indicators are often not included when assessing change in the Arctic, and their development has lagged behind their physical and biological counterparts (Box et al., 2019). The challenges of working across disciplines may be, at least in part, to blame for this. Being confronted by perspectives from different disciplines allows for deep learning experiences, catalyzing researchers to increase the scale and reach of their research and make an impact on global-scale problems. Within a flexible framework—with program activities (e.g., research, education, and outreach) at times being motivated by top-down leadership and at times emerging from bottom-up efforts—collaborations at the convergence of disciplines or of previous understanding can be very impactful. The challenge of convergence research also includes the difficulties of continuously carrying forward momentum and coming full-circle by feeding newly gained knowledge back to our own disciplines. In times of a global pandemic, this may be even more difficult because many scientists, especially early career ones, are confronted with the necessity of having to balance work and family obligations in new and not necessarily deliberately chosen ways (Myers et al., 2020). From our experience, encouraging peers to create lasting bonds that help us address socially informed questions about the past, present and the futures of the Arctic, while incorporating these into our educational curricula, is key to convergence research.

The experience of ASIAQ confirms the challenge and reward of creating interdisciplinary and integrated Arctic research collaborations and outcomes that are simultaneously aspirational and measurable. One early career researcher challenged the participants at the third ASIAQ meeting with the provocative question, “Is a common goal in a transdisciplinary environment a false hope?” From our experiences, we say no, but contend that crystallizing a vision and taking actionable steps towards the goal may be hard-won. Fortunately, we see valuable progress along the way, as the process of searching for common goals stretches our research capacity as individuals. We recognize that developing a common goal and making advancements within a large and diverse cohort takes considerable time, iteration, and the generation of common understanding (Petrov et al., 2017). However, this is imperative to make scientific progress that affects societal change in a real way. Rather than abandoning longer term aims of addressing grand challenges in the Arctic for more easily attained, narrowly focused disciplinary efforts, it is important to recognize—at individual, institutional, and governmental levels—the challenges of integrated, international research efforts and to engineer the process to move towards solutions. The roadmap to long-term success starts with a clearly defined common goal, willingness to learn from other disciplines and cultures, patience and perseverance, and creative approaches to the development and nurture of these relationships.

Data Availability Statement

Data were not used, nor created for this research.

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