

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

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## **Authors' Response to Peer Review Comments on Original Version of Manuscript (2020AV000359)**

Response to Reviewer #2

Reviewer #2 organized their comments around a series of headings and major points. We copy those below and offer our response. At the end of this document we also respond to minor comments. We reference new line number locations for ease of finding the edits in our revised document. Because our responses include reference to "mainstream science" instead of the reviewer's proposed "Western science", we record that response first to outline our rationale for keeping "mainstream" in this manuscript.

1. mainstream: to refer to Western research paradigms. This centers Westerns science and marginalizes non-Western scientific traditions (Eastern, Indigenous). Recommendation is to use "Western" rather than mainstream.

***Our Response:*** *We have spent much time considering terminology in this paper and appreciate the reviewer's attention here. We are concerned that using "Western" geoscience indicates an exclusive membership to Western countries and sciences. For example, referring to "Western science" does not consider the tens or hundreds of thousands of Asian scientists who actively participate, contribute, and engage in this work, not to mention African nations, etc. We understand that the reviewer is hoping to center the origins and history of mainstream geoscience in Western philosophy, but if we replace this word in the text, it also reads as an exclusive Western membership, which is not the case. We are concerned that "Western" science could imply that those non-Western participants in mainstream science have engaged through assimilation. We do not want to imply that Asian or African scientists who have published and worked in mainstream geoscience have forsaken their cultures and become Westerners. We also appreciate that there are many non-Western influences in mainstream geoscience, notably the role of Arab and Islamic scholars in critical advances in mathematics that many geoscientists employ regularly. In handling this terminology in other venues, some of our authors have also used "conventional" or "traditional" but we eschew using the former as it is indicative of mainstream science as non-creative and non-innovative, and the latter as it suggests negation or even erasure of other traditions. On the other hand, "mainstream" connotes an approach used by the majority of a group, here the geoscience community. It does not imply that the approach is better, simply more prevalent.*

Heading 1 From Reviewer #2: **"This paper does [not] sufficiently acknowledge or situate the historical context from which the authors operate, meaning that is a Western academic gaze."**

***Our Response:*** *We agree with the reviewer that a greater spotlight on the origins of mainstream science epistemologies is a good idea, and we have attempted to anchor our*

*paradigmatic statements in the literature. We also agree with the reviewer that there is the potential to connect our proposed equitable exchange to a broader review of multiple epistemologies, and through that lens the history of science. As Reviewer #2 has indicated, there are entire books that illuminate a potential path forward towards decolonizing science. But this commentary is not focused on a review of epistemologies – in fact it just doesn't have the space to do such an effort justice - instead it provokes discussion of one proposed avenue for change in mainstream science - place-based, community-focused science practiced through an equitable exchange.*

*We do realize that there are opportunities to shift the manuscript in less fundamental ways to better acknowledge multiple ways of knowing. Please see specific changes below documenting how we have accomplished this through additional sentences and references in the attached, track changes document.*

1. There is very little discussion about what has constituted legitimate knowledge and related to that, the fact that "mainstream" science has been used to justify colonial and imperialistic needs of Europe and the West.

***Our Response:*** *We do not argue with the reviewer on this point, and we also believe that the focus of our article is only one approach to reconstitute what is legitimate knowledge, and who are legitimate members of a science team, within the geosciences. To that end, we are reluctant to expand the purview of the article to include a wider consideration about the ways in which science as practiced by the mainstream is reflective of, and protective of, a colonial dominant socio-culture. This is important work, but doing so here (in the short number of words we have) will dilute our main message about the value of EE to the present and future of the geosciences.*

- o Line 90: "Elevating" local/traditional knowledge is not the same thing as equivalence because elevating above erasure does not mean it is considered at the same level as Western knowledge.  
Should reconsider language

***Our Response:*** *We have edited Lines 89-91 (now line 98) to indicate a more equitable playing field with LEK and TEK: "Place-based research that is authentically inclusive of local communities, and equally values local and traditional knowledge systems and knowledge-holders, alongside mainstream science, can be one form of co-production."*

2. The authors have also not included numerous educational initiatives in the geosciences whose curriculum was built around place-based research in order to increase equity and inclusion. There are key tenets within these programs that are translatable and applicable to research (some of which have involved authors ex. COSEE). Separating teaching pedagogies from research paradigms is a missed opportunity to leverage off of already tried and true methods that

have engaged a broad swath of learners and community partners. Failing to mention these programs could potentially emphasize that other epistemologies are sufficient for education but not for research. >> lines 84-84 and lines 156 - 176

