Equitable Exchange: A framework for diversity and inclusion in the geosciences

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Abstract

We highlight a mechanism for the co-production of research with local communities as a means of elevating the social relevance of the geosciences, increasing the potential for broader and more diverse participation. We outline the concept of an "equitable exchange" as an ethical framework guiding these interactions. This principled research model emphasizes that "currencies"- the rewards and value from participating in research - may differ between local communities and geoscientists. For those engaged in this work, an equitable exchange emboldens boundary spanning geoscientists to bring their whole selves to the work, providing a means for inclusive climates and rewarding cultural competency.

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Key Points:

- We need new mechanisms to broaden participation in the geosciences
- Co-production of science with local underrepresented communities may improve societal relevance and diversify and extend the geosciences
- The Equitable Exchange creates an ethical framework for co-production and inculcates skills related to cultural competency and attention to inclusive practices into the geosciences

Abstract

We highlight a mechanism for the co-production of research with local communities as a means of elevating the social relevance of the geosciences, increasing the potential for broader and

more diverse participation. We outline the concept of an "equitable exchange" as an ethical framework guiding these interactions. This principled research model emphasizes that "currencies"- the rewards and value from participating in research - may differ between local communities and geoscientists. For those engaged in this work, an equitable exchange emboldens boundary spanning geoscientists to bring their whole selves to the work, providing a means for inclusive climates and rewarding cultural competency.

Plain Language Summary

This paper expands on prior work to outline an ethical framework to guide research co-created with local communities. We propose appreciation for the differing perspectives geoscientists and local community members bring to problem-solving and to creating knowledge around questions and issues pertinent to geoscience. A respectful and "Equitable Exchange" between individuals working together in these contexts can foster greater scientific creativity and societal relevance, and may ultimately broaden and diversify participation in the geosciences.

1 Introduction

Despite growing demographic diversity in the U.S. population at large, in the 50 years that the National Science Foundation has been keeping demographic statistics, there has been a continuing lack of diversification in the Science, Technology, Engineering and Mathematics (STEM) workforce, leading to growing frustration and a compelling need for both equity and inclusion (Bernard & Cooperdock, 2018).

Within the geosciences (Earth, Atmosphere, Ocean and Polar Sciences), there is a current wave of energy and attention to issues of equity and social justice in geoscience spaces that is long overdue. Calls to action (Morris et al., 2020; Ali et al., 2020), publications (e.g. Marín-Spiotta et al., 2020; Chen et al., 2020), personal stories (#BlackAndStem[1] twitter feed), new centers (e.g. AGU Ethics and Equity Center), and emerging movements (URGE: https://urgeoscience.org/) are pushing the edges and reforming approaches to broadening participation. This is encouraging, as past strategies to accelerate demographic and ethno-cultural representation have not succeeded as hoped. Many existing approaches portray the lack of diversity as a problem of unequal access (e.g., via affordability or as a consequence of structural racism), and/or one of unequal interest, with evidence existing for both perspectives (Dutt, 2020; Posselt, 2020). One mechanism to broaden participation in the geosciences is to actively engage individuals who are outside of the scientific mainstream to integrate inclusion into the definition of geoscience research.

Here, we hope to contribute to this conversation by illuminating a mechanism for change focused on expanding the geoscience research space that necessarily requires a coincident focus on inclusion. In particular, we describe the value in identifying how gains may be made around justice, equity, diversity, and inclusion via work in the realms of open public science, community-based research, participatory research, and place-based research. By definition, these research approaches invite a broader membership in the geoscience endeavor, and require attention to both engagement and cultural competency. Because there is a deep history of doing this work across the whole of science, we argue that there is great potential for rapid transformation by elevating, championing, rewarding and expanding existing efforts rather than building from the ground-up.

[1] #BlackAndStem was created by Stephanie Page, PhD (twitter: @ThePurplePage)

Mainstream science in the tradition of the Academy invokes those with scientific credentials - degrees, research jobs - as those with permission to conduct science and add to the scientific knowledge base. Approaches that engage a wider range of the public will require a broadening of the definition and pursuit of the geosciences. Knowledge co-production[2] offers a framework that shifts knowledge creation away from a uni-directional transfer of information developed by scientific experts to end users in society, towards a broader exchange of knowledge, skills and interpretation between mainstream researchers and a wide range of invested publics. Place-based research that is inclusive of local communities, and equally values local and traditional knowledge and knowledge-holders alongside mainstream science, is one form of co-production. We argue here that emboldening this kind of contextualized research that is place-based, tied to community, and addresses societal issues expressed locally, can increase the sense of belonging for underrepresented groups in the geosciences in terms of interest, self-efficacy, and identity (see also Callahan et al., 2018).

