

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 ~~decades~~ after decades of work and
20 widespread calls for improvement and action. We propose an approach and specific opportunities for educators to improve diversity in geoscience education within higher education: 1) advocating for institutional change, 2) incorporating diverse perspectives and authors in curricula, 3) teaching historical and ~~soeio~~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
25 agency.

1 Introduction

~~Geosciences~~ While geosciences play an essential role in addressing ~~key~~ societal issues, ~~but~~ it is an inequitable and exclusive field because of its complex entangled-entanglement with past and ongoing prejudices (Dowey et al., 2021; Berhe et al., 2022)with past and ongoing prejudiced practices, making it an inequitable and exclusive field. While some advances have
30 been made. Geoscience education that does not interrupt ~~racism and colonialism~~prejudice contributes to the hostile climates and structural problems that hinder diversity ~~in the geosciences~~ (Marín-Spiotta et al., 2020).
~~In this manifesto, we offer six points of reflection that higher education geoscience educators can act upon to recognize and unlearn their biases and to diversify geoscience education (Figure 1). These reflections complement existing~~ Many ~~resources and calls-to-arms have come from~~ leading and communities and leaders ~~leading these movements~~for decades but change is

35 ~~slow in and beyond geoscience education~~ (e.g., Huntoon and Lane, 2007; Bernard ~~and Cooperdock et al.~~, 2018; Gates et al.,
2019; Liboiron, 2021; ~~Science Educators for Equity, Diversity, & Social Justice~~ ADVANCEGeo). ~~Herein, we offer six specific~~
~~points of reflection and action that individual higher education geoscience educators can undertake to recognize and unlearn~~
~~their biases to support geoscience education diversity (Figure 1).~~ Furthermore, ~~we hope to it serves as a starting conversation~~
40 ~~point to gather continue interest and~~ momentum to establish a community-built framework for implementing and strengthening
diversity, equity, inclusion, and justice ~~holistically~~ in geoscience education.

2 Champion Meaningful Transformation

~~Foundational geoscience~~ ~~Extracting knowledge and resources extracted~~ from ~~excluded and exploited~~ communities ~~without~~
~~clear reciprocity~~ ~~has~~ historically benefited dominant groups (~~Keane, 2017; Stefanoudis et al., 2021; Wight, 2021~~), ~~while~~
~~excluding and exploiting oppressed communities.~~ ~~To combat extractive mindsets, visiting~~ ~~To combat extractive mindsets,~~
45 ~~geoscientists educators, learners, and researchers must not presume access to access nor community obligation to provide~~
~~knowledge, opportunities, nor resources.~~ ~~Educators can~~ ~~Geoscience educators and students should not presume access to~~
~~knowledge, opportunities, or communities.~~ ~~Communities are not obligated to offer visiting scientists opportunity to engage,~~
~~advocate for investing resources in communities and experts that contribute to knowledge and diversity in geoscience to help~~
50 ~~build trust and repair the legacy of injustices (e.g., colonial transfer of land and resources) that have led to the institution's~~
~~success.~~ ~~Eand scientists must enter these spaces with respect and humility (la paperson, 2014).~~ ~~Engagement requires building~~
~~relationships, reciprocity, trust, and accountability (Lewis and Sadler, 2021; Liboiron, 2021).~~ ~~As such, educators must~~
~~challenge the status quo, commit to action~~ ~~for equity~~, and develop accountable relationships ~~built on respect, reciprocity, and~~
~~trust~~ with communities ~~for knowledge exchange for systemic change (Indigenous Action Media, 2014; la paperson, 2014;~~
Powell and Kelly, 2017; Squire, 2019; Jones, 2021; Ali ~~et al.~~, 2021; ~~Lewis and Sadler, 2021; Liboiron, 2021~~).

