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Catalyzing Remote Collaboration During the COVID-19 Pandemic and Beyond: Early Career Oceanographers Adopt Hybrid Open Science Framework

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The COVID-19 pandemic introduced many challenges for research scientists: reduction of lab and field observation collection and in-person meetings. These new constraints forced researchers to remote work and virtual networking, dramatically influencing scientific inquiry. Such challenges are compounded for those in early stages of their career, where data collection and networking are vital to be seen as productive. However, during this trying time of remote work, we, as a collective of early-career oceanographers, were actively developing and improving on an already-existent hybrid community of practice. Through our experiences, we believe this type of framework can enhance virtual collaboration to the point that it outlasts the pandemic and helps create new synergies that will diversify and enhance scientific inquiry within the ocean science community. We describe a hybrid community of practice and an example workflow that models effective collaboration. We have found that three components to this model are necessary for effective collaboration, inspiration, and communication: 1) openly accessible data, 2) software, computational, and professional-development resources, and 3) a team science approach. In our experience, both the in-person and remote aspects of the model are important. In person collaboration is key to expanding the community of practice and invigorating those already within the community. Remote collaboration has been critical for effective collaborations between in-person activities and has proven to maximize outputs during in-person collaborations. While the three components of this model are not new to the scientific community, we believe that utilizing them strategically post-pandemic will diversify and expand scientific collaboration in oceanography.

Keywords: virtual collaboration, early career scientists, open science, community of practice (CoP), team science, COVID-19 pandemic

INTRODUCTION

The forced switch to remote work brought on by the COVID-19 pandemic has presented many challenges for researchers, particularly those in the early stages of their career (within 10 years of highest terminal degree) who are navigating such challenges on top of being new to the research world (Pain, 2014). Aside from virtual burnout and lack of child care, major challenges were centered around the requirement for researchers to ramp down their laboratory and field-based research, cancel in-person meetings, workshops, and conferences, and switch to virtual platforms. These challenges hindered data collection efforts, networking opportunities, and scientific exchange of ideas (Jarvis et al., 2020; Pardo et al., 2020; Termini and Traver, 2020), which are especially crucial for early career scientists (Pain, 2014; Pain, 2015). This period demonstrated that some existing remote communication and collaboration techniques were functional but may not have been fully used.

Since the emergence of the internet, the scientific community was early to adopt remote forms of collaboration, using email and social media platforms. However, the COVID-19 pandemic highlighted opportunities for virtual collaboration that may once have been seen as secondary within the oceanographic community. At a superficial level, as long as one has access to the internet and a virtual teleconferencing account, remote collaboration is possible. We have found that a multitude of other components exist that can enhance virtual collaboration to the point that this mode may outlast the pandemic and help create new synergies that will diversify and enhance scientific inquiry within the oceanographic community. Here we propose a "hybrid community of practice": an example workflow that models effective remote collaboration and is structured to remain relevant and productive after the pandemic has subsided.

MODEL FOR A HYBRID COMMUNITY OF PRACTICE

A community of practice (CoP) is a group of people who share a common concern, set of problems, or interest in a topic and who come together to fulfill both individual and group goals (http://www.communityofpractice.ca/background/what-is-a-community-of-practice/). The term "hybrid" in this context is defined as an entity (the CoP) relying on a combination of in-person components and online components which sustain community when in-person meeting is not feasible. Therefore, we define a hybrid CoP as a CoP that has built-in online resiliencies (e.g., remote computing, data already available from open sources negating the need for field work, use of virtual platforms) and sustains community not only by its online presence but also by in-person meetings and subcomponents described below.