In fact, the nature of current research challenges facing geosciences can enable this expansion. Global biophysical change now rapidly occurring within the Earth system affects billions of people and cannot be separated from human behavior, economics and equity (Leach et al., 2018; Steffen et al., 2015). The resulting research challenges are transdisciplinary, even convergent, and require innovation beyond the sole perspective of mainstream science (e.g. Riedlinger and Berkes, 2001). Thus, the geosciences could expand through consideration of social and societal relevance when gauging the importance and urgency of questions, incorporation of public science and other forms of public inclusion, and a robust ethical framework for engaging with geographic, ethnographic and "of practice" communities.

Here we propose ***Equitable Exchange*** (EE) as a process of co-production that is grounded in ethical considerations about power, that incorporates voices and approaches beyond mainstream science, and that expects cross-cultural competency of its adherents. A basic tenet of EE is that a variety of currencies, or the information and accolades of value to participants, will be exchanged in the course of the work. Here we use “currencies” intentionally to signal a medium of exchange, and where each member and each social structure - local community, mainstream geoscience - both pays and is paid. Some currencies will be knowledge-based, such as publication authorship, educational opportunities, or acknowledgment of knowledge-holder status. Others will include financial and/or resource-based exchange. Centering co-production in equity[3] requires participants to ask who will benefit, and how, from a given interaction; to move beyond a sole focus on the transactional to incorporating the value of relationships and trust, and to consider the collective good to balance pre-existing disparities.

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[2] A number of terms have been used to describe community-engaged science, including co-production or co-creation of knowledge, as well as community-based, place-based, and participatory action research. There is an extensive literature in these approaches (e.g. Haraway, 1988; Lazarus et al., 2016; Strasser et al., 2019). Brunson & Baker (2015) also expand a definition of “translational ecology,” emphasizing new training platforms for competencies needed by scientists to engage in boundary spanning research in the environmental sciences.

[3] How equity is understood has significant consequences for what actions and changes may be deemed necessary. We define equity as “reconfiguring structures, cultures, and systems to close disparities and empower marginalized groups” (Posselt, 2020, p. 3).

We posit that the practice of EE fosters greater diversity and inclusion in the geosciences by enabling a wider range of publics to be valued as co-creators, empowering individuals to step into science while maintaining strong, central membership in their community.

2 Geoscience Research at the Intersection of Place and Community

A common paradigm for geoscience research is discovery emanating from wonder: curiosity-driven data collection and analysis centered on discovering how the natural world works. In mainstream geoscience, this emphasis on the role of wonder and awe can be connected to 18th century European philosophers (Kant, 1790 (translation 2000), Steffens, 1977) a tradition that continues to influence research praxis today (Berling et al., 2019). Historically, mainstream discovery science has largely been implemented by testing and advancing discipline-specific theory, which has made and will continue to make important contributions to human knowledge (e.g. Steffens, 1977).

However, mainstream discovery science and the institutional structures that have sustained and celebrated this approach have a poor record of inclusivity. Too often, people who seek to incorporate different approaches, ideas or end goals; as well as those who look and act different, espouse different traditions of knowledge-gathering, and/or elevate non-degree holders as experts, are eschewed relative to those who conform to mainstream scientific norms. For example, Weissmann et al. (2019) highlight the prevalence of "low-context" training culture in U.S. university science programs, which focuses on individual work and linear learning not situated in place, issue or problem - even as many underrepresented students are motivated by high-context work associated with localized problem-solving.

Solutions science, also known as actionable science (Theobald et al., 2015; Palmer, 2012) is another paradigm in geosciences, emerging not as a replacement, but as a complement to the discovery approach. While not devoid of theory, solutions science follows from a broader context of sustainability (Stewart, 2016), and emanates from the very real and often short-term need to address particular place-based problems, and/or tackle issues resulting from inequities including those defining environmental justice (e.g. Ramirez-Andreotta et al., 2016). Because these issues are by definition place-based, and often affect disenfranchised communities, embracing solutions science may provide a framework for increasing the societal relevance of geoscience, if an honestly place-based, authentically inclusive and equitable approach can be adopted.

