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

Caitlyn A. Hall[1], Sam Illingworth[2], Solmaz Mohadjer[3], Mathew Koll Roxy[4], Craig Poku[5], Frederick Otu-Larbi[6], Darryl Reano[7], Mara Freilich[8], Maria-Luisa Veisaga[9], Miguel Valencia[10], and Joey Morales[11]

[1]The W.A. Franke Honors College and Biosystems Engineering Department, University of Arizona, Tucson, Arizona, United States
[2]Department of Learning and Teaching Enhancement, Edinburgh Napier University, Edinburgh, Scotland
[3]Department of Earth and Environmental Sciences, University of Central Asia, Khorugh, Tajikistan
[4]Climate Research Lab, Indian Institute of Tropical Meteorology, Pune, India
[5]Department of Chemistry, University of York, York, United Kingdom
[6]Lancaster Environment Centre, Lancaster University, United Kingdom
[7]School of Earth and Space Exploration, Arizona State University, Tempe, Arizona, United States
[8]Scripps Institution of Oceanography, University of California San Diego, San Diego, California, United States
[9]Kimberly Green Latin American and Caribbean Center, Florida International University, Miami, Florida, United States
[10]Department of Earth and Environment, Florida International University, Miami, Florida, United States
[11]Florida International University and Miami Northwestern Senior High School, Miami, Florida, United States

Correspondence to: Caitlyn A. Hall (cahall@arizona.edu) and Sam Illingworth (s.illingworth@napier.ac.uk)

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 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 the

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 have historically benefited dominant groups (Keane, 2017; Stefanoudis et al., 2021; Wight, 2021). To combat extractive mindsets, geoscientists 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 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., 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.

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 bias 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 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 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 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

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 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 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 (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).

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 globally, resulting in a more robust contextualisation of concepts learned in courses with what is happening in their environment.

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, 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 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 and 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 (MacLeod, 2021; Kornei, 2021). This diversity 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., 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; 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).

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.