- o Apple, Jude, Judy Lemus, and Steven Semken. "Teaching geoscience in the context of culture and place." (2014): 1-4.
- o DeFelice, Amy, et al. "Engaging underrepresented high school students in an urban environmental and geoscience place-based curriculum." *Journal of Geoscience Education* 62.1 (2014): 49-60.
- o Ward, Emily M. Geraghty, Steven Semken, and Julie C. Libarkin. "The design of place-based, culturally informed geoscience assessment." *Journal of Geoscience Education* 62.1 (2014): 86-103.
- o Johnson, Adam N., et al. "Indigenous knowledge and geoscience on the Flathead Indian Reservation, northwest Montana: Implications for place-based and culturally congruent education." *Journal of Geoscience Education* 62.2 (2014): 187-202.
- o Gilligan, Matthew R., et al. "Building a diverse and innovative ocean workforce through collaboration and partnerships that integrate research and education: HBCUs and marine laboratories." *Journal of Geoscience Education* 55.6 (2007): 531-540.
- o Matsumoto, George I., et al. "A collaborative and mutually beneficial Tribal Marine Science Workshop format for Tribal natural resource professionals, marine educators, and researchers." *Journal of Geoscience Education* 62.1 (2014): 74-85.
- o Dalbotten, Diana, et al. "NSF-OEDG Manoomin Science Camp Project: A model for engaging American Indian students in science, technology, engineering, and mathematics." *Journal of Geoscience Education* 62.2 (2014): 227-243.
- o Dublin, Robin, et al. "COSEE-AK ocean science fairs: a science fair model that grounds student projects in both western science and traditional native knowledge." *Journal of Geoscience Education* 62.2 (2014): 166-176.
- o Cajete, Gregory. *Look to the mountain: An ecology of indigenous education*. Kivaki Press, 585 E. 31st St., Durango, CO 81301, 1994.
- o Cajete, Gregory A. *Igniting the Sparkle: An Indigenous Science Education Model*. Kivaki Press, PO Box 1053, Skyland, NC 28776, 1999.

**Our Response:** *We recognize there are many education initiatives in this vein, with the caveat that a central point of our paper is that the challenge we face in the geosciences is seeing how little impact these education programs have had on broader representation in the geosciences as detailed by Bernard and Cooperdock (2018). This has created a moment of self-reflection for our community (including, as the reviewer notes, several of the authors who lead these programs) to consider other factors that have contributed to a*

*lack of progress, and has inspired papers like ours to consider other mechanisms and solutions. We understand the point here from Reviewer #2 is that the lessons learned from these initiatives should be propagated into the research sphere. We believe that such an endeavor could be a worthwhile subject of its own paper. In the context of the EE, we agree that these lessons are useful in terms of emphasizing findings from educational research that highlight the role of identity and culture in students' interest in geosciences. And we have referenced other educational research in this way (e.g. Weissman et al. 2019 and Berling et al. 2019). We have pulled a few of the suggested references, for which we thank the reviewer, into the following edit at line 142 of the original submission (line 162 track changes document). The placement of the edits in this location connects the educational findings from these references to the value of solutions based science: "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."*

3. Because there is poor acknowledgement of historical context, seminal works in this area have not been cited and they should be considered in this paper.
  - o Paulo Freire: Pedagogy of the Oppressed
  - o Linda Tuhiwai Smith: Decolonizing Methodologies
  - o Robin Wall Kimmerer: Braiding Sweetgrass

**Our Response:** *This is a good suggestion and we thank the reviewer. We have included the following at line 210 of the edited manuscript: "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."*

4. Lines 95 – 103, 156-179: Other examples of place-based research that would be appropriate include the large body of literature concerning Indigenous peoples of the Arctic and climate change
  - o Riedlinger, Dyanna, and Fikret Berkes. "Contributions of traditional knowledge to understanding climate change in the Canadian Arctic." *Polar record* 37.203 (2001): 315-328.
  - o Berkes, Fikret, Carl Folke, and Madhav Gadgil. "Traditional ecological knowledge, biodiversity, resilience and sustainability." *Biodiversity*

conservation. Springer, Dordrecht, 1994. 269-287.

**Our Response:** *We have incorporated these references of other insightful examples at lines 109 and 185 of the track changes document.*

5. Line 119: stipulating that a “common paradigm for geoscience is discovery emanating from wonder” fails acknowledge that paradigm is a Western framework that developed in the 17th century as an outcome of the Enlightenment. In addition, it seems odd that a common paradigm would have a citation that is as recent as 2019. Recommend to either change “common” to “emerging” or cite additional less recent references.
  - o Importantly, there is an assumption (based on the title of Figure 1) that this is “how individuals relate to science”, which is a Western science view. At minimum the authors should modify the figure to include other paradigms including actionable science but also non-Western science paradigms. At minimum, marginalized communities should not be relegated to solution- based science only. Also, where does applied science lie in this graph?
  - o This paragraph in general was poorly referenced.

**Our Response:** *We have clarified historical context by adding the following sentence at line 135, as well as including additional references, including a translation of Kant's 1790 contribution “A Critique of Judgement”:* “In mainstream geoscience, this emphasis on the role of wonder and awe can be connected to 18<sup>th</sup> century European philosophers (Kant, 1790 (translation 2000), Steffens, 1977) a tradition that continues to influence research ethics today (Berling et al., 2019).”

