

Equitable Socio-Ecological Learning Across STEM Disciplines Through a Histories of Places Framework

Veronica Cassone McGowan, Santiago Lopez, Jeffrey Jensen, Jordan Sherry-Wagner, Carrie Tzou
vmcgowan@uw.edu, cslopez@uw.edu, jsjensen@uw.edu, jsherr13@uw.edu, tzouct@uw.edu
University of Washington Bothell

Megan Bang, Northwestern University, megan.bang@northwestern.edu

Abstract: Socio-ecological histories of places are political, contested, and intimately linked with ways of knowing and being in the world. Thinking within and across time scales is necessary to understand the complexity of socio-ecological systems more deeply and to account for these layered and intersecting scales as a part of ethical decision making with and for places. In this paper, we describe our work as an interdisciplinary team of geoscientists, ecologists, fisheries biologists, and learning scientists to understand how STEM educators can use the Learning in Places Socio-ecological Histories of Places Framework, to support justice-centered, field-based learning. Our initial findings show that the framework supported STEM faculty in 1) situating humans as a part of the natural world, 2) making visible Indigenous peoples' time as central to disciplinary learning, and 3) thinking about ethical decision making as a central practice in disciplinary STEM work with students and communities.

Introduction

Socio-ecological histories of places are political, contested, and intimately linked with ways of knowing and being in the world in everyday as well as disciplinary contexts. Histories span across land, waters, plants, animals, and human communities over time, yet undergraduate science education in the U.S. is often taught in ways that render the powered and historical intersections of social and ecological systems invisible to learners and researchers (Learning in Places Collaborative, 2021). Thinking within and across many time scales is necessary to understand the complexity of socio-ecological systems more deeply and to account for these layered and intersecting scales as a part of ethical decision making with and for places— a practice that is critical to enacting just and equitable STEM research with places and communities. The Histories of Places framework involves thinking across six time scales to support learners in understanding how decisions lead to ethical, just, and sustainable futures and possibilities for humans as a part of the more-than-human world (see Figure 1). Providing a framework for thinking across multiple time scales supports learners and educators across contexts (i.e. K12, undergraduate, and professional) in being able to think about past, present, and future impacts to our lands and waters when engaging in field-based learning and research.

Environmental science research and learning rarely address colonialism in their fields of study, and often reproduce colonial structures and practices by engaging in ahistorical, universalizing, and discovery-focused field-based investigations that invisibilize the heterogeneity and complexity of ecological process that occur across peoples, lands, and waters at multiple scales (Liboiron, 2021). Supporting educators and learners in perspective taking and reasoning through contested histories of places are equity practices that allow for multiple and diverse stories to be told, honored, and incorporated into environmental and STEM professional learning and practice (McGrath & Jebb, 2015). Providing a framework for STEM researchers and faculty to engage in powered and historical analyses around the social, historical, and ecological dimensions of the places they study is required for enacting more just decisions in the future (Learning in Places Collaborative, 2021; Liboiron, 2021). Further, a failure to incorporate these histories reduces opportunities for STEM professionals to understand the complexities of social and ecological systems central to 21st century challenges, such as the environmental injustices that arise from the intersection of ecological crises and systemic racism.

The work we describe in this paper describes Learning in Places (LiP), a four-year, participatory design research study funded by the National Science Foundation. Learning in Places seeks to co-design (with classroom educators, families, and community-based organizations) learning engagements that support science learners and educators with equitable, culturally-based, socio-ecological systems learning and sustainable, ethical decision-making using field-based science education across settings and in partnership with families and communities. In this work we come together as an interdisciplinary team of geoscientists, ecologists, fisheries biologists, and learning scientists to understand how undergraduate STEM educators can use the Learning in Places Socio-ecological Histories of Places Framework, associated tools, and practices to support justice-centered, field-based learning in their own contexts that include undergraduate courses, projects, and multigenerational citizen-science efforts. **Research questions that guided this analysis are: (a) How do two STEM faculty across disciplines**

take up and use the Histories of Places framework in their own research and teaching?, and (b) How can attending to Histories of Places create more just and equitable framings of disciplinary learning across classroom, field, and community contexts?

Theoretical framing

STEM fields are increasingly recognizing the need to address social theories and context in the study of natural systems (Schell, et al, 2020; Hildebrandt, et al, 2018; Liboiron, 2020). We draw heavily from work in social design experiments (Gutiérrez & Jurow, 2016) and participatory design research (Bang & Vossoughi, 2016) to co-construct meanings and applications of Histories of Places across disciplines and contexts in partnership with STEM faculty in ways that integrate core principles of Learning in Places into their fields of study. These principles include positioning humans as a part of (rather than apart from) natural systems (Learning in Places, 2021), broadening what counts as STEM knowledge to include cultural and community ways of knowing, and making visible racialized and powered human decisions and actions that have shaped socio-ecological landscapes over time. Participatory design research requires a fundamental examination and critique of structural sources of inequity, and collective dreaming of alternative, more just forms of partnering. In the work, we intentionally engaged in co-design with STEM faculty to support the development of co-designers as historical actors (Gutiérrez & Jurow, 2016), and designers of their discipline’s present and future orientations towards justice in higher education as well as community contexts. This involves not only a sense of one’s own identity in broader cultural and systemic contexts, but also a historicized understanding of how certain practices--in particular, practices that perpetuate inequality--came to be and are sustained over time within STEM fields. We use this as a lens through which to examine the case studies presented below.