Our CoP organically became hybrid pre–pandemic because the members, which originally met in-person, were located among geographically-distant institutions and needed to develop an effective method to collaborate remotely until we could meet in-person. We believe that establishing a hybrid CoP in person prior to going virtual led to more effective collaboration, especially during the COVID-19 pandemic. Through common interests in the Ocean Observatories Initiative (OOI; Trowbridge et al., 2019) (the "catalyst" in **Figure 1**), we, a group of early career oceanographers of various subdisciplines (i.e., physical, biological, chemical, and geological, which in this context will be referred to as "interdisciplinary"), held an in-person workshop in Washington DC in early May 2019. The meeting was established to learn about OOI data access, build a community of interest, and brain-storm ideas for future research. After the workshop, participants used open-source online platforms (described below) and opportunities at scientific meetings (Ocean Sciences 2020, AGU Fall Meeting 2020, 2021) to further cement the community established during the original meeting. As the COVID-19 pandemic forced many to shift to remote work, the open framework of this hybrid community allowed for research to continue seamlessly. As a result, Levine et al. (2020) was able to publish their interdisciplinary research (the "product" in **Figure 1**), the bulk of which was done by remote collaboration, demonstrating the value of a hybrid CoP model for early career researchers.

Based on our experience, we have identified three essential components for a hybrid CoP (**Figure 1**): 1) open science, 2) resources, and 3) team science. "Open science" revolves around the FAIR principles (Findable, Accessible, Interoperable, Reusable; Wilkinson et al., 2016), including but not limited to open data, methodology, and peer review. "Resources" not only refers to online collaboration and communication tools that were essential during telework but also in-person workshops and conferences, funding, time, professional development, mentoring, and community support. "Team science" describes the inherent skills that are necessary for effectively working in an interdisciplinary, collaborative work environment (i.e., interpersonal skills). While the three components are not necessarily new to the scientific community, we believe that using them strategically in this framework before and during the pandemic (the intersections and arrows around the diagram in **Figure 1**) has kept our group of oceanographers productive despite the challenges that collaborative remote working groups often face.

Open Science

The pandemic decreased researchers' ability to complete field and laboratory-based research because of nation-wide shelter-in-place and social distancing mandates. However, "open science" practices that were in place prior to these shutdowns paved a way to continue scientific inquiry amongst these data collecting challenges. Based on FAIR (Findable, Accessible, Interoperable, Reusable) data principles, open science provides equitable access to scientific data (FAIR principle A1.1) and the ability to reproduce previous scientific findings with the data (FAIR principle R1) (Wilkinson et al., 2016). "Equitable" and "inclusive" in this context indicates that anyone with a computer and internet connection can equally access (Merriam-Webster, 2022) data, conduct analysis, and publish