*We wholeheartedly agree that discovery and wonder are not the sole purview of mainstream science, and that there are both individuals as well as other epistemologies that emphasize this approach. In hindsight these comments make clear that the figure is not conveying the concept that we had hoped. We have removed the figure.*

6. Lines 208-222: Work undertaken by other areas of the academy (primarily social sciences) to engage in and develop authentically new research paradigms based (e.g. post-positivism, critical theory). There’s no discussion about positioning EE actionable science or discovery emanating from wonder in relation to these established paradigms

**Our Response:** *The vision for equitable exchange is indeed, well-aligned with critical paradigms including decolonialization of knowledge and critical participatory research. We have edited and added to the paragraph you noted for more explicit recognition of this alignment. Thank you for drawing that out!*

“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. "

7. Also that participatory-based methods have been attempted in other science fields (biomedical science) to some success. referenced in terms of lack of recognition of previous efforts in other "mainstream" sciences to integrate/adopt participatory methodologies in their their research paradigms (e.g. biomedical sciences)

**Our Response:** *As noted in response above, we have added a short paragraph at line 210 that cites a few examples – indeed we had some of these papers cited in an earlier version of the manuscript but had trimmed due to page constraints. There is certainly a hope that this commentary can at least introduce geoscientists new to these concepts to a bit of that literature and we hope that this is an addition that will be feasible in our page limits.*

**Heading #2: "Furthermore, throughout this paper, the authors use problematic terminology or misuse terms":** Language matters. Use of terms inappropriately perpetuates and reproduces systemic problems within the academy.

2. currencies: is particularly problematic as the authors propose to move from transactional to relational interactions between researchers and community but use transactional, monetized terms to describe EE. There is an over-emphasis on equitable exchange but perhaps more attention should be paid to reciprocity.

**Our Response:** We very much agree that language matters. We chose "currency" very specifically to signal to the mainstream geoscience community:

1. you must acknowledge there are payments, monetary or otherwise, that members must make/receive to remain in the group
2. think about funding, and the inequity of funding control and funding flow in many mainstream projects that currently incorporate communities

Currency is a powerful word because in the modern context it conjures money, although it isn't limited to money. It can also mean any medium of exchange, and that concept dates back to prehistoric times and spans cultures.

*We do take the reviewer's point; however, and attempt to be more explicit in what we mean (lines 117 of the track changes document: " 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."*

3. paradigms: used in reference to "discovery emanating from wonder" and "actionable science" seems to be a misapplication of the term. Research paradigms derive from distinct ontological, epistemological, methodological axiological frameworks. >> the paradigms referenced in this piece all derive from the positivist research paradigm so they are different methodologies. It would be appropriate and recommended for the authors to include examples of non- Western research paradigms here.

**Our Response:** We respectfully disagree with the reviewer. Paradigm can mean both a theoretical framework and typical example or archetype. It is a word that has been used in natural science to connote an approach to science, or a way of knowing, including ways that call out the implicit effect of the dominant culture on science praxis, as did Fedigan's book pointing out the misogyny inherent in the study of primate behavior "Primate Paradigms."

*In this paper, we are contrasting two different starting points for the scientific endeavor: one based in curiosity with an end-point of knowledge gain for the sake of knowledge; and a second based in a particular, localized problem or issue that begs a solution, with an end-point of solving the problem. This dichotomy has variously been called basic versus applied, discovery versus solutions, basic versus actionable. Here we elect discovery and solutions.*



### **Heading #3: Inherent issues with EE:**

1. Conception of knowledge as being mutually “owned” (line 224) is at odds with most Indigenous epistemologies, which hold knowledge as being communally held rather than individual. This is a critical tension between Western and Indigenous knowledges and research paradigms.

**Our Response:** *We thank the reviewer for pointing out the difficulty with the use of “owned” and have edited the writing here to read: “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.”*

2. Onerous burden is placed on boundary spanners to carry out EE in the “*who is involved*” section (lines 230 – 245). Given that the ability to nurture more boundary spanners involves education, this would be another area to provide additional examples of curricular geoscience programs that support these students (see citations above)

**Our Response:** *We have edited this section to indicate it is only one, likely imperfect, model for this work and highlight an additional program that also uses boundary spanners, but in a different model (Thriving Earth Exchange). While we clarify here that we don’t consider the boundary spanners to commonly be students, we do reference again the Brunson and Baker (2015) paper outlining new graduate education approaches in this vein. “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 identity.”*

### **MINOR COMMENTS**

1. Line 37 & 304: consider “historically marginalized” rather than “under- represented”

**Our response:** In these instances, we are being very specific in our use of “underrepresented”. Indeed, this comment inspired a conversation among our co-authors with the input that we prefer to use underrepresented or disenfranchised throughout the document. In particular, input from authors felt that use of this term requires specificity and also runs the risk of referencing underrepresented populations in a deficit model, which we want to avoid.

2. Line 67: #BlackinX was created by Stephanie Page, PhD (@ThePurplePage). Appropriate attribution should be made; should also include efforts such as Urge (<https://urgeoscience.org/>)

**Our response:** We have provided attribution to Stephanie Page and referenced URGE.

3. Line 190: It's not clear what "maintaining individuality" mean?

**Our response:** *We have edited the sentence to read:*

"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 while avoiding assimilation and maintaining culture and tradition"

4. Citations in the text that are missing from the References: *Thank you for identifying these.*
  - o Pandya 2012 - added
  - o Borrelle et al 2020 - added
  - o Spencer et al 2020 - added