Design

In the Learning in Places project, we have designed a set of *educator frameworks* that make visible core dimensions of practice for just and equitable field-based science education. In this paper, we focus on one of those frameworks, called *Socio-ecological Histories of Places* (Learning in Places Collaborative, 2021). When scientists study complex systems phenomena in places, they need to understand those places across different scales of time and space. For example, when engaging in restoration, scientists need to first understand the history of a place and the various historical decisions that have been made to shape the land and waters of a place. They need to think across timescales—from geologic time to nation-state time to global time to the future—to understand how natural processes intersect with human decisions and the effects those might have on the future health of a place for all of its inhabitants (cf. Santos-Martin et al, 2019). The socio-ecological histories of places framework (see Figure 1) provides a pathway for supporting more expansive framings of disciplinary learning, teaching, and doing to account for the temporal and spatial variation of natural phenomena at scale, with a focus on centering humans and human decision making as a natural and emergent part of ecological systems.

Figure 1: Histories of Places visual graphic



Methods and analysis

This study takes place in one public university in the Pacific Northwest. We use a case study method to understand how two STEM faculty members, who are co-authored on this proposal, understood, applied, and adapted the Histories of Places framework to their own teaching and research (Yin, 2017). For each faculty case study, we have collected multiple sources of evidence that included collaborative discussions about the nature and use of Histories of Places in their work during monthly faculty meetings (18 hours total), artifacts of their adoption of the histories of places framing for their work across contexts (including multigenerational citizen science

programs, and STEM course design), and recordings of academic and community talks and workshops in which each faculty member describes their work the six socio-ecological timescales.

Initial findings

We found that the Histories of Places framework was taken up across multiple faculty members that participated in a small, interdisciplinary co-design group aimed at developing just and equitable models of science learning across STEM fields. Below we highlight two examples of how this framework was used by a geoscientist in an undergraduate GIS course, and a fisheries biologist in a university-partnered citizen science program.

Case Study 1: Visualizing socio-ecological Histories of Places with geospatial mapping tools

In co-design conversations geoscientists, Luis, shared that “most environmental issues or problems have a spatial and temporal dimension. When we teach undergraduates about these issues, we need to make sure they have an understanding of the complexity that this entails. There are many tools we can use today to help students visualize and interpret the interconnections between multiple socio-temporal dimensions to gain insights about where and why socio-ecological issues arise. These are usually contentions spaces, where people compete for resources and geopolitical control, but this is all mediated by particular cultural and socioeconomic conditions between people and places. Geospatial technologies such as geographic information systems (GIS) can help assess complex socio-ecological systems to address global environmental challenges and can help students visualize the scale of powered decision making over time.”

In this case study, this faculty member shared how he used multiple layers in ArcMap to engage his undergraduate students in thinking about the multiple, historically-situated, and politically-contested socio-ecological histories of the areas around our University. These mapping layers moved from *hydrogeologic time* to *plant, animal and soil time* by showing how glacial formations shaped our region in ways that supported the emergence of unique ecosystems. He then positioned humans as a part of (rather than apart from) nature through these emergent systems by layering *Indigenous peoples’ time* onto the map, noting that “we have a map of the ancestral territories of this area, and we can have a clear image of the human footprint even before Europeans arrived.” In moving towards *nation-state time*, Luis shared that, “we know that these landscapes are contested and shaped by socio-ecologic and geopolitical factors, and here we have a layer of land that is currently under the jurisdiction of Indigenous peoples in the area.” In moving between Indigenous peoples’ and nation-state layers, students could clearly see the immense scale of land loss for Indigenous peoples locally as well as nationally. These visualizations supported students in understanding the patterns and lasting impacts of colonialism on peoples, lands, and waters in ways that oriented their independent GIS work towards proposing pathways for more just and equitable futures in relation to land-based decision making.

Case Study 2: Histories of Places through Stories and Study of Kokanee Salmon

In our second case study, a fisheries biologist, Greg, shared how the Histories of Places framework enabled him to “draw connections between biological systems and their historical and socio-ecological context” for Kokanee salmon. Greg noted that “there is a complicated history between what settlers have done to the landscape and what historically has been.” Greg shared how he used the Histories of Places Framework across multiple contexts, including his work with tribal research partners, his undergraduate courses, a STEM field camp for marginalized youth, and a citizen science salmon monitoring program in order to tell the “many stories that can emerge from the study of Kokanee.” In a talk with local community members about the future of Kokanee salmon, Greg shared that, “the story of Kokanee begins in the ice ages... much biology was built after the glacier receded and left behind freshwater lakes... Native Americans and Kokanee have lived here together since the retreat of the glacier over 10,000 ago. Historical records and stories show the origins of this relationship over time... Just over 100 years ago the small streams were loaded with Kokanee salmon, which were thought to have gone extinct by the middle of the 20th century... but in 2021 we found middle-run Kokanee in a local stream. We found that these salmon that are historically important and culturally important are still with us, which brings up ethical responsibilities and possibilities for how to [sustain these populations] into the future.”

