POSITION PAPER

Theoretical diversity and inclusivity in science and environmental education research: A way forward

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Abstract

As distinct communities of practice (COP), science education research (SER) and environmental education research (EER) have both matured a great deal in recent decades, coming to include a greater diversity of theoretical perspectives, worldviews, and researcher and participant voices. In this paper, we present a view of theoretical inclusivity that promises a rich, robust research landscape for both EER and SER through the deliberate inclusion of non-Western theories. This view has several components: it requires researchers to be explicit and clear about their theoretical stances and to use critical reflection to evaluate their research; and it encourages the field to expansively explore phenomena and issues using multiple epistemologies and continue to deepen their focus on developing praxis. EER's interdisciplinary and cross-disciplinary nature make it uniquely positioned to model such inclusivity and move forward together with SER to create knowledge that is more robust and more just. We identify and discuss three key imperatives for the two fields to embrace this theoretical inclusivity now and the paths forward to support scholars doing work in both EER and SER and for the productive future of these fields.

As sociocultural researchers in environmental education research (EER) and science education research (SER) respectively, we recognize that while we work in two distinct communities of practice (COP; Lave & Wenger, 1991), we hold certain common values, most particularly the role that context, culture, language, and identity play in providing insights about how knowledge is constructed, whether it is in the classroom, the workplace, or the academy. We know that as a society, we are grappling with tough questions. Equity, social justice, and sustainability are key among them. We know that both fields need to address these issues directly. We use these values as a foundation for the argument we make in this paper concerning how the fields of EER and SER are and can be situated with respect to the development of greater theoretical diversity and inclusivity and the implications for this growth on the field's relationship with science education research. Our values lead us to believe that knowledge is contextual and that lived experience and knowledge cannot be disentangled (onto-epistemologies). The issues described above have emerged from certain Western, capitalist onto-epistemologies which are reproduced in science and environmental education. and we believe that other onto-epistemologies that can be highlighted through a TI framework and provide new understandings of both education and the world in which it is embedded and yield potential new paths forward for scholars working within COP in both disciplines. Acknowledging the role of context, our work here is seated in a United States context, though many of the standing issues as well as the lessons that emerge can be applicable outside of that system.

EER and SER have grown and matured a good deal from their early days. Even as we strive to better understand how people teach and learn about science and the environment, create connections, and become active and aware citizens, we do so in increasingly unstable social-ecological systems. What began as male-driven, positivist fields have made huge strides in becoming more inclusive with regard to gender, culture, race, and ethnicity. They have embraced broader and more diverse methodologies and theoretical lenses. As with all domains and disciplines, however, we must continue to grow and strengthen our field, and this requires continued critical self-reflection on where the field is, the extent to which it addresses issues at hand, and the ways it might become both more responsive and more generative. Knowledge, such as our understanding of teaching and learning and the interplay of the social and the bio-physical in our environments, is not static. As we learn more, we have the potential to identify gaps in our understanding as well as possible paths for greater knowledge generation. However, not all paths forward are equally productive or supportive of our goals.

As researchers in EER and SER, we have wrangled with this issue of knowledge generation by considering ideas for how to bolster the already considerable development of theory in these fields, what could support the continued maturation of theory, and how the two disciplines could grow together. In this article, we examine three imperatives for continuing to develop EER's and SER's theoretical inclusivity (TI) to the benefit of theory and practice alike. We use the term TI to mean the deliberate inclusion of multiple theoretical perspectives, particularly non-Western theories such as Indigenous knowledges, critical race theory, decolonial research, and intersectional feminist work. To support our exploration of TI in EER and SER and the imperatives we describe, we use the Communities of Practice framework (COP; Lave & Wenger, 1991).

COPs are groups of individuals engaged in common enterprise who collectively develop a shared repertoire of practices, tools, and language, which in turn shapes the onto-epistemologies of members of the group. An individual belongs to multiple COPs across the breadth and length of their life, and those communities are sometimes in conversation (Wenger-Trayner & Wenger-Trayner, 2014). EER and SER are two such communities. We recognize that EER and SER are distinct disciplines that overlap, with researchers who are members of both communities. Both disciplines, and the researchers within, would benefit from increased TI. We believe that in order to address complex problems such as TI and the more equitable research it engenders, it is critical that researchers in both SER and EER engage in conversation and critical reflection both within and across COP boundaries so that both disciplines can move forward in a way that is equitabe.