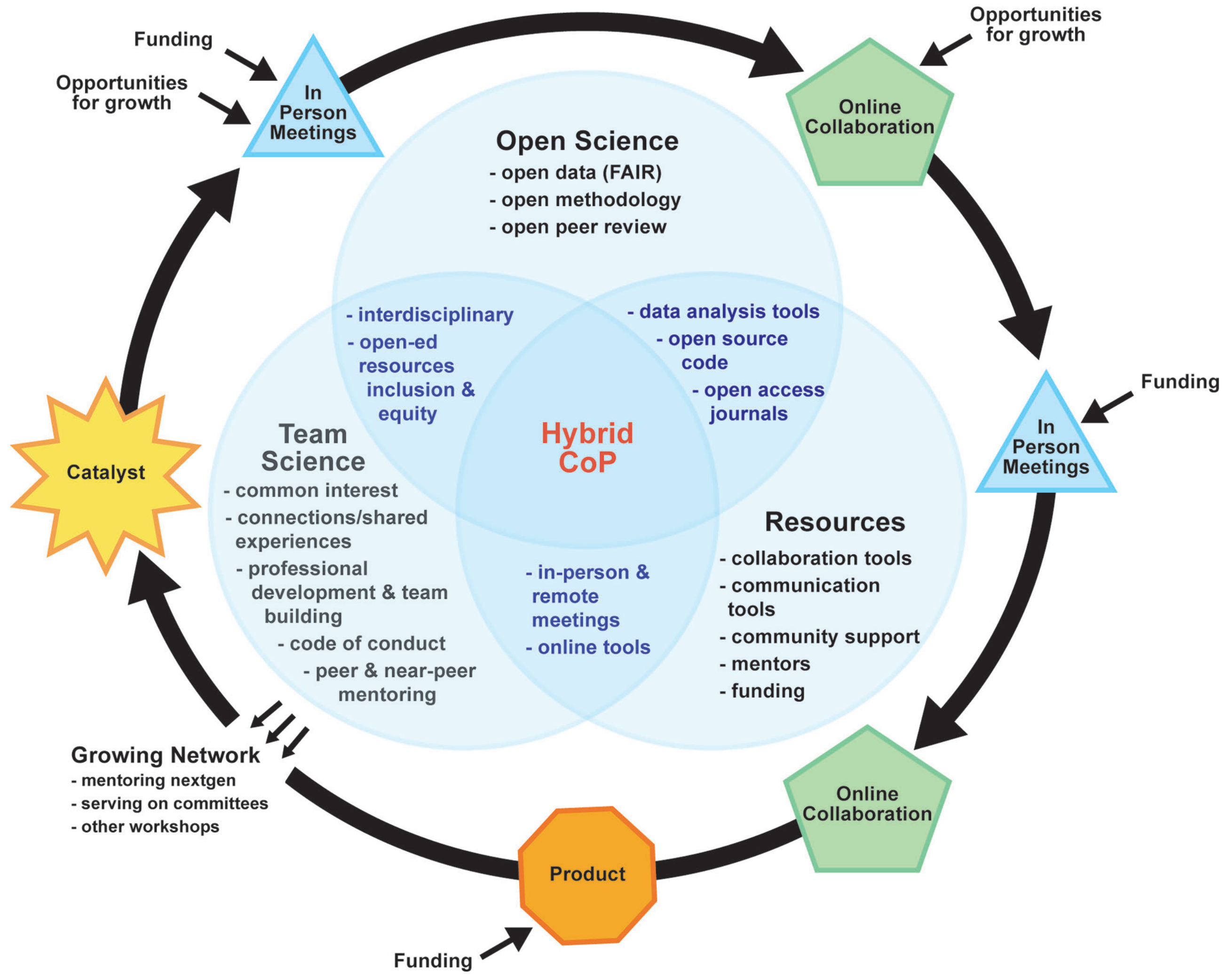

FIGURE 1 | Schematic of Hybrid Community of Practice Model. Core components of the model outlined in the text are in the Venn Diagram. The black arrows surrounding the Venn Diagram represent time. The model "starts" at the "Catalyst" marker, where the "Catalyst" is an idea or common interest. Next is the "In-person Meeting", which is an "Opportunity for growth" and "Funding" is needed for this meeting. After the meeting passes, online collaboration picks up and that is how the group moves forward until the next in-person gathering. Eventually a "Product" as a result of collaborating is produced (i.e. manuscript, conference presentation) and a result of this product is the "Growing of the Network" as others see the product. As the network grows, the group's service also grows towards the other group members and the cycle restarts with other ideas/interests with the new members.

results (FAIR principle A1.1), regardless of career stage, funding, or locality (described below in Discussion).

Observing systems, such as the OOI, the NASA Earth Observing System Data and Information System (https://earthdata.nasa.gov/eosdis), and the National Ecological Observatory Networks (https://www.neonscience.org) (and their associated data repositories) that are autonomously collecting and posting data, provided an invaluable resource to generate research products amidst the setbacks of canceled research cruises, field days, and locked-down labs (Pennisi, 2020). These resources span the earth science realm, from *in situ* ocean monitoring data (buoys, moorings), satellite data, model reanalysis products from atmospheric and oceanic models, historical field experiment data, etc. These repositories create equitable opportunities for science inquiry, because of their ready-to-download data, which make them an excellent resource to use in a remote collaborative environment.

