

GC Insights: Diversifying the Geosciences in Higher Education: a Manifesto for Change

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Abstract

There is still a significant lack of diversity and equity in geoscience education, even after decades of work and widespread calls for improvement and action. We join fellow community voices in calls for improved diversity, equity, inclusion, and justice in the geosciences. Herein this manifesto, we present a list of opportunities for educators to bring about this cultural shift within higher education: 1) advocating for institutional change, 2) incorporating diverse perspectives and authors in curricula, 3) teaching historical and socio-political contexts of geoscience information, 4) connecting geoscience principles to more geographically diverse locations, 5) implementing different communication styles that consider different ways of knowing and learning, and 6) empowering learner transformation and agency.

1 Introduction

While geosciences play an essential role in addressing societal issues, it is an inequitable and exclusive field because of its complex entanglement with past and ongoing prejudices (Dowey et al., 2021; Berhe et al., 2022). While some advances have been made, geoscience education that does not interrupt prejudice contributes to the hostile climates and structural problems that hinder diversity (Marín-Spiotta et al., 2020).

Many resources and calls to arms have come from communities and leaders for decades, but change is slow (e.g., Huntoon and Lane, 2007; Bernard and Cooperdock, 2018; Gates et al., 2019; Liboiron, 2021; ADVANCEGeo). In this manifesto, we call for six specific points of reflection and action that individual higher education geoscience educators can undertake to recognise and unlearn their biases to support geoscience education diversity (Figure 1). Furthermore, we hope to continue

35 momentum to establish a community-built framework for implementing and strengthening diversity, equity, inclusion, and justice in geoscience education.

2 Champion Meaningful Transformation

Foundational geoscience knowledge and resources extracted from excluded and exploited communities has historically benefited dominant groups (Keane, 2017; Stefanoudis et al., 2021; Wight, 2021). To combat extractive mindsets, geoscientists 40 outside of a community must not presume that said community must provide access to knowledge, opportunities, or resources. Educators can advocate for investing resources in communities and experts that contribute to understanding and diversity in geoscience to help build trust and repair the legacy of injustices (e.g., colonial transfer of land and resources) that have led to the institution's success. Educators must challenge the status quo, commit to action for equity, and develop accountable 45 relationships built on respect, reciprocity, and trust with communities for systemic change (la paperson, 2014; Powell and Kelly, 2017; Squire, 2019; Jones, 2021; Ali et al., 2021; Lewis and Sadler, 2021; Liboiron, 2021).

Educators should examine institutional factors leading to the lack of diversity in the geosciences and their role in perpetuating them while calling for the prioritisation of recruiting and retaining educators and learners from marginalised communities (Land Grab Universities; Carbajal and Atchinson, 2020; Ormand et al., 2021; Cooperdock et al., 2021; Ranganathan et al., 50 2021). Cultural, structural, and individual interventions and accountability systems are required to lower barriers and power imbalances while supporting diverse individuals and groups across all measures (Núñez et al., 2019; Kingsbury et al., 2020; Olcott and Downen, 2020).

3 Diversify Sources

Not diversifying one's sources when developing curriculum can perpetuate structural and unconscious bias on the value of specific research sources and types, leading to a structural exclusion system proliferating unconscious bias.

55 Most search engines decrease the visibility of research published in smaller and regional journals by directing users to often-referenced work in high-impact journals, often due to search algorithm bias based on a user's history (e.g., current location, language). This results in an erasure of non-Western authors that may rely on local or regional journals because of the inaccessibility and exclusivity of high-profile journals (even after considering publication discounts) (Jeater, 2018). Therefore, publications by Western scientists carrying out research in non-Western regions like the work of local scientists are valued and 60 cited more widely than their local, non-Western counterparts (Wight, 2021).

Repositories offer a diverse selection of resources to reduce strain on educators looking for work by marginalised researchers, though these databases are often biased. For example, SCImago lists journals from over 200 countries but still has heavy United States influence.

Language barriers from diverse sources may constitute an additional barrier in English-dominated academic settings, but this
65 may result in limited consideration of diverse expertise (Helsinki Initiative, 2019). Providing primary resources, including phrases in the original language that have no direct translation, is an opportunity to discuss diverse geoscience perspectives while considering context and complexities.

Co-creation of reading lists by educators and students to centre diversity can empower students and improve curriculum inclusivity (Schucan Bird and Pitman, 2019). Diversifying sources must also include author acknowledgement and reciprocity
70 to reduce further othering and exploitation (Keane et al., 2017). For example, many sustainability efforts extract information from Indigenous practises without considering Indigenous science's complex, holistic origin and implications (Tsosie, 2019). For guidance on incorporating Indigenous knowledge into curriculum refer to the CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) principles (The Global Indigenous Data Alliance).

4 Integrate Historical Context

75 Many scientists have and continue to downplay marginalised researchers' and participants' contributions to their research, which leads to exclusionary curricula (Dowey et al., 2021). Educators support diversity and equity by including discussion of socio-political contexts in curriculum (GeoContext). Learners can develop and practice more inclusive, diverse, and culturally sensitive approaches to science when included. By highlighting historical, cultural, and socio-political dimensions of geoscience discoveries, we can bring value to those historically marginalised by emphasising the meaningfulness of their
80 contributions. For example, local Indian Pandits helped the British during their colonial land survey project, the Great Trigonometrical Survey, by bringing their critical knowledge of their homeland. While this project helped establish the concept of isostasy, the Pandits receive little acknowledgement in Western education (Sarkar, 2012; Cartier, 2021).