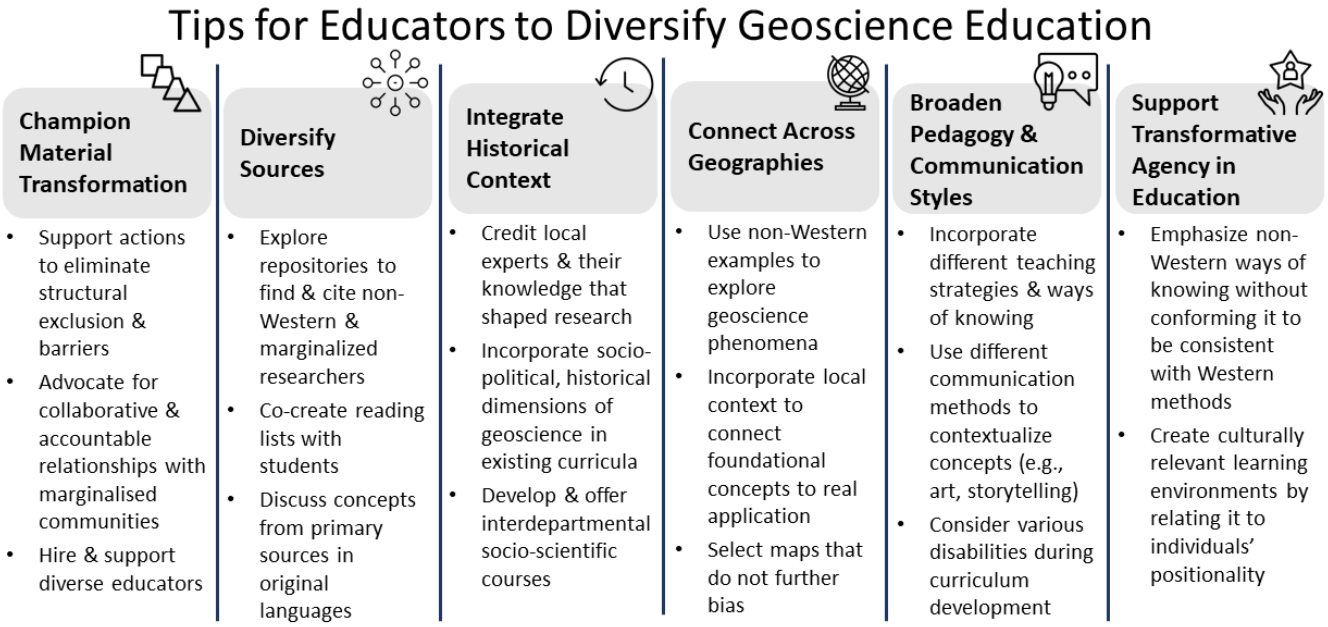

Figure 1: Summarised recommendations for educators to diversify their geoscience curriculum and education.

References

Adewumi, B. and Mitton, L.: Diversifying the Social Policy Curriculum: A Collaborative Approach, Science Policy and Society, 21(1), 54-67, https://doi.org/10.1017/S1474746421000506, 2022.

ADVANCEGeo.: https://serc.carleton.edu/advancegeo/index.html, last access: 25 July 2022.

Alexiades, A. V., Haeffner, M. A., Reano, D., Janis, M., Black, J., Sonoda, K., Howard, M., Fiander, C., and Buck, M.: Incorporating Traditional Ecological Knowledge within inclusive pedagogy increases retention and success outcomes of STEM students, The Bulletin of the Ecological Society of America, 102(4): e01924, https://doi.org/10.1002/bes2.1924, 2021.

Ali, H.N., Sheffield, S.L, Bauer, J.E., Caballeo-Gill, R.P., Gasparini, N.M., Libarkin, J., Gonzalez, K.K., Willenbring, J., Amir-Lin, E., Cisneros, J., Desai, D., Erwin, M., Gallant, E., Jeannelle Gomez, K., Keisling, B.A., Mahon, R., Marin-Spiotta, E., Welcome, L., and Schneider, B.: An actionable anti-racism plan for geoscience organisations, Nature Communications, 12, https://doi.org/10.1038/s41467-021-23936-w, 2021.

Atwater, M., Butler, M., and Russell, M. (Eds.): Multicultural science education: Preparing teachers for equity and social justice, Springer, New York, United States, 2014.

Bang, M., Brown, B., Calabrese Barton, A., Rosebery, A., and Warren, B.: Toward more equitable learning in science: Expanding relationships among students, teachers, and science practices, in: Helping students make sense of the world using next generation science and engineering practices, edited by: C. V. Schwarz, C. Passmore, and B. J. Reiser, 33-58, National Science Teachers Association (NSTA) Press, Arlington, United States, 2017.

Berhe, A. A., Barnes, R. T., Hastings, M. G., Mattheis, A., Schneider, B., Williams, B. M., and Marín-Spiotta, E.: Scientists from historically excluded groups face a hostile obstacle course, Nature Geoscience, 15, 2-4, https://doi.org/10.1038/s41561-021-00868-0, 2022.

Bernard, R.E., Cooperdock, E.H.G.: No progress on diversity in 40 years. Nature Geosci., 11, 292–295, https://doi.org/10.1038/s41561-018-0116-6, 2018.

Carbajal, I.G., and Atchinson, C.L.: An investigation of accessible and inclusive instructional field practices in US geoscience departments, Advances in Geosciences, 53, 53-63, https://doi.org/10.5194/adgeo-53-53-2020, 2020.

Cartier, K.M.S.: Teaching Geoscience History in Context, Eos, https://eos.org/articles/teaching-geoscience-history-in-context, 2021.

Cooperdock, E. H. G., Chen, C. Y., Guevara, V. E., and Metcalf, J. R.: Counteracting Systemic Bias in the Lab, Field, and Classroom, AGU Advances, 2(1), e2020AV000353, https://doi.org/10.1029/2020AV000353, 2021.