While EE, and by extension EER, emerged 50 years ago, it is only in the past 30 years that EER scholars have engaged in critical self-reflection within the field. (See the work of Hart & Nolan, 1999; and Robottom & Hart, 1993, as early examples of such reflection.) The relative youth of such work, coupled with a rapidly changing society, provide many opportunities for continued reflection and maturation of the field. But while there is a greater breadth of both methodology and onto-epistemology (Hart, 2002), there remain concerns about the field's lack of impact on society as a whole (Ardoin et al., 2013; Blumstein and Saylan, 2007), considering that after 50 years of environmental education, humans still face many environmental issues, some of which have worsened or emerged during that time.

It is important to consider the history, philosophy, and theoretical underpinnings of EER work because the introduction of NGSS has brought sustainability, citizenship, and attention to human-imposed environmental impact into the national science curriculum discussion. These issues are central to the well-being of the planet and people. But there is an equally important and related reason for attending to such issues in order to broaden our knowledge of and responses to real and potential damage being done to our planet. The impact of natural disasters has never been felt more significantly; the occurrence of more frequent and more devastating wildfires, extreme weather and flooding are just a few of the more recent examples of natural disasters which have had devastating consequences in terms of human life and livelihood, not only locally but in areas removed from the origin point of these disasters. Additionally, while the multiple impacts of these disasters are being felt across racial, gender, and economic boundary lines, they are felt most acutely by those who often have been unseen and unheard in society, i.e., people of Color, individuals with disabilities, and the poor (e.g., Benevolenza & DeRigne, 2019; Ratcliffe et al., 2020). Loss of life, food, water and job insecurities, and lack of access to safe and affordable housing are the most visible of consequences, and these often have long-lasting effects on individuals, families and entire communities. These issues make it clear that there must not only be increased movement across the boundaries of the two COPs so that we learn from each other, but we must also work together to move forward towards a world that is just and sustainable.

1 | THE RELATIONSHIP BETWEEN EER AND SER

The COPs of EER and SER have a relationship that has ebbed and flowed, particularly around whether science education is an appropriate "home" for EE. (See Gough, 2002 for an accounting of the debate.) Similarly, EER and SER have matured on paths that sometimes run in parallel and at other times intersect. We find ourselves now at one of those intersections (Wals

et al., 2014), being present in the same space and grappling with issues that affect both fields deeply. These are reflective of challenging global issues - a rapidly changing climate creating cascading environmental issues, long overdue racial and economic reckonings, and a mutual desire to no longer exacerbate these issues as a result of our scholarly attention or inattention. The two fields are increasingly aligned with respect to the goal of catalyzing the development of a more sustainable, just world. A focus on equitable TI can help us move in that direction.

How do we make the most of these points of intersection to improve the fields? Certainly the two are not the same - researchers in EE and SE may overlap in practice, and may inquire into similar phenomena, but often situate themselves principally in one or the other of these two communities and have primary professional identities aligned with that field. One factor may be a belief that EER is broader in that it includes an emphasis on learner dispositions and behavior that is not as prevalent in SER and seeks transformative learning (D'Amato & Krasny, 2011; Hart, 2010; Wals, 2011) and extends into content areas beyond science. This distinction between communities is reflected in the journals, conferences, and communities with which researchers align themselves, e.g. the North American Association for Environmental Education (NAAEE) as compared with NARST. While EER sometimes appears in SER journals and vice versa, this does not appear to be common. To verify this apparent lack of representation, we undertook a two-step analysis: first, we chose two SER journals with high impact factors – *JRST* (2019 impact factor 3.87) and *Science Education* (2019 impact factor 3.035) and used the search terms "environment", "environmental", "sustainability", "climate change", and "water" (two major global environmental issues) in the last ten volumes. A secondary review of titles and abstracts was done for the ten volumes to find other related articles. Only 4.27% of articles in *JRST* (volumes 49–58) and 3.5% in *Science Education* (volumes 96–105) were focused on environmental topics. We then examined the content of articles in the newer journal *Cultural Studies in Science Education* (2019 impact factor 0.75)*, which has a more explicit mission of investigating the culturally bound, multidisciplinary aspects of science education. This yielded 8.25% of articles related to EER, which is still a significant minority. These findings clearly reflect the lack of representation of EER work not only in the more established and higher impact SER journals but at least up until now, in an SER journal which has a mission particularly well suited to the goals of contemporary EER. This analysis suggests that the COPs associated with these two disciplines continue to be quite distinct. We return to this framing of EER and SER as COPs later in the paper.