Educators can mitigate the erasure of marginalised populations by integrating historical context during lessons that illustrate the concept and research process while meeting learning objectives. While this can be incorporated in fundamental or advanced
85 geoscience classes, offering socio-scientific courses (e.g., geoethics) can lead to deeper understanding and interdisciplinary collaborations.

5 Connect Across Geographies

Place-based learning introduces different ways of exploring geoscience concepts through geographically and culturally relevant practices, and by diversifying geographic case studies and including local expertise surrounding the institution
90 (Johnson et al., 2014; Semken et al., 2017). It allows educators to bridge the disconnect between foundational principles, global-theoretical frameworks, and local-practical applications, such that phenomena may impact different locations and communities. This practice amplifies local experts and supports diverse student learning by diversifying examples that consider

non-Western regions. For example, many textbooks use Western examples to illustrate ocean-atmosphere dynamics, like the Gulf Stream but omit details about the Somali Current and its impact on monsoon behaviour (Schott, 1983).

95 Map selection can further perpetuate unconscious bias because scales, symbology, and colour can emphasise Western regions and ideology (Perkins, 2018). When educators use diverse and equitable geographical contexts and resources, learners can develop a broader understanding of geoscience across the globe which results in more robust contextualisation of concepts learned in courses with what is happening in their environment.

6 Broaden Pedagogy, Epistemology, & Communication Styles

100 We can diversify the geoscience curriculum by broadening our approaches to communication, teaching, and epistemology (or ways of knowing) (Le Grange, 2017; Hall and Tandon, 2017). When educators embrace diverse teaching approaches, student motivation grows and can lead to better engagement and retention (Tremblay-Wragg, 2019). Embracing these approaches helps educators create inclusive learning spaces, be respectful of diverse audiences, be culturally sensitive, and support the full inclusion of disabled learners and educators (Feig et al., 2019). Educators can also develop inter-institution classroom 105 collaborations to co-develop virtual exchanges and course-based collaborative learning projects (Stefanoudis et al., 2021).

We can diversify our communication styles by utilising different strategies in teaching (Mintz, 2020; Illingworth, 2020) to stimulate learners to diversify how they communicate knowledge. Knowledge sharing (e.g., storytelling, oral histories) by the communities may not conform to Western teaching practices tend to be excluded as references and from academia. Academic citations and curricula should be adapted to bring academic recognition to all ways of knowing, learning, and relating 110 (MacLeod, 2021; Kornei, 2021). This will enable educators to practice place-based learning and honour the knowledge and communities of a more diverse student population.

7 Support Transformative Agency in Education

Educators can support transformative and critical science agency by valuing the connected and holistic learning-teaching-knowledge-experience grounded in students' diverse social, emotional, and cultural needs (Rodriguez, 1998; Durlak et al., 115 2011). Agency refers to learners' ability to create knowledge and translate lessons learned to pursue actions with tangible benefits for themselves and/or their communities, strengthened by collaborative learning opportunities among learners and educators (Schenkel and Calabrese Barton, 2020; Adewumi and Mitton, 2022).

Pedagogy that places Western scientific knowledge as the ultimate source of knowledge and epistemology prevents the development of agency among learners, especially those from historically excluded communities (Smith, 1999; Masta, 2018; 120 Alexiades et al., 2021). Diversifying knowledge systems in curriculum (e.g., Traditional Ecological Knowledge, Western science) can lead to stronger overall education, rather than weakening previously centred systems (Virkkunen, 2006; Reano

and Ridgway, 2015; Smythe, 2017). Multiple epistemologies can be considered and valued in geoscience without being broken down, othered, or changed to be consistent with one another (Alexiades et al., 2021).

125 Education scholars have begun implementing strategies demonstrating how transformative agency and actions support educational equity while serving individual learners' community interests (Atwater et al., 2014; Bang et al., 2017; Miller et al., 2020). Reano (2020) describes how a co-created climate change adaptation plan with the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation) supported the transformative agency of Indigenous students.

Tips for Educators to Diversify Geoscience Education

Champion Material Transformation	Diversify Sources	Integrate Historical Context	Connect Across Geographies	Broaden Pedagogy & Communication Styles	Support Transformative Agency in Education
<ul style="list-style-type: none">Support actions to eliminate structural exclusion & barriersAdvocate for collaborative & accountable relationships with marginalised communitiesHire & support diverse educators	<ul style="list-style-type: none">Explore repositories to find & cite non-Western & marginalized researchersCo-create reading lists with studentsDiscuss concepts from primary sources in original languages	<ul style="list-style-type: none">Credit local experts & their knowledge that shaped researchIncorporate socio-political, historical dimensions of geoscience in existing curriculaDevelop & offer interdepartmental socio-scientific courses	<ul style="list-style-type: none">Use non-Western examples to explore geoscience phenomenaIncorporate local context to connect foundational concepts to real applicationSelect maps that do not further bias	<ul style="list-style-type: none">Incorporate different teaching strategies & ways of knowingUse different communication methods to contextualize concepts (e.g., art, storytelling)Consider various disabilities during curriculum development	<ul style="list-style-type: none">Emphasize non-Western ways of knowing without conforming it to be consistent with Western methodsCreate culturally relevant learning environments by relating it to individuals' positionality

130 **Figure 1: Summarised recommendations for educators to diversify their geoscience curriculum and education.**

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