Dowey, N., Barclay, J., Fernando, B., Giles, S., Houghton, J., Jackson, C., Khatwa, A., Lawrence, A., Mills, K., Newton, A., Rogers, S., and Williams, R.: A UK perspective on tackling the geoscience racial diversity crisis in the Global North, Nature Geoscience, 14, 256-259, https://doi.org/10.1038/s41561-021-00737-w, 2021.

Durlak, J. A., Weissberg, R. P., Dymnicki, A. B., Taylor, R. D., and Schellinger, K.: The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions, Child Development, 82, 405-432, https://doi.org/10.1111/j.1467-8624.2010.01564.x, 2011.

Feig, A. D., Atchison, C., Stokes, A., and Gilley, B.: Achieving Inclusive Field-based Education: Results and Recommendations from an Accessible Geoscience Field Trip, J. of the Scholarship of Teaching and Learning, 19(2), 66-87, https://doi.org/10.14434/josotl.v19i1.23455, 2019.

Gates, A.E., McNeal, K., Riggs, E., Sullivan, S., and Dalbotten, D.: New developments in diversity and inclusiveness in geosciences, Journal of Geoscience Education, 67:4, 285-286, https://doi.org/10.1080/10899995.2019.1671713, 2019.

GeoContext.: https://geo-context.github.io/, last access: 11 February 2022.

Global Indigenous Data Alliance.: https://www.gida-global.org/care, last access: 11 February 2022.

Hall, B. L. and Tandon, R.: Decolonisation of knowledge, epistemicide, participatory research and higher education, Research for All, 1(1), 6-19, https://doi.org/10.18546/RFA.01.1.02, 2017.

Helsinki Initiative.: Helsinki Initiative on Multilingualism in Scholarly Communication. Helsinki: Federation of Finnish Learned Societies, Committee for Public Information, Finnish Association for Scholarly Publishing, Universities Norway & European Network for Research Evaluation in the Social Sciences and the Humanities, https://doi.org/10.6084/m9.figshare.7887059, 2019.

Huntoon, J.E., and Lane, M.J.: Diversity in the Geosciences and Successful Strategies for Increasing Diversity, Journal of Geoscience Education, 55(6), 447-457, https://doi.org/10.5408/1089-9995-55.6.447, 2007.

Illingworth, S.: Creative communication – using poetry and games to generate dialogue between scientists and nonscientists, FEBS Letters, 594(15), https://doi.org/10.1002/1873-3468.13891, 2020.

Jeater, D.: Academic Standards or Academic Imperialism? Zimbabwean perceptions of hegemonic power in the global construction of knowledge, African Studies Review, 61(2), 8-27, https://doi.org/10.1017/asr.2017.132, 2018.

Jones, J. C.: We need accomplices, not allies in the fight for an equitable geoscience. AGU Advances, 2(3), e2021AV000482, https://doi.org/10.1029/2021AV000482, 2021.

Johnson, A. N., Sievert, R., Durglo, Sr., M., Finley, V., Adams, L., Hofmann, M. H.: Indigenous Knowledge and Geoscience on the Flathead Indian Reservation, Northwest Montana: Implications for Place-Based and Culturally Congruent Education, J. of Geo. Edu., 62, 187 - 202, https://doi.org/10.5408/12-393.1, 2014.

Keane, M., Khupe, C., and Seehawer, M.: Decolonising methodology: Who benefits from indigenous knowledge research?, Educational Research for social change, 6(1), 12-24, http://dx.doi.org/10.17159/2221-4070/2017/v6i1a2, 2017.

Kingsbury, C. G., Sibert, E. C., Killingback, Z., and Atchison, C. L.: "Nothing about us without us:" The perspectives of autistic geoscientists on inclusive instructional practices in geoscience education, J. of Geoscience Education, 68(4), 302-310, https://doi.org/10.1080/10899995.2020.1768017, 2020.