2 | ONTO-EPISTEMOLOGIES AND TI

Onto-epistemology refers to the junction of how one knows the world to be (ontology) and how one understands knowledge and what is knowable (epistemology). Ontology and epistemology are, as Barad (2007) points out, inextricable: "Practices of knowing and being are not isolable; they are mutually implicated. We don't obtain knowledge by standing outside the world; we know because we are of the world." (Barad, 2007, 185). We argue that if onto-epistemology is what we know and how we go about seeking knowledge within a particular discipline, then disciplinary COPs are spaces within which these understandings and this work develop and are communicated. Onto-epistemologies drive the theories we use to explain the world, so we use theoretical inclusivity to represent onto-epistemological diversity. We believe that by continuing to develop TI in a way that makes clearer the role of theory in understanding the problem at hand and consciously includes a wider array of epistemologies and worldviews, we can better

understand the problems we research and lay the groundwork for greater impact. Later in this paper we lay out three imperatives that can guide such work: that EER and SER going forward must be generative (Imperative 1); that the continued growth of both communities must happen in critical conversation with each other (Imperative 2); and **t**hat both the EER and SER communities must take on a "systems thinking" approach to understanding teaching and learning processes (Imperative 3). But first, we "unpack" the origin and meaning of key ideas which serve as the foundation for these imperatives.

3 | DIVERSITY AND INCLUSIVITY

While both EER and SER have made some great strides in many areas of diversity and inclusion, we fall short of both true equity or, as Calabrese Barton and Tan (2019) have pointed out, rightful presence. Though demographic diversity in the field is increasing (Gupta et al., 2019), it remains a discipline dominated by privileged white faces. (See the demographics in Ardoin et al., 2013.) We are not the first to call for more diversity in EER and SER. Zandvliet, in his edited volume (2009), called for and provided examples of diverse theoretical and methodological approaches to EER. These include cultural historical activity theory (VanEijk & Roth, 2009), socio-cultural phenomenology (Abrams, et al., 2009), and critical discourse analysis (Chamber, 2009). Rodriguez and Morrison (2019) similarly call for an expanded enactment of diversity, equity, and social justice in SER, practice, and policy. They describe four key arguments for why diversity, equity, and social justice are necessary: to be globally competitive, to pay off the education debt previously given minority learners, to address demographic shifts, and to produce social or personal transformative change. All of these are applicable in the context of EE as well.

This call for increased theoretical diversity is echoed in the *International Handbook of Research on Environmental Education* (2013) as well, while examples of those types of approaches to research are also documented. Lotz-Sisitka et al. (2013) account for an expansion in EER after Robottom and Hart's (1993) critique of the field, yet note that there are still too few pieces of research with post-structuralist, feminist, and queer orientations, a situation which persists almost a decade later. Wals and Dillon (2013) also focus on this emerging "post-normal" EER that focuses on socioconstructivism and emancipatory learning, and the production of "ethically practical knowledge for making context-specific value judgments about ends and means" (p. 259). In this same volume, other scholars go even further and call for more non-Western theories, such as indigenous knowledges (Lowan-Trudeau, 2013; Shava, 2013). And Haluza-DeLay points out that the "...inclusion of Aboriginal, gay and lesbian, and diverse cultural approaches [to EE] are forms of participatory and recognitional justice" (2013, p. 398) We call for more work in the direction that Haluza-Day describes, a participatory and recognitional justice, where these theories are not positioned at the periphery, but rather are afforded a rightful presence in the work of the field.