55 ~~E~~ ~~Educators must should question-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, as detailed by (Land Grab Universities; Carbajal and Atchinson, 2020; Ormand et al., 2021; Cooperdock et al.,~~
~~2021; Ranganathan et al., 2021).~~ ~~For sustainable change, educators must call for educational institutions must to prioritise the~~
~~recruitment and retention of educators and learners from marginalised and excluded communities (Carbajal and Atchinson,~~
60 ~~2020; Ormand et al., 2021).~~ ~~Cultural.~~ ~~This also means that physical and systemi~~ ~~structural, and individual~~
~~infrastructure~~ ~~interventions and accountability systems isare required to lower access-barriers and power imbalances, while and~~
~~supporting diverse individuality and groups across all measures (e.g., closed-captioning during lectures; equity accountability~~
~~measures)(Núñez et al., 2019; Kingsbury et al., 2020; Olcott and Downen, 2020).~~ ~~Those who benefit from established~~
~~institutions should champion investing resources in communities and experts that contribute to diversity in geoscience.~~
65 ~~Advancing diversified geoscience education requires telling the truth about and repairing the legacy of injustices that~~
~~transferred land and resources to universities, including colonialism and slavery, to build trust and self-determination.~~

3 Diversify Sources

~~Teaching is research based as it requires educators to incorporate research output into lessons.~~ Without diversifying one's sources in developing curriculum, structural and unconscious bias on the value of specific research sources and types may be perpetuated, leading ~~to low inclusion, a lack of diverse sources, and~~ to a system of structural exclusion that proliferates unconscious bias.

~~By directing users to often referenced work published in high impact journals, most~~ Most search engines decrease the visibility of research published in smaller ~~(e.g., regional) and regional journals~~ by directing users to often-referenced work in high-impact journal, 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~~ Non-Western authors may rely on local or regional journals ~~due to prohibitive publication costs~~ because of the inaccessibility and exclusivity of high-profile journals ~~and lack of accessibility and inclusion in 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 cited more widely than their local, non-Western counterparts (Wight, 2021).

~~While some journals offer discounted publication rates and fee waivers, finding and citing work by researchers without access to these journals is a resource intensive task for educators.~~ 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 remains heavily influenced by those in the United States.

~~As a result, publications by Western scientists carrying out research in non-Western regions (with or without local researchers) that are similar to~~ like the work of local scientists are cited more widely than their local, non-Western counterparts. ~~While some journals offer discounted publication rates and fee waiver requests, finding and citing work by marginalised researchers and those without ample resources remains a resource intensive task.~~ Repositories like SCImago offers a diverse selection of journals, though these are often regionally biased and is a great place to start.

~~Use of different languages~~ Language barriers from diverse sources may in regional journals constitutes an additional barrier in incorporation in teaching and learning in English-dominated academic settings but this 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 ensuring that concept context and complexities are considered. However, translations often misses important context and complexity, as well as limits consideration of expertise in diverse languages (Helsinki Initiative, 2019). ~~This issue is further exacerbated when different~~

~~languages in regional journals constitute a barrier for incorporation in teaching and learning.~~ ~~While some journals offer discounted publication rates and fee waiver requests, finding and citing work by marginalised researchers and those without ample resources remains a resource intensive task.~~ SCImago offers a diverse selection of journals and is a great place to start. Co-creation of reading lists by Educators and students to can collaborate to Working with students to create an audit and update of the current geoscience reading lists readings to centre diversity can empower students and improve curriculum

100 ~~inclusivity on a geoscience programme is another way to address the lack of diversity in sources (Schucan Bird and Pitman, 2019). When enacting changes, source diversification must centre around author acknowledgement and reciprocity (Keane et al., 2017). Diversifying sources alone, however, could~~ must also include author acknowledgement and reciprocity to reduce further othering and exploitation (Keane et al., 2017). For example, many sustainability efforts extract information from Indigenous practises without considering the complex, holistic origin, and implications of Indigenous science (Tsosie, 2019).

105 Principles such as CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) can be used by educators when incorporating Indigenous knowledge into curriculum.