Open methodology is also gaining momentum in the oceanographic community and benefits from a robust ecosystem of open-source algorithm repositories (such as GitHub, BitBucket, Pangeo), which allow users free access to algorithms and software (i.e. Python, Google Collaboratory). These open community resources allow multiple users in a group to contribute towards a project goal. This aspect of open science ensures that users can 1) identify data sources, 2) have access to the methodology used to be able to reproduce experiments, and 3) have access to a network of software developers willing to discuss novel adaptations of the work they have made publicly available.

Resources

Online collaboration and communication tools, such as Google Docs, Slack, and Zoom, are key resources for keeping researchers connected during remote work (Levine et al., 2020; Pardo et al., 2020). A "functional" familiarity with these tools, in conjunction with the vast amounts of open data that have become available online over the last decade, were a pandemic lifeline that enabled many scientific researchers to continue collaborative work. Utilizing open data sources and online collaboration platforms effectively may have had an initial steep learning curve, however training, community support, and mentorship can help a community navigate and overcome these obstacles (further explained below and in Discussion). These points emphasize the importance of team science (below) to aid in dealing with these barriers of entry. For example, many members of our hybrid CoP had only a little familiarity with using GitHub and Python, but the more experienced members of the group were able to guide members in their usage.

Other important resources are time and funding. The nature of open-source resources allows participation in research for those who do not have (or are yet to have) traditional grant funding to attain it. One is able to work on their own time at their own pace to achieve publication and/or grant funding, whether that be individually or in a group setting such as the hybrid CoP. Research productivity as a result of open science and resources can lead to traditional grant funding that may not have been possible without these devices because of locality or their affiliated research group. However, issues arise when funding is needed for publication, professional development, or supplies as a result of open-source research. This paradox leads to members of the hybrid CoP needing to seek alternative sources of funding to support these expenses. Hence, a key resource for an effective CoP is "community support" from these open data sources as it relates to funding, publishing, and furthering research based on open data. Examples of community support elements available to researchers are specific funding streams for open data usages (i.e., the National Science Foundation's OOI request for proposals, https://oceanobservatories.org/proposals/), conference travel grants, and publication fee support.

Team Science

A recent report entitled "Sustainable Ocean for All" by the Organization for Economic Cooperation and Development noted that "the conservation and sustainable use of the ocean needs to unlock sustainable development across social, environmental and economic dimensions" (OECD, 2020). In the report, the authors highlight the importance of both interdisciplinary and transdisciplinary work between ocean scientists, social scientists, and economists. In addition to these groups, data science is another field that shares growing interests in inter/transdisciplinary research within oceanography. Shared research interests, such as those for ocean sustainability, are a natural focus for teams (Bennett and Gadlin, 2012), but effective collaboration (also referred to as "teamwork") is not necessarily straightforward, especially when working with both interdisciplinary and transdisciplinary groups. Because of this coalescence of different backgrounds, there are instances where such teams may be less efficient than if the science had been completed with fewer scientists (National Research Council, 2015). Hence, it is recommended that such teams develop "interpersonal skills", those that are at the heart of team science. Team science, defined as research conducted by more than one individual (National Research Council, 2015), has been shown to be more effective when members are aware of the impact that interpersonal skills such as trust, reciprocity, team building, communication, and leadership, have on a team (Bennett and Gadlin, 2012).

At the earliest stages of our gathering, our hybrid CoP members identified that we would need to incorporate these components to effectively work as an interdisciplinary team of oceanographers and be successful. During the original workshop, we received training in team science from the American Institute of Biological Science, which provided background and understanding of how teams should be developed and maintained. For example, participants assembled into small teams were tasked with building free-standing towers using limited supplies and time to expose common challenges in team science including team planning, relationships, and responsibilities. As suggested by the team training, to proactively manage the success of the team, we designed a collaborative agreement that addresses authorship, participation (e.g., establishment of leaders), means of communication, and policies to handle grievances. Operating under these guidelines has aided in the success of the group, which we define as producing primary research outputs and engaging the science community through conference events (e.g., town halls, conference presentations). However, continued education and training to perform team science efficiently are necessary to ensure effective collaboration in the future and to grow the group. A variety of free, online training modules relating to team science are offered by Northwestern Medicine (teamscience.net) that can substitute for in-person training, which may not be available until a hybrid CoP is well established.