In this excerpt, Greg makes visible the significance of Indigenous knowledge systems and relations to Kokanee in the region, and the impact of settler colonialism and resource extraction on both ecological and human communities over time, with an emphasis on ethical decision making for re-making more just relations with tribal members and Kokanee now and in the future. Greg recognized how colonial practices work to invisibilize these layered histories and how conservation work requires us to make them visible and present as a part of our decision making practices. In talking with local community members, Greg reflected, “If you think about kokanee and their cultural history of their evolution in lake systems... all of that is still here, but it’s easier to overlook because

our views are limited by our day-to-day interactions and it can be hard to see this history [because of powered decision making about the land and waters in our area].” In moving between timescales, Greg noted that “Native Americans and salmon have been here together since the departure of the glaciers, and Kokanee have and continue to be very important to Native Americans living in and around [our local lakes]. Greg shared how historic records and stories were foundational to understanding the biology and significance of Kokanee over time. In this talk, Greg shared a portion of the origin story for the Snoqualmie tribe, but juxtaposed this historical account with a contemporary one, stating that “Kokanee continue to be an important cultural component for the Snoqualmie tribe today and in the future” as is represented by the two quotes below. In this way, Greg, uses the Histories of Places Framework to uphold Indigenous presence in present and future awareness.

“There’s a little story about how the Snoqualmie came to settle in Lake Sammamish, Lake Washington. To find that red fish and that red fish was only in two lakes, I think ... Then they got a taste of that red fish, and they settle there.” -Ed Davis, Snoqualmie community elder (1888-1987)

“Gathering on days like this, on this beautiful evening, is one small step in honoring the kokanee and caring for the communities connected by this little red fish. The Snoqualmie Tribe and these kokanee have been here since time immemorial.” - Snoqualmie Tribal Council Member Jolene Williams. 10/12/22

Our initial findings show that the Histories of Places framework supported STEM faculty in 1) situating humans as a part of the natural world, 2) making visible Indigenous peoples’ time and cultural knowledges as central to disciplinary learning past, present and future, and 3) thinking about ethical decision making as a central practice in disciplinary STEM work with students and communities.

Conclusion & implications

Shifting the dynamics of power and historicity in moment-to-moment interaction is central to creating educational equity and forms of education that support culturally thriving communities. We have a paucity of work that traces the learning pathways of STEM faculty learning more justice-centered practices, particularly as it relates to Indigenous peoples and histories. This study marks a new dimension of how place-based science education addresses the complicated and layered social histories of places as central to equitable learning within and about STEM fields.

References

- Bang, M., & Vossoughi, S. (2016). Participatory design research and educational justice: Studying learning and relations within social change making. *Cognition and instruction, 34*(3), 173-193
- Gutiérrez, K.D., & Jurow, A.A. (2016). Social design experiments: Toward equity by design. *Journal of the Learning Sciences, 25*(4), 1-34.
- Hildebrandt, C. C., & Marron, J. M. (2018). Justice in CRISPR/Cas9 research and clinical applications. *AMA journal of ethics, 20*(9), 826-833.
- Learning in Places Collaborative. (2021). *Framework: Socio-Ecological Histories of Places Framework: Supporting Sense-Making and Decision-Making toward Ethical Futures*. Bothell, Seattle, WA & Evanston, IL: Learning in Places.
- Learning in Places Collaborative. (2021). *Framework: Nature-Culture Relations*. Bothell, Seattle, WA & Evanston, IL: Learning in Places.
- Liboiron, M. (2021). *Pollution is colonialism. Pollution Is Colonialism*. Duke University Press.
- McGrath, A., & Jebb, M.A. (2015). *Long history, deep time: Deepening histories of place*. Canberra ACT, Australia: Australian National University Press and Aboriginal History, Inc.
- Santos-Martín, F., García-Mon, B.G., González, J.A., Iniesta-Arandia, I., García-Llorente, M., Montes, C., & Martín-López, B. (2019). Identifying past social-ecological thresholds to understand long-term temporal dynamics in Spain. *Ecology and Society, 24*(2). <https://doi.org/10.5751/ES-10734-240210>
- Schell, C. J., Dyson, K., Fuentes, T. L., Des Roches, S., Harris, N. C., Miller, D. S., & Lambert, M. R. (2020). The ecological and evolutionary consequences of systemic racism in urban environments. *Science, 369*(6510).
- Yin, R. K. (2017). *Case study research and applications: Design and methods*. Sage publications.

Acknowledgments

This work was funded by the National Science Foundation, grant number 1720578. We would like to thank our partners, including teacher collaborators and participating students and their families who shared their stories and knowledges with us to make this work possible.