Kornei, K.: Academic citations evolve to include Indigenous oral teachings, Eos, 102, https://doi.org/10.1029/2021EO210595, 2021.

la paperson: A ghetto land pedagogy: an antidote for settler environmentalism, Environmental Education Research, 20(1), https://doi.org/10.1080/13504622.2013.865115, 2014.

Land Grab Universities.: https://www.landgrabu.org/, last access: 11 February 2022.

Le Grange, L.: Integrating Western and Indigenous Knowledge Systems: The Basis for Effective Science Education in South Africa?, International Review of Education, 53, 577-591, https://doi.org/10.1007/s11159-007-9056-x, 2007.

Lewis, E. Y. and Sadler, R. C.: Community–academic partnerships helped Flint through its water crisis, Nature, 594(7863), 326-329, https://doi.org/10.1038/d41586-021-01586-8, 2021.

Liboiron, M.: Decolonising geoscience requires more than equity and inclusion. Nat. Geosci. 14, 876–877, https://doi.org/10.1038/s41561-021-00861-7, 2021.

MacLeod, L.: More Than Personal Communication: Templates For Citing Indigenous Elders and Knowledge Keepers. KULA: Knowledge Creation, Dissemination, and Preservation Studies 5(1), https://doi.org/10.18357/kula.135, 2021.

Marín-Spiotta, E., Barnes, R. T., Berhe, A. A., Hastings, M. G., Mattheis, A., Schneider, B., and Williams, B. M.: Hostile climates are barriers to diversifying the geosciences, Advances in Geosciences, 53, 117-127, https://doi.org/10.5194/adgeo-53-117-2020, 2020.

Masta, S.: What the grandfathers taught me: Lessons for an Indian country researcher. The Qualitative Report, 23 (4), 841-852, https://doi.org/10.46743/2160-3715/2018.3254, 2018.

Miller, R., Liu, K., and Ball, A. F.: Critical counter-narrative as transformative methodology for educational equity. Review of Research in Education, 44, 269-300, https://doi.org/10.3102/0091732X20908501, 2020.

Mintz, S.: Pedagogy and Course Design Need to Change. Here's How., Inside Higher Ed, https://www.insidehighered.com/blogs/higher-ed-gamma/pedagogy-and-course-design-need-change-here%E2%80%99s-how, last access: 11 February 2022.

Núñez, A., Rivera, J. and Hallmark, T.: Applying an intersectionality lens to expand equity in the geosciences, Journal of Geoscience Education, 68(2), 97-114, https://doi.org/10.1080/10899995.2019.1675131, 2020.

Ormand, C.J., Macdonald, R.H., Hodder, J., Bragg, D.D., Baer, E.M.D., and Eddy, P.: Making departments diverse, equitable, and inclusive: Engaging colleagues in departmental transformation through discussion groups committed to action, J. of Geoscience Education, https://doi.org/10.1080/10899995.2021.1989980, 2021.

Perkins, C.: Critical cartography, in: The Routledge Handbook of Mapping and Cartography, edited by: Kent, A.J. and Vujakovic, P., Routledge, Abingdon, Oxon, 80-89, https://doi.org/10.4324/9781315736822.ch6, 2018.

Powell, J., and Kelly, A.: Accomplices in the academy in the age of Black Lives Matter. Journal of Critical Thought and Praxis, 6(2), https://www.iastatedigitalpress.com/jctp/article/id/551/, 2017.

Ranganathan, M., Lalk, E., Freese, L. M., Freilich, M. A., Wilcots, J., Duffy, M. L., and Shivamoggi, R.: Trends in the Representation of Women Among US Geoscience Faculty From 1999 to 2020: The Long Road Toward Gender Parity, AGU Advances, 2(3), e2021AV000436, https://doi.org/10.1029/2021AV000436, 2021.

Reano, D.: Using Indigenous research frameworks in the multiple contexts of research, teaching, mentoring, and leading. The Qualitative Report, 25(11), 3902-3926, https://doi.org/10.46743/2160-3715/2020.4317, 2020.