4 Integrate Historical Context

~~Today~~ Historically to now many scientists downplay marginalised researchers' and participants' contributions in their research (e.g., exclusion from the author list), which leads to exclusionary curricula (Dowey et al., 2021). Research is shaped by

110 ~~collaborators and their exclusion trickles to exclusive education~~ E, which is ~~educators can support diversity and equity by including discussion of socio-political contexts in curriculum further cemented when most educators do not include these historical contexts in curriculum (GeoContext). When included, learners can develop and practice more inclusive, diverse, and culturally sensitive approaches to science. (Stefanoudis et al., 2021). We can make geoscience education more inclusive b~~ By

115 ~~highlighting historical, cultural, and sociopolitical~~ socio-political dimensions of geological-geoscience discoveries, educators ~~we can bring value to those historically~~ Scientists and m ~~marginalised groups is lost. Cartier (2021) and GeoContext raised that~~ For example, local Indian Pandits helped the British during their colonial land survey project, the Great Trigonometrical Survey, by sharing their critical knowledge of their homeland and access to places that the British did not. While this project

120 ~~helped establish ew instructors attempt to explain geoscience in historical contexts, like the concept of isostasy, the Pandits receive little acknowledgement in Western education and its connection to the British colonial project, the Great Trigonometrical Survey, that aimed to survey the land (Sarkar, 2012; Cartier, 2021). Pandits (Indigenous explorers) brought their intimate knowledge of the land and access to places that the British did not. Pandits contributed significantly to this project yet receive no acknowledgment in Western education. Even today, many scientists downplay local researchers' contributions by excluding them from the author list or only mentioning them in the acknowledgments (Stefanoudis et al., 2021). However, geoscience research is a collaborative endeavour and its culture is shaped by narratives of all collaborators.~~

125 ~~By excluding them in our education, we are robbing future scientists of the chance to develop and practice more inclusive, diverse, and culturally sensitive approaches to science.~~

Educators can mitigate erasure of marginalised populations by ~~To~~ integrating historical context during lessons that illustrate the concept and research process while meeting learning objectives ~~into our taught curriculum, we must construct narratives that give a more complete representation of how scientific findings take place. While, this can be incorporated in fundamental~~

130 or advanced geoscience classes. One way to do this is by offering socio-scientific courses (e.g., geoscience history, culture,

~~and geothics) to learners, or by incorporating related topics into introductory courses. This will also benefit can lead to deeper understanding of geoscience concepts and interdisciplinary collaborations with humanities and social sciences.~~

5 Connect Across Geographies

135 ~~Place-based learning introduces different ways of exploring the world geoscience concepts, through geographically and culturally relevant practices (Johnson et al., 2014; Semken et al., 2017), and can be enhanced achieved by diversifying geographic case studies and by including local sites using local expertise surrounding the institution (Johnson et al., 2014; Semken et al., 2017) to understand geoscience concepts. It allows educators to bridge the disconnect between foundational principles, global-theoretical frameworks, and local-practical applications, such that phenomena can be related to observations with greater awareness of how different locations and communities are impacted. This practice amplifies local experts and~~
140 ~~supports diverse student learning by diversifying examples that consider non-Western regions. Geoscience curriculum often focuses on global scales with m, overlooking local scale context. Most teaching materials emphasize providing local context examples from of Western regions. For example, many textbooks use Western examples the Gulf Stream as an example of to illustrate ocean-atmosphere dynamics, like the Gulf Stream but omit details about the Somali Current and its impact on monsoon behaviour (Schott, 1983).~~

145 ~~Additionally, tMap selection the selection of maps can further perpetuate unconscious bias because scales, symbology, and colour can emphasize Western regions and ideology (Perkins, 2018). By including When educators use diverse and equitable geographical contexts and resources, learners can develop a broader understanding of geoscience diversity and variability across the globe that results in stronger contextualization, and better connect of concepts learned in courses with what is happening in their environment.~~

150 ~~Place-based learning introduces different ways of exploring the world, through culturally relevant practices (Johnson et al., 2014; Semken et al., 2017), and can be achieved by diversifying geographic case studies and by using local expertise to understand geoscience concepts. It allows educators to bridge the disconnect between foundational principles, global-theoretical frameworks, and local practical applications, such that phenomena can be related to observations with greater awareness of how different locations and communities are impacted. This practice amplifies local experts and supports diverse~~
155 ~~student learning.~~