Movements to increase diversity, inclusion, and equity in the sciences and in the academy have important social goals: to increase representation of under-represented and marginalized peoples, to improve their true inclusion and full participation in the field(s), and to bring a plurality of lived experiences and knowledge production into the field(s). It is this last goal that we build upon here in our discussion of inclusivity. The more faces, voices, onto-epistemic perspectives, and worldviews we can include in EER and SER, the more robust and relevant the knowledge we produce.

Epistemic injustice, the explicit or tacit exclusion of individuals as knowers, most commonly those holding minoritized worldviews or epistemologies, harms the knowledge production process (Frank, 2013; Fricker, 2007; Zimmerman & Chinn, 2020). As Frank (2013, p. 369) describes "... if we see that others might be better able to speak to the truth of our shared experiences than we are, then we are in a better position to start doing the difficult work of learning what is true, even if this means coming to terms with the privilege-induced vision we use to filter experience through."

This becomes especially true in regard to the complex socioscientific problems we study in both science and environmental education practice and research. With many human and non-human actors, layers of power and privilege, and a nested nature that results in spatial and temporal impacts that differ and may be delayed, it is impossible for one single perspective to reveal the whole picture. The myriad *experiences* of these impacts are intersectional as well - that is, they are affected by place, power, and privilege - and in a way that can be best understood when regarded with multiple epistemologies and through engagement with multiple methodologies. An illustrative example is climate change - impacts vary worldwide (Arnell et al., 2016) and can be affected by site (droughts on the African continent, monsoons in southeast Asia, instability in the polar vortex in North America causes extreme cold snaps); they vary across time (what are inconveniences now may be life threatening in twenty years); and the impacts vary by gender, culture, and race (Black residents of the rural south are more heavily impacted by hurricanes, and poor Bangladeshi women are more impacted by the social and physical instability from monsoons than affluent Western white men are affected by either). In addition, poor and minoritized peoples are less likely to have access to structures for participation and decision making on climate issues (Hemmati & Röhr, 2009). By welcoming multiple onto-epistemologies, we can understand aspects of climate change such as adaptation and mitigation, as Makondo and Thomas (2018) did with African traditional oral histories. A diversity of methods, of theoretical perspectives, of contexts, and of people will create a stronger disciplinary knowledge for EER. We must extend that to our individual work as well, critically reflecting what our own methods and epistemologies represent well, what they may be missing, and what may be misrepresented by its presence or absence.

4 | WHAT IS THEORETICAL INCLUSIVITY?

We define theoretical inclusivity (TI) as the deliberate, expansive inclusion of multiple theoretical perspectives and the active use of this multiplicity to create a more robust understanding of learning, teaching, and education in and about society and the environment. If we have as a goal the production of research that is inclusive and equitable, and which builds towards a body of work that deeply engages with issues of teaching, learning and education, then we must consider three entwined issues of ontological, epistemological, and methodological diversity, as they all help determine our study of the world (Guba & Lincoln, 1994). TI, as we envision it, makes space for both multiple ontologies and epistemologies. In terms of ontology, an inclusive research body relies on different worldviews and lenses to identify multiple lived experiences and the issues and questions that result. It is on these grounds that many calls for diversity and inclusivity rest - that the more diverse a pool of participants in an endeavor, the more complex and diverse the views of key issues are likely to be. Epistemologically, it is vitally important to raise voices that have been neglected and silenced to be full participants in knowledge production that is both just (Fricker, 2007) and makes for more robust research (Zimmerman &

Chinn, 2020). In addition, encouraging multiple epistemologies will result in a more multi-dimensional understanding of the complex issues which characterize the way that people—both individuals and groups—interact with the world. This involves disrupting the settled expectations of science education that benefit white supremacy (Bang & Marin, 2015; Bang et al., 2013). As we noted above, ontology, epistemology, and methodology are entwined. One's lived experience in the world affects one's view of what constitutes knowledge, and what knowledge is valuable. This in turn affects the choice of how we inquire into a problem and analyze the information yielded by such inquiry. As a result of such decisions, some understandings of the world around us are illuminated, and some obscured. With regard to this issue, we applaud Kincheloe's (2001) call for greater bricolage - being open to the strengths of our own epistemologies and methodologies as well as to their weaknesses, and using multiple approaches to create a more robust inquiry.