Where Research Progresses: Intersections Between the Components

The hybrid CoP thrives at the intersection of the three components detailed above: open science, resources, and team science (**Figure 1**). As mentioned previously, resources such as funding, time, and community support are necessary to facilitate team science and research. Conducting research using open data, open coding and computational software, and collaborating with open-source platforms does not rely on funding, an obvious advantage of the hybrid CoP. However, publishing, presenting at conferences, and growing the careers of early career scientists does need community support in terms of both funding and time (Open Science + Team Science + Resources). Further, open science is fruitful when including an array of interdisciplinary and transdisciplinary scientists from both different scientific backgrounds (i.e., ocean science, computational sciences, and social sciences as highlighted previously) and cultures (Open Science + Team Science) (Bennett and Gadlin, 2012 and further discussed below). Without all three components of the model and their overlap, research does not progress as efficiently.

DISCUSSION: USING A HYBRID COP FRAMEWORK POST-PANDEMIC

The recent major disruptions felt across the academic community have changed how researchers collaborate. The sudden limitations that COVID-19 imposed on field-based data collection, access to facilities and the isolation associated with the sudden need for "social distance" accelerated a shift from collaboration focused within scientific disciplines. Because sensor networks and online data repositories were for the most part not disrupted, scientists were incentivized to use a new and potentially more democratic model for research and collaboration centered on openly available data and open-source methodology and platforms. Working groups, such as our own, may have had an advantage during the COVID-19 disruptions to research because of the hybrid CoP described above that was already in place. Producing a scientific publication in the midst of the COVID pandemic is considered a measure of this advantage. While the model for a hybrid CoP was beneficial during COVID-19 mandatory telework that shut off in-person collaboration, we believe this model has far reaching benefits past effective utilization during a worldwide pandemic.

CoPs based on interest, expertise, and a willingness to contribute have the potential to allow for a more creative and inclusive process compared to grant-dependent hierarchical structures. Since collaboration within the hybrid CoP is centered on open data and open-source resources, it is less dependent on the traditional "apprenticeship model" (Marckmann, 2001) and "who you know" networking. Rather, the hybrid CoP is open to contributions from scientists drawn from the entire spectrum of research and teaching institutions in academia. In this context, inclusivity relates to how our hybrid CoP allows people from all areas of academia to conduct research and network, not just those who have funding, or are located within a particular research group or at an institute that has a highly-decorated ocean observing program ("increasing access" in Johri et al., 2021).

Our group consisted of early career scientists representing a range of oceanographic subdisciplines and encompassing institutional affiliations that extended well beyond the normal coastal research institutions. Building a collaborative team that includes graduate students, post-doctoral scholars, tenure-track faculty, and draws from primary undergraduate institutions, Community Colleges, Regional Comprehensive, and R1 Universities highlights the way that open data and online resources can make oceanographic research more inclusive. The flat internal hierarchy (team science without traditional PI leadership) of the hybrid CoP sacrifices some efficiencies, but it incentivizes individual initiative and allows for those who would usually feel reticent in a traditional apprenticeship model to have their ideas and perspectives heard. Hence, an aspect of the hybrid CoP's success can be related to the diversity of its members and how each member offers their unique contribution. These contributions include the technical and interpersonal skills each scientist has and each individual's cultural and research background (i.e., marine science, computer science, political science, etc.). While our hybrid CoP is still in its early stages, we expect that such a mechanism will aid in promoting the research interests and perspectives of those who have been previously underrepresented (Foramitti et al., 2021; Johri et al., 2021; Niner and Wassermann, 2021; Skiles et al., 2021) in the oceanographic community. Additionally, the professional development aspect of the hybrid CoP may assist in reducing barriers in career growth for individuals that wouldn't usually have access to such opportunities (Johri et al., 2021; Nocco et al., 2021).