There are notable examples of successful geoscience education initiatives that have demonstrated the value of place-based learning (e.g. Cajete, 1999; DeFelice et al., 2014; Johnson et al., 2014), reinforcing the value of culturally responsive contexts and solutions-based experiences in motivating students to engage in the geosciences (e.g. Apple et al. 2014; Ward et al. 2014). However, the lack of progress in translating these initiatives into gains in representation in the geosciences indicates a disconnect, or at least long lag, between education and research spheres.

We note that historically disenfranchised groups may view even solutions-based research with suspicion and distrust when it is led by scientists and managers from institutions external to the community and/or from majority demographics (Pandya, 2012). Histories of exploitation and colonialism have legacies in many mainstream geoscientists' work: some fail to consider local values, cultures and knowledge; others fail to involve community members directly in the

research process (Cuker, 2001; David-Chavez & Gavin, 2019; Stefanoudis et al., 2021), even when engaging in place-based work. Within communities that continue to experience loss of land, rights, jobs, culture or traditions, problem-based approaches to science learning are likely to fall short of inclusion because they are rooted in the assimilation of indigenous uniqueness into a larger (i.e. mainstream science) whole (Deloria & Wildcat, 2001). More authentic forms of co-creating knowledge which do not by necessity begin only with the mainstream science tradition, could help bridge social and symbolic boundaries between communities and geoscience professionals and educators, expanding both the discovery and solutions science space.

Place-based research focused on a compelling location based on its environmental conditions is not new to the geosciences (Berkes et al., 1994; Semken, 2005; Londono et al., 2016). The iconic direct record of rising atmospheric CO_2 concentrations used worldwide comes from the Mauna Loa Observatory, a facility intentionally situated high on an island volcano in the middle of the Pacific Ocean to maximize distance from continental land masses (Keeling & Whorf, 2005), albeit without attention to the socio-cultural values of the site, or incorporation of the indigenous community into the science (see no mention in Keeling, 1998). Site selection for these measurements is comparable (in geoscience) to the location of a suite of telescopes on top of neighboring Mauna Kea because of the quality of observations possible there. Both of these examples underscore the problems with place-based research driven only by scientific goals and constraints, without consideration of community values and goals (Alegado, 2019). The summit of Mauna Kea is sacred to Indigenous Hawaiians, and astronomers' insistence on continuing to build telescopes there has led to increasing conflict that further marginalizes the Indigenous community and also threatens the continuity of astronomical observations (Kahanamoku et al., 2020; Borrelle et al., 2020; Spencer et al., 2020). By contrast, recent research on the flanks of Mauna Kea (among other places in Hawai‘i) makes use of both the special features of the island and Indigenous knowledge of traditional agriculture to evaluate landscape-ecosystem interactions based on community needs (Lincoln et al., 2018). The He‘eia National Estuary Research Reserve exemplifies a contemporary Indigenous Community and Conserved Area of reciprocal research and management collaboration with the Indigenous people and local community (Winter et al., 2020). David-Chavez & Gavin (2019) refer to these latter examples as a "collegial" approach, where co-creation grants community members the authority to lead, thereby disrupting colonial legacies of power within the academy.

Although co-production, co-creation, and community-based, place-based science may be relatively new to the geosciences, it is not new to the research endeavor. The work of Freire (1968) and Smith (1999) challenged mainstream pedagogies and methodologies in general, pushing for democratization and decolonization of academic endeavors. Kimmerer (2013) and Venkatesan et al., (2019) offer case studies in botany, ecology, and astronomy where indigenous knowledge and mainstream science are held together in ways that are transformational. Additional scientific fields such as public health (e.g. Wallerstein and Durban, 2010) and fisheries research (Lepore et al., 2020) have similarly deep experience in community engagement that can inform and illuminate a path forward for the geosciences.

3 Research as an Equitable Exchange

To advance and link the scholarship and impact of discovery and of application (Boyer, 1990), we propose a vision for geoscience research distinguished by scientists and local

community members co-constructing an "Equitable Exchange" (EE) of knowledge, values, and cultural reciprocity.