Our position also is that theoretically inclusive research can be viewed at the level of the individual researcher and that of the field writ large. At the individual level, the researcher is first clear about their epistemological and theoretical grounding—the theories that inform their contributions to the knowledge base. These theories are clear in all phases of the research—from design and data collection to analysis and sense-making. Secondly, researchers use the epistemic and cultural tools available within and outside their worldviews (e.g., theoretical lenses, data gathering and analysis methodologies) to regard those theories critically and identify their shortcomings (Kincheloe, 2001) as well as their affordances. This process begins at the most basic level with recognizing that there are multiple non-Western ways of knowing about the world, positioning those with such understandings as rightfully present participants in knowledge creation, and looking beyond the privileged Western notions of science, environment, and education. This requires working and dialoguing with colleagues with different theoretical grounding and worldviews than one's own, interrogating our own biases, seeking out colleagues (sometimes beyond academia), and developing a collaborative space where multiple epistemologies can enrich each other (Reid et al., 2020).

At the field level, theoretically inclusive research is expansive. It includes multiple methodologies and onto-epistemologies. Restricting either is detrimental to the field and the people, places, and beings we value (Erickson & Gutierrez, 2002). Theoretically inclusive research has as a goal the development of *praxis*—practice and theory in dialogue, mutually influencing the other—that promotes a rightful presence of learners and practitioners who are also knowledge producers. It deliberately seeks out and makes room for the rightful presence of onto-epistemologies that have been neglected or oppressed in mainstream EER and SER communities and which offer different understandings of social-ecological systems, teaching, and learning.

5 | A VIEW OF THEORETICAL INCLUSIVITY INFORMED BY DIVERSITY

We expand on the four components of our vision of theoretical inclusivity below. In this conceptualization, researchers are explicit and clear about their theoretical grounding; researchers use critical reflection to evaluate their research; the field expansively explores phenomena and issues using multiple epistemologies; and there is a focus on developing praxis. In the text that follows, we expand briefly on each of these.

First, TI requires being open, explicit, and clear about the theor(ies) that inform our knowledge production. A strong theoretical grounding is what helps us make sense of the world. In

its absence, observations and claims have no broader explanatory power. A theoretically inclusive researcher is clear-eyed and explicit about how their onto-epistemologies and epistemologies drive their questions, data collection, and analysis. Because of this, they are able to weave their research into the web of knowledge in their field that has been created by past research and create pathways forward that not only further improves our understanding of a phenomenon, context, or cultural construct but expand what is understood as knowable and valuable, using multiple onto-epistemologies, both Western and non-Western. Beyond the epistemic value of being open about your onto-epistemologies and open to others', such practices also further the work towards social justice in science and environmental education (Rodriguez & Morrison, 2019).

Second, theoretically inclusive researchers borrow from Kincheloe's (2001) usage of *bricolage* (Kincheloe, 2001), which holds that "critical bricoleurs employ historiographical, philosophical, and social theoretical lenses to gain a more complex understanding of the intricacies of research design" (Kincheloe, 2001, p. 679) but go further to include theories that represent non-Western onto-epistemologies such as Indigenous theories or critical race theory. Rather than limit bricolage to methodology, he advocates using the concept to critically reflect on what one's theory affords and constrains, and what others may offer. Theoretically inclusive researchers contemplate what effects their positionalities have on the questions being asked and the answers found. They not only make use of the epistemic tools available within and without one's worldviews to regard those theories critically and identify their shortcomings, but also consciously construct space for theories which have been historically and presently marginalized and which support epistemic justice. This does not lead to an abandonment of theoretical stance, but rather an honest examination of it. Identifying what other theories could add to the research at hand does not weaken one's own research but rather strengthens the overall research endeavor by creating a more tightly constructed tapestry of understanding, woven of knowledge built in different social, political, and cultural contexts. As Kincheloe (2001, p. 688) describes it, this work as bricoleurs "... helps researchers move into a new, more complex domain of knowledge production where they are more conscious of multiple layers of interaction between the knower and the known, perception and the lived world, and discourse and representation."

For example, in their 2020 paper, Reid et al. describe "Two-Eyed Seeing", from Mi'kmaw, but also present in Indigenous cultures around the world, which brings together two sets of knowledge to focus on a common problem. The two knowledges create a collaborative third knowledge that is deeper, more three-dimensional, which honors important cultural components such as multi-generational conservation and sustainability, and requires action be taken on this new knowledge. This differs from an assimilative model which co-opts non-Western knowledge to meet Western goals. It is this "Two-Eyed Seeing" which we are calling for, enacting multiple onto-epistemologies to create a third space of understanding that would not otherwise be possible.

At the field level, TI is envisioned as a way to ensure praxis - a two-way conversation between theory and practice. By including multiple epistemologies in our research on, say, student learning about climate, we will then have a more robust understanding of the phenomenon and have more tools available to practice climate change education with a diverse audience. While a critical stance is important, we must not fall into the trap described by Payne (2019)—becoming absorbed in a performative abstractionism, regarding critically other researchers and theory, while neglecting praxis, which is central to the field because of its historical and current applied nature. The field of EE grew out of practical concerns regarding how to integrate ecology and conservation into curricula in and out of schools (Gough, 2013). The field has quite obviously expanded beyond that, but residing at its heart is learning and education in, for, and about the environment, inclusive of both human and more than human. And

in SER, what began as inquiry focused on how students and teachers understand (and in the latter case, also teach) particular kinds of concepts in classrooms, has broadened enormously and addresses the multiple ways in which understandings develop—or are prevented from developing—in complex systems, both in schools and outside of these institutions. The problems we investigate in EER and in SER are important and urgent, perhaps now more than ever as we reckon with the devastating effects of climate change alongside other environmental issues, as well as the lack of access particular groups of learners have to meaningful resources in support of learning and of healthy and productive living. The research we conduct as a field must inform practice in a tangible way, and changing practice must also inform the research agenda.

Lastly, this definition of inclusivity is intentionally expansive. Restricting this to specific methodologies or epistemologies is detrimental to the field and the people, places, and beings we value (Erickson & Gutierrez, 2002). The issues and phenomena we study in EER and increasingly in SER are wicked ones - by this we mean that they are complex, unpredictable, open ended, heavily context-dependent, and have no one best solution. They benefit from a continued multiplicity of perspectives, worldviews, and researchers doing the work to address them. When dealing with wicked problems in social-ecological systems, context matters. Multiple lenses and methodologies are helpful for illuminating the many complexities with nuance (e.g., Rist & Dahdouh-Guebas, 2006).

For examples of how TI, particularly non-Western theories, can be beneficial, we can turn to fisheries management. Fisheries are complex, tightly coupled social-ecological systems (Reid et al., 2020) that are struggling after hundreds of years of management under colonial systems using Western science. Atlas et al. (2021) highlight the differences in salmon fisheries management in colonial/Western and Indigenous styles. Indigenous people around the northern Pacific rim have managed such fisheries for 10,000 years. In the last few hundred years, colonization in North America forcibly removed and forbade Indigenous methods of salmon harvest and management. Indigenous management is place-based and oriented to multi-generational sustenance and sustainability, and "...derived from millennia of experiences in very specific geographies" (Atlas et al., 2021, p. 190), which contrasts with un-placed commercial and sport salmon fisheries that occur in the ocean and with no connection to previous or future generations. Atlas argues that learning from management and harvest techniques that kept salmon fisheries strong even under heavy use will benefit the current management of those fisheries. Reid et al. (2020) go further, and use the Mi'kmaw principle of "Two-eyed Seeing," or using two views of a fishery problem—one Indigenous, one Western—to develop a new vision with more depth and breadth. Using three case studies from across Canada, Reid provides evidence that such an approach yields a deeper understanding of the impacts of watershed pollution in the Saskatchewan and Slave River Deltas. Using local Indigenous oral histories and knowledges provided insight into the current state of the salmon and the watershed that was not available from Western data that did not have the same lengthy historical record. The authors also point out that using a Two-Eyed Seeing not only benefits fisheries but also advances decolonial and reconciliation efforts in Canada, creating epistemic and social justice.

6 | EER IS UNIQUELY POSITIONED FOR SUCH THEORETICAL INCLUSIVITY

While this view of TI is applicable broadly across educational fields, EER is uniquely positioned for work that is theoretically inclusive and can serve as a model of and support for

such work in SER. EER is interdisciplinary (blending the practices of multiple disciplines; Seel, 2012); it is cross-disciplinary (crossing the boundaries of disciplines but not the ideals; Seel, 2012); and it has grown from having an emphasis on practice to a focus on praxis. These three characteristics position EER to create and support inclusive knowledge-building structures. Below we expand on each of these characteristics as we consider their relationship to the growth of TI.

6.1 | EER is interdisciplinary in nature

Both the practice and research of EE bring together multiple natural sciences (e.g. biology, chemistry, ecology, physics) and social sciences (e.g. geography, psychology, sociology), as well as design and various arts (e.g. language, fine, performing). EER can be similarly characterized. As a field, EER inquires into the intersection of humans (taking into account individual, social, and cultural factors) and the biophysical environment in myriad ways, and such inquiries require knowledge and methods from multiple disciplines at the same time. The following are illustrative examples of how this approach has contributed to our understanding of such complex interactions. Ballantyne and Packer (2009) bring an understanding of education policy and formal and informal pedagogy together to create a fifth productive pedagogy for high-quality outdoor education. Similarly, work in early childhood environmental education, such as that of Cutter-Mackenzie and Edwards (2013), requires the perspective of child development and early childhood pedagogy, to understand the importance of play-based pedagogy in early childhood-focused EE. Additionally, Braun and Dierkes (2017) integrate environmental psychology and child development to illustrate how different lengths of outdoor education programs affect children's connection to nature differently at different stages. Another pair of investigators (Hunter & Jordan, 2020) leverage knowledge of ecology, the social and political systems at play in environmental issues, and the psychological and social aspects of environmental behavior and identity to make sense of the interactions among educators' environmental self-efficacy and behavior. Such interdisciplinary work, though canonical in orientation, can lay the groundwork for research that includes non-Western perspectives. One example of research that moves in that direction is Kaler Surata and Vipriyanti's (2018) study of student attitudes towards the Indonesian subak cultural landscape.

6.2 | EER is cross-disciplinary

EE is not a unified field. Sauve (2005) pointed out that EE has always had multiple pedagogical currents, from those that have lasted since the early days of EE (the naturalist, conservationist/resourcist, and problem-solving currents, for example) to those that are more recent (e.g. social critical, feminist, and sustainability currents). These currents often overlap in the same programming, as topics are addressed from multiple perspectives. This is reflected in EER in turn, which can look at environmental learning, behavior, and dispositions, among others, from multiple perspectives. For example, if we look at the concept of "place", an important tenet in EER, in just one journal, *The Journal of Environmental Education*, we can see research using psychology (Lawrence, 2012), place-based education (Greenwood, 2017; Powers, 2004), and critical theory (Stahelin, 2017). These multiple lenses provide the potential for deep understanding of EE's many facets by collectively providing a well-rounded,

holistic understanding of an issue or phenomenon that will lead to more robust praxis. Similarly, searching for work on "water", another common EE topic in *Environmental Education Research,* yields research that uses indigenous pedagogy (Twance, 2019), new materialism (Crinall & Somerville, 2019), systems thinking (Sheehy et al., 2000), and educational psychology (Agelidou et al., 2000).

In addition to disciplinary lenses, EER also includes multiple theoretical stances. Studies of behavior as a program outcome are one example. Breunig and Russell (2020) interpreted the behavior of secondary students in an environmental studies program 5–23 years after program completion using a feminist perspective and highlighted gender disparities in environmental behavior and in anti-environmental backlash present in surveys they administered. From a sociocognitive perspective, de Leeuw et al. (2015) used the theory of planned behavior to make recommendations for educational interventions at the high school level. The theory of planned behavior focuses on individual behavior, and states that such behavior is determined by one's intention to engage in that behavior and one's perceived control over that behavior. Each of these is determined by multiple "internal" (e.g. gender, ethnicity, education) and "social" (e.g. perceived social benefits or negative consequences, parents' values) factors. Krasny and her colleagues (e.g., Krasny et al., 2009; Krasny & Roth, 2010; Krasny & Tidball, 2009) used an activity theory lens to look at social-ecological system resiliency as a behavior-related outcome. In this perspective it is not only individual behavior that is an important outcome of EE, but how individuals engage with the community or system in co-management practices. These three studies take different theoretical stances and yield different types of knowledge about environmental behavior.

As Gough (2013) notes, the roots of EER were in practical application, though over time, an emphasis on *praxis*, the practical application of theory, has emerged. This original emphasis on practical application resulted in an increasing number of studies in which the focus was on examinations of program outcomes. Because these studies were often more aligned with program evaluation than with research, the findings were often limited in scope and generalizability. However, the field has matured greatly since these early years, and approaches to key problems have increasingly come to be marked by a theory-informed approach. Such an approach provides the conditions necessary in order for that work to have a broader impact on the field. Moreover, research in EE is increasingly marked by a concerted effort to engage in practice informed by theory and the intent to make recommendations for practice that are theoretically based and that take into account complex systems. Work that moves towards TI through the inclusion of non-dominant epistemologies is present in both EER and SER. At the present time, it represents a small fraction of the overall published research in both disciplines; however, this body of work has the potential to serve as a foundation upon which to build greater theoretical inclusivity within both.

Below we describe three imperatives for EER and SER to promote TI, and reflect on how the two fields can contribute to and benefit from their implementation. We believe we must act on these imperatives in order to produce greater understanding within and between fields and greater collective impact.

7 | THREE IMPERATIVES

With this view of TI in mind, and knowing the potential for EER to foster inclusivity, we offer three imperatives for both disciplines to move forward as a model.

7.1 | Imperative 1: The continued co-evolution of EER and SER must be generative

If we could draw a quick sketch of how SER and EER have grown and changed (for a more detailed rendering, see Gough, 2013), it would be as disciplines that have increased in scope and complexity and that reflect an acceptance that there is no universal truth, but rather many ways of experiencing and knowing. They have grown beyond having a focus on classroom (SER) and field trip (EER) activities to investigations of community and informal teaching and learning. This growth and expansion in both disciplines calls for greater TI, in order to make clear where we as researchers are coming from and where we hope our research and readers will go.

If we look more closely, we see that EER followed close upon the heels of EE itself (Gough, 2013; Sauve, 2005). The latter emerged from the environmental movement in the United States in the late 1960s, in response to calls from the conservation sciences for greater ecological understanding among the public. There was an early focus on integrating ecology into school curriculum (Gough, 2013), and research often described programming in a very decontextualized manner. With this background in the sciences, it is not surprising that in its early years, EER was characterized by a positivist, quantitative focus and applied common science methodologies. Research from this nascent era often quantified changes in behavior and dispositions such as values, attitudes, and behaviors as a result of curriculum or programs. Though there was an emphasis on developing an environmentally knowledgeable and responsible citizenry in the field's early guiding documents (UNESCO, 1975; UNESCO, 1977), often what was enacted in practice and reported in research focused on individuals, neglecting collective or systemic action. This quantitative emphasis on individual changes in behavior and attitudes persisted through the 1980s. Beginning in the 1990s, there appeared a growing recognition that quantitative instruments provided a limited view of learning and knowledge. Both interpretive methods and critical perspectives grew during this time, in addition to more quantitative ones. More significantly, research in the field has moved beyond positivist understandings of knowledge and made room for multiple theoretical lenses on EE, such as indigenous (e.g. Somerville & Hickey, 2017), feminist (e.g. Rizzo, 2018), post-colonial (e.g. Tuck et al., 2014), and social-ecological resilience (e.g. Krasny & Roth, 2010) voices (Gough, 2013).

Even with this expanded view of EER, there remains a need for more community-focused, contextualized research