Potential Challenges and Proposed Solutions

Through our experience, we have identified some of the challenges that this framework can present. Time and funding become essential in the long term to keep the hybrid CoP alive. One of the largest challenges is the voluntary nature of this model since it does not rely on a traditional funding structure to fund one's dedicated research time. This work, especially in the grass-roots stage, solely relies on one's free-time unless funding becomes available to "charge" one's time to. Because of this voluntary requirement, it has become apparent that members need an incentive to participate, whether that is publishing, conference presentations, in-person networking, etc. (see funding arrows in **Figure 1**). During the remote-component of the hybrid CoP, creating "value" to participate is more difficult, especially when one is already inundated with virtual meetings. Moreover, participation without some sort of "product" (**Figure 1**) can become a barrier to further professional development in early career scientists (Johri et al., 2021). Hence, some type of funding assistance is necessary to promote and publish the work of the hybrid CoP members. This reality emphasizes the importance of community support ("Resources") such that these efforts can either be funded and/or looked upon as "productive" in one's career.

Funding and time are not the only hindrances to the success of a hybrid CoP. Extended periods of remote-only collaboration (i.e., mandatory telework mandates and virtual conferences) make it difficult to sustain group participation as well as recruit new participants. We have found in these extended periods that research momentum is lost due to members undergoing "screen fatigue" when there is no incentive to participate (as described above). Besides screen fatigue, remote-only research collaborations can create inequality with respect to users learning new platforms (learning curve for learning a new skill) and readily-available internet connection (Center on Reinventing Public Education, 2020). Hence, we believe in-person meetings are still necessary because they help to establish rapport for future collaboration (team science interpersonal skill), help to recruit new participants (i.e., town hall at annual conferences or funded workshops), and help network with team members to sustain group interest. These in-person components add a specific type of value (human camaraderie, belonging; West et al., 2011) that has been shown to increase the effectiveness and satisfaction of remote teams (Baumeister and Leary, 1995; Driskell et al., 2018).

Lastly, we have found that the model requires that participants have basic knowledge in a variety of skills. Participants may not be familiar with open-source software and computing, especially those that do not have the time to devote to learning new languages or software. Additionally, participants may not be equipped with the "soft skills" that are necessary for successful collaborations. Hence, a diverse team of technical expertise to help team members overcome computing hurdles and free resources that promote professional development (such as teamscience.net) are desirable.

Guidelines for Applying the Hybrid CoP Framework

Figure 1 can be summarized in the below in a "quick start guide" for what is necessary for a hybrid CoP to function effectively:

1. Open Data Repository
2. Initial group of interested scientists
3. Research Resources: Virtual video call platforms, cloud storage for sharing documents (i.e., Google Drive), Open-source code storage (GitHub or Bitbucket), team communication (email, Microsoft Teams, Slack, Google Chat)
4. Team Science Elements: Introduction survey, code of conduct, team science training
5. Community Support Resources: Funding for publications, conference presentations, workshops, and townhalls (i.e., community of practice grants, no-fee or reduced fee journals, early career conference grants, funding support from sponsor who funds open-source data)
6. Recruitment outlet to promote hybrid CoP