Reano, D. and Ridgway, K. D.: Connecting geology and Native American culture on the reservation of Acoma Pueblo, New Mexico. GSA Today, 25 (8), 26-28, https://doi.org/10.1130/GSAT-G235GW.1, 2015.

Rodriguez, A.: Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and for understanding. Journal of Research in Science Teaching, 35 (6), 589-622, https://doi.org/10.1002/(SICI)1098-2736(199808)35:6%3C589::AID-TEA2%3E3.0.CO;2-I, 1998.

Sarkar, O.: The Great Trigonometrical Survey: Histories of Mapping 1790–1850, ETraverse The Indian Journal of Spatial Science, 3(1), 1-6,

https://www.academia.edu/8906484/The_Great_Trigonometrical_Survey_Histories_Of_Mapping_1790_185, 2012.

Schenkel, K., and Calabrese Barton, A.: Critical science agency and power hierarchies: Restructuring power within group to address injustice beyond them, Science Education, 104(3), 1-30, https://doi.org/10.1002/sce.21564, 2020.

Schott, F.: Monsoon response of the Somali Current and associated upwelling. Progress in Oceanography, 12(3), 357-381, https://doi.org/10.1016/0079-6611(83)90014-9, 1983.

Schucan Bird, K., and Pitman, L.: How diverse is your reading list? Exploring issues of representation and decolonisation in the UK, High Educ, 79, 903–920, https://doi.org/10.1007/s10734-019-00446-9, 2020.

SCImago.: https://www.scimagojr.com/journalrank.php, last access: 11 February 2022.

Semken, S., Geraghty Ward, E., Moosavi, S., and Chinn, P.W.U.: Place-Based Education in Geoscience: Theory, Research, Practice, and Assessment, Journal of Geoscience Education, 65:4, 542-562, https://doi.org/10.5408/17-276.1, 2017.

Smith, L. T.: Decolonising Methodologies: Research and Indigenous Peoples, Zed Books, London, United Kingdom, 1999.

Smythe, W., Hugo, R., and McAllister, S. M.: Incorporation of Traditional Knowledge into geoscience education: An effective method of Native American instruction. Journal of Sustainability Education, 14, http://www.susted.com/wordpress/content/incorporation-of-traditional-knowledge-into-geoscience-education-an-effective-method-of-native-american-instruction_2017_06/, 2017.

Squire, D. D.: Ending allies through the eradication of the ally (industrial) complex, in: Rethinking LGBTQIA Students and Collegiate Contexts, edited by: Zamani-Gallagher, E.M., Dibya Choudhuri, D., and Taylor, J.L., Routledge, London, United Kingdom, 186-203, 2019.

Stefanoudis, P.V., Licuanan, W.Y., Morrison, T.H., Talma, S., Veitayaki, J., and Woodall, L.C.: Turning the tide of parachute science, Current Biology, 31(4), R184-R185, https://doi.org/10.1016/j.cub.2021.01.029, 2021.

Tremblay-Wragg, E., Raby, C., Ménard, L., and Plante, I.: The use of diversified teaching strategies by four university teachers: what contribution to their students' learning motivation?, Teaching in Higher Education, 26:1, 97-114, DOI: 10.1080/13562517.2019.1636221, 2021.

Tsosie, R.: Indigenous Sustainability and Resilience to Climate Extremes: Traditional Knowledge and the Systems of Survival, Connecticut Law Review, 407, https://opencommons.uconn.edu/law_review/40, 2019.

Virkkunen, J.: Dilemmas in building shared transformative agency, Activités [En ligne], 3-1, https://doi.org/10.4000/activites.1850, 2006.

Wight, A. J.: Why Aren't There More Journal Papers by African Geoscientists?, Eos, https://eos.org/articles/why-arent-there-more-journal-papers-by-african-geoscientists, 2021.

Yakama Nation.: Climate adaptation plan for the territories of the Yakama Nation Version 1, https://critfc.org/fish-and-watersheds/climate/, last access: 14 February, 2022.