What is exchanged? For engagement with communities who have historically lacked access to power, self-determination and/or decision-making regarding land and resources, the exchange requires conscious consideration of equity and even reparation. If one goal in community-based research is to create, at a minimum, a collaborative or collegial approach rather than one that is extractive, we propose starting with an understanding of what currencies could be exchanged as a way to foster equity and agency, avoid assimilation, and maintain culture and tradition. Within the sciences, currencies include published manuscripts, grant awards, peer recognition and awards, and promotion and tenure. From the perspective of a place-based and/or ethnographic community member, currencies may include resources to address local human health and/or environmental management issues; recognition of knowledge, knowledge-holders and knowledge systems; data sovereignty; funding; and linkage to and advancement of K-16 educational opportunities. A failure to recognize and/or translate across currency systems can limit or even derail collaboration. Thus a successful EE must include efforts to ensure that all parties are rewarded in culturally-relevant currencies - ones discovered through dialogue and transparent processes aimed at developing mutual understanding and, more fundamentally, trust.

Co-production with underrepresented communities with a shared goal of facilitating their empowerment also necessitates that community members experience greater benefit and authority in these collaborations than has historically been the case. This underscores our emphasis on equity, which involves recalibrating scales of power and privilege. Implementing this approach within geoscience will require careful attention to project design, project teams, funding amounts and allocations, expectations for project deliverables, recognition of a diversity of knowledge, and training for all team members in cultural competencies. We note that these issues are not easy, and will require tenacity, courage, follow-through and time.

Knowledge co-constructions within an EE can be abstract, in the form of collaborative brainstorming or development of conceptual models. However, it is also likely that the exchange will be explicit, for instance: local community members contributing knowledge that informs research site selection; mainstream geoscientists contributing expertise in data collection and/or analysis to address a particular environmental issue; or the realization of multiple information collection schemes flowing simultaneously from traditional knowledge and environmental science. In each of these cases, it is vital to consider what distinguishes an exchange as equitable.

Consistent with other models of critical participatory research, participants should ensure that the terms of involvement for community members are transparent, mutually beneficial, and co-constructed. Central to critical participatory and decolonial paradigms, broadly, is a reorientation of conventional power relationships, so that researchers ultimately answer to community (Mosurka & Ford, 2020; Patel, 2015). Within an equitable exchange, community members should have significant influence in deciding who owns, interprets, and communicates the data and the science — and to what ends. Similarly, who is paid, who learns, and who gets credit must be carefully designed to avoid co-optation or exploitation. In addition to these forms of compensation, scientists in an EE participate in several specific activities of co-construction: cultural translation across the languages of science and place-based, communities; incorporating traditional and local knowledge into the development, process and interpretation of research

research at the behest of, and with permission from, local knowledge-holders; and creating and reinforcing mechanisms that allow all participants to be heard and respected.

The EE embraces the fact that the scientific process and its outcomes are mutually, communally, held, and with this plurality comes moral and ethical responsibilities that all parties must co-create, acknowledge and navigate. Envisioned as a long-term commitment, an EE should, over time, build trust between parties who wish to span discovery-and-solutions spaces (Quigley et al., 2000). This trust is generative, such that future scientific work is enabled, as is the creation of a more positive image of mainstream science for younger generations within the community; those who may participate as boundary spanners in the future.

Who is involved? Developing a geoscience-focused EE begins with people coming together to articulate and work on a challenge or question that is of mutual interest, which may stem from curiosity and/or concern. From the outset, the project team must include both mainstream geoscientists and key community members. As a consequence, the process holds space for multiple ways of knowing, including traditional cultural wisdom, traditional disciplinary knowledge, and practical experience (Basso, 1996). We emphasize that this work is aided by the support and cultivation of "boundary spanners" - individuals with the unique leadership skills and interests to traverse cultures and guard against extractive practices (e.g. Safford et al., 2017). Ideally, boundary spanners possess dual membership in, and/or permission to act within, geoscience and the local community, and are therefore able to understand the rules defining each institutional structure, and facilitate cultural translation between them (Meyer et al., 2016). An EE may also include: community leaders (who may be boundary spanners themselves) who facilitate access to communities; content experts who possess relevant local, cultural, and/or traditional knowledge; researchers with project-relevant expertise; and students and other learners who are entrained as part of the social contract inherent both in the academy and the community to empower future generations.