Through trial and error, we have noted that there are a few key elements that interested parties should consider implementing to make this framework function most effectively when establishing their own hybrid CoP. We have found that in addition to the main components described in the above sections, an introduction survey, a group code of conduct, and continued in-person gatherings with professional development opportunities are needed for future use for this model. An introduction survey for all new participants that asks for contributors' fields of study, scientific and team science skills is useful in an interdisciplinary group to identify meaningful working relationships. A group code of conduct is crucial to establish at the first in-person gathering such that expectations are clear to the entire group for the remainder of remote meetings and collaboration. A few examples we found were useful were authorship requirements, establishing agendas, and how to measure success (i.e., yearly publications and conference presentations). Lastly, we found that continued in-person professional gatherings and development are useful to promote momentum, productivity, gauge interest, and recruit new participants (see "opportunities for growth" arrows at "in-person meetings" triangles in **Figure 1**). Pre-pandemic we were able to meet at annual conferences and host town hall meetings to brainstorm ideas and promote our CoP. We noticed a downturn in momentum and participation when we weren't able to meet in-person at least once during COVID-19. Reducing the length of remote-only time periods may help to sustain group enthusiasm and engagement.

CONCLUDING REMARKS

We have outlined a case study describing how a group of early career oceanographers leveraged open science principles to build a hybrid CoP which supported and facilitated the generation of primary research outputs using open data generated by the NSF-funded OOI arrays. This CoP demonstrated itself to be resilient during the course of the COVID-19 pandemic when access to field sites and labs was greatly restricted. We argue that such hybrid CoPs, which include diverse participants from a range of scientific disciplines, institutions, and cultural backgrounds, can provide a model whereby intellectual capital and creativity is not limited by the ability to collect data in the field, acquire instrumentation or secure funding. When used harmoniously, the components of the hybrid CoP lend all the necessary ingredients for early career scientists to undertake open and collaborative scientific research and be fruitful in their scientific investigations. Even after the COVID-19 restrictions have been lifted, we believe that this hybrid CoP model will still prove to be an effective and more equitable way of scientific collaboration such that collaboration is less likely to be hindered based upon traditional funding structure (including travel funding, Jarvis et al., 2020), institutional background, or country of origin. Thus, in some ways, the normalization of virtual networking has opened up new avenues for collaboration, especially for researchers who previously did not have relevant collaborators at their own universities or institutions. Such an approach could be leveraged to increase diversity, equity, and inclusion more broadly in the geosciences and be the catalyst that drives the next way of collaborative, interdisciplinary oceanographic discovery.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

JR, project management, article conceptualization, methodology, visualization, writing, and revising. DS, JW, HB, SC, and KF, article conceptualization, methodology, visualization, writing, and revising. We also wish to acknowledge the members of the OOI ECS Working Group for their contributions to our hybrid

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REFERENCES

Baumeister, R. F., and Leary, M. R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychol. Bull.* 117, 497–529. doi: 10.1037/0033-2909.117.3.497

Bennett, L. M., and Gadlin, H. (2012). Collaboration and Team Science: From Theory to Practice. *J. Investig. Med.* 60 (5), 768–775. doi: 10.2310/JIM.0b013e318250871d

Center on Reinventing Public Education (2020). *The Digital Divide Among Students During COVID-19: Who Has Access? Who Doesn't*? Available at: https://crpe.org/the-digital-divide-among-students-during-covid-19-who-has-access-who-doesnt/ (Accessed February 21 2022).

Driskell, J. E., Salas, E., and Driskell, T. (2018). Foundations of Teamwork and Collaboration. *Am. Psychol.* 72 (4), 334–348. doi: 10.1037/amp0000241

Foramitti, J., Drews, S., Klein, F., and Konc, F. (2021). The Virtues of Virtual Conferences. *J. Cleaner Prod.* 294, 126287. doi: 10.1016/j.jclepro.2021.126287

Jarvis, T., Weiman, S., and Johnson, D. (2020). Reimagining Scientific Conferences During the Pandemic and Beyond. *Sci Adv*, 6 (38), eabe5815. doi: 10.1126/sciadv.abe5815

Johri, S., Carnevale, M., Porter, L., Zivian, A., Kourantidou, M., Meyer, E. L., et al. (2021). Pathways to Justice, Equity, Diversity, and Inclusion in Marine Science and Conservation. *Front. Marine Sci.* 8, 696180. doi: 10.3389/fmars.2021.696180