6 Broaden Pedagogy, Epistemology, & Communication Styles

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, their students' motivation grows, ~~and can lead to resulting in better engagement and retention~~ (Tremblay-Wragg, 2019), ~~leading to~~
160 ~~better student engagement and retention.~~ This also helps educators ~~to~~ 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 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). This will in turn stimulate learners to diversify how they communicate knowledge. Knowledge sharing (e.g., storytelling, oral histories) by the communities that may not conform to Western teaching practices and tend to be excluded as references and from academia. [Academic eCitations and curriculum should be adapted to bring academic recognition to all ways of knowing, learning, and relating \(MacLeod, 2021; Kornei, 2021\)](#). 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, critical science~~ agency by valuing the [connected and holistic learning-teaching-knowledge-experience that is grounded in students' current diverse social-, emotional, and cultural needs \(Rodriguez, 1998; Durlak et al., 2011\)](#). ~~Here, we write these concepts as one hyphenated term to show that they are connected and must be considered holistically.~~ Agency refers to learners' ability to [create knowledge and translate their lessons learned to take knowledge and intentionally pursue actions that produce pursue into meaningful 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 ~~singular, or~~ the ultimate, source of knowledge [and epistemology prevents the development of agency among learners, especially those from historically excluded communities \(Smith, 1999; Masta, 2018; Alexiades et al., 2021\)](#). ~~However, the weakening of collective and individual agency is not an inevitable outcome of considering different knowledge systems within higher education (Virkkunen, 2006)~~. [Different Diversifying knowledge systems in curriculum \(e.g., Traditional Ecological Knowledge and Western science\) can lead to stronger overall education, rather than a weakening of previously centred systems \(Virkkunen, 2006; Reano and Ridgway, 2015; Smythe, 2017\)](#). [Multiple epistemologies can be considered \(e.g., Traditional Ecological Knowledge and Western science\) can be included and valued in the geoscience curriculum without being broken down-, othered, or changed to be consistent with one another \(Reano and Ridgway, 2015; Smythe, 2017\)](#). [\(Alexiades et al., 2021\)](#).

Education scholars have begun implementing strategies demonstrating how supporting transformative agency and actions [support reinforce 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 a co-created~~ climate change adaptation plan ~~created by with~~ the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation) supported the transformative agency of Indigenous students ~~in a communication and policy geoscience module. Holistic educational frameworks support individual learning while serving individuals' community interests.~~

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 & barriers • Advocate for collaborative & accountable relationships with marginalised communities • Hire & support diverse educators 	<ul style="list-style-type: none"> • Explore repositories to find & cite non-Western & marginalized researchers • Co-create reading lists with students • Discuss concepts from primary sources in original languages 	<ul style="list-style-type: none"> • Credit local experts & their knowledge that shaped research • Incorporate socio-political, historical dimensions of geoscience in existing curricula • Develop & offer interdepartmental socio-scientific courses 	<ul style="list-style-type: none"> • Use non-Western examples to explore geoscience phenomena • Incorporate local context to connect foundational concepts to real application • Select maps that do not further bias 	<ul style="list-style-type: none"> • Incorporate different teaching strategies & ways of knowing • Use 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 methods • Create culturally relevant learning environments by relating it to individuals' positionality

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Tips 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 action-driven efforts to eliminate structural exclusion and barriers • Act in solidarity and develop accountable relationships to advance social justice • Hire and support diverse educators 	<ul style="list-style-type: none"> • Cite non-Western researchers and marginalized researchers • Explore different ways of knowing (e.g., Indigenous) and exploring geoscience • Conduct a diversity audit on your sources and curricula 	<ul style="list-style-type: none"> • Credit local experts and their knowledge that shaped research • Incorporate historical dimensions of geological discoveries • Co-create and offer interdepartmental socio-scientific courses 	<ul style="list-style-type: none"> • Use non-Western examples to explore geoscience phenomena • Incorporate local context to connect foundational concepts to real application 	<ul style="list-style-type: none"> • Include multiple teaching strategies • Use different communication methods to contextualize geoscience (e.g., art, storytelling) 	<ul style="list-style-type: none"> • Emphasize non-Western ways of knowing without conforming it to be consistent with Western methods • Create culturally relevant learning environments

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

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305 Two of the authors are members of the editorial board of *Geoscience Communication*. The peer-review process was guided by an independent editor, and the authors also have no other competing interests to declare.

Data Availability

310 This paper contains opportunities for geoscience educators in higher education can support diversity. As such, other than the sources cited in the references, no data was used to produce this work.

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