Although boundary spanners are often the fulcrum of exchanges between underrepresented communities and mainstream science, in the geosciences they are currently rare. One reason may be that working in-community on local, place-based issues that may be actionable but do not count as discovery in the senses of publishable theory construction or knowledge acquisition, simply does not pay enough of the currencies that academia requires of scientists to be successful. A second reason is that underrepresented scientists are continually asked to code-switch, a mentally and socially exhausting exercise that may result in success in both worlds, or potentially rejection by both as not authentic. These reasons point to fundamental challenges for boundary spanners who experience implicit and explicit messages that erode a sense of belonging in the geosciences (e.g. Pickrell, 2020). In our vision, exercising the EE broadly should elevate new currencies and rewards for co-produced research across the geosciences, elevating the status of boundary spanners and their skillsets while providing a ground-up mechanism for raising expectations for cultural competencies and the creation of an inclusive research climate for everyone. We acknowledge that this model places a great responsibility on boundary spanners and are hopeful that additional models for this work evolve as it is valued. For example, the American Geophysical Union's Thriving Earth Exchange, a group focused on nurturing co-production in community, supports boundary spanners who operate as an additional member of the community-geoscience relationship supporting and liaising without directly executing the geoscience research. We are also encouraged that initiatives such as those outlined by Brunson and Baker (2015) encourage a reworking of our

graduate educational programs in the environmental sciences to cultivate these skills for all students, regardless of cultural or ethnographic identity.

Without downplaying other functions and partners in an EE, we propose that supporting the development of mainstream|community boundary spanners will increase the success of community-based research, with a secondary impact of enhancing the relevance of geoscience to underrepresented populations. Because geoscience boundary spanners are - by definition - geoscientists, their leadership can also increase the visibility of geoscience career paths. As such, elevating the opportunities and status of boundary spanners may provide a mechanism for more diverse representation in geoscience fields.

The challenge of boundary-spanning inherent in EE is one of collaboration across difference. By encouraging boundary spanners as skilled and knowledgeable agents to implement an EE, a supportive framework for inclusive research in the geosciences can be designed and refined, effectively extending the science of geoscience. In transforming the rules about who has influence on science and on what basis, as well as whose interests' scientific activity ultimately serves, the EE could advance structural change in geoscience disciplines to confront issues of power and systemic racism, and inform other fields where place-based and/or community-based research can occur.

4 A Way Forward

We acknowledge that this framework will require new focus on compensating and investing in communities alongside training of geoscientists, collaboration with social scientists, and elevation of those who are already engaged in this work to higher status positions. It will require grappling with social dynamics of research that are often taken for granted, and negotiating incentive structures that are currently less supportive of research with long timelines and unconventional products. The contribution of different ways of knowing – local and indigenous knowledge - will similarly warrant recognition, compensation, and the capacity of the research endeavor to incorporate these needs. Already, however, community- and place-based work is gaining credence within the geosciences. In-practice professorships in environmental science (e.g., Professors-of-Practice within the Julie Ann Wrigley Global Institute for Sustainability at Arizona State University) have elevated community-based work as a position requirement. Scientific societies have created clearinghouses that connect communities and geoscientists (e.g., Thriving Earth Exchange), and recognize exemplary in-community work (e.g., American Society of Limnology & Oceanography's Ruth Patrick award). An emphasis on convergence research and diversity at the National Science Foundation has resulted in initiatives such as Coastlines and People. We feel hopeful that there is much potential to encourage, support, and expand these efforts to an emphasis on broadening participation and spaces that can support the tenets of an EE.

5 Conclusions

Understanding the ongoing changes, emerging risks, and local-to-global hazards associated with the Anthropocene (Steffen et al., 2007) is clearly within the purview of the geosciences. These issues have community implications and require community wisdom. A demographically homogenous population of geoscientists limits the likelihood that these challenges will be met and decreases the likelihood that findings will be accepted by the full diversity of humanity at a time when the public trust in science is in crisis (Oreskes, 2019) Given the rapid shift in the demographics of the United States (Garza, 2015), it is imperative that the geosciences explore strategies for engaging historically underrepresented groups--strategies that resonate both with the sensibilities of scientists, and with those of the communities who have traditionally been excluded or have elected not to join. In advancing ethical and inclusive approaches to geoscience research that celebrate its societal relevance, we can broaden participation, raise the public profile of the geosciences, and increase the creativity and innovation needed to navigate modern environmental challenges.

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