Levine, R. M., Fogaren, K. E., Rudzin, J. E., Russoniello, C. J., Soule, D. C., and Whitaker, J. M. (2020). Open Data, Collaborative Working Platforms, and Interdisciplinary Collaboration: Building an Early Career Scientist Community of Practice to Leverage Ocean Observatories Initiative Data to Address Critical Questions in Marine Science. *Front. Marine Sci.* 7, 593512. doi: 10.3389/fmars.2020.593512

Marckmann, G. (2001). Teaching Science vs. The Apprentice Model–do We Really Have the Choice? *Med. Health Care Philos.* 4 (1), 85–89. doi: 10.1023/a:1009956310614

Merriam-Webster (2022). *Equitable*. Available at: https://www.merriam-webster.com/dictionary/equitable (Accessed February, 10, 2022).

National Research Council (2015). "Enhancing the Effectiveness of Team Science. Committee on the Science of Team Science," in *Board on Behavioral, Cognitive, and Sensory Sciences, Division of Behavioral and Social Sciences and Education*. Eds. N. J. Cooke and M. L. Hilton (Washington (DC): National Academies Press (US)).

Niner, H. J., and Wassermann, S. N. (2021). Better for Whom? Leveling the Injustices of International Conferences by Moving Online. *Front. Mar. Sci.* 8, 638025. doi: 10.3389/fmars.2021.638025

Nocco, M. A., McGill, B. M., McDonough,, MacKenzie, C., Tonietto, R. K., Dudney, J., et al. (2021). Mentorship, Equity, and Research Productivity: Lessons From a Pandemic. *Biol. Conserv.* 255, 108966. doi: 10.1016/j.biocon.2021.108966

OECD. (2020). Sustainable Ocean for All: Harnessing the Benefits of Sustainable Ocean Economies for Developing Countries, The *Development Dimension*. Paris: OECD Publishing. doi: 10.1787/bede6513-en

Pain, E. (2014). An Emerging Global Picture of Early-Career Scientists. *Sci. Careers*. doi: 10.1126/science.caredit.a1400023

Pain, E. (2015). Advice to a Young Scientist. *Sci. Careers*. doi: 10.1126/science.caredit.a1500124

Pardo, J. C., Ramon, D., Stefanelli-Silva, G., Elegbede, I., Lima, L. S., and Principe, S. C. (2020). Advancing Through the Pandemic From the Perspective of Marine Graduate Researchers: Challenges, Solutions, and Opportunities. *Front. Marine Sci.* 7, 528. doi: 10.3389/fmars.2020.00528

Pennisi, E. (2020). Pandemic Carves Gaps in Long-Term Field Projects. *Science* 368 (6488), 220–221. doi: 10.1126/science.368.6488.220

Skiles, M. E., Yang, O., Reshef, D. R., Muñoz, D., Cintron, M. L., Lind,, et al. (2021). Conference Demographics and Footprint Changed by Virtual Platforms. *Nat. Sustain.* 5, 149–156. doi: 10.1038/s41893-021-00823-2

Termini, C. M., and Traver, D. (2020). Impact of COVID-19 on Early Career Scientists: An Optimistic Guide for the Future. *BMC Biol.* 18 (1), 1–4.

Trowbridge, J., Weller, R., Kelley, D., Dever, E. P., Plueddemann, A., Barth, J., et al. (2019). The Ocean Observatories Initiative. *Front. Marine Sci.* 6, 74. doi: 10.3389/fmars.2019.00074

West, S. A., El Mouden, C., and Gardner, A. (2011). Sixteen Common Misconceptions About the Evolution of Cooperation in Humans. *Evol. Hum. Behav.* 32 (4), 231–262. doi: 10.1016/j.evolhumbehav.2010.08.001

Wilkinson, M., Dumontier, M., Aalbersberg, I.Coauthors (2016). The FAIR Guiding Principles for Scientific Data Management and Stewardship. *Sci. Data* 3, 160018. doi: 10.1038/sdata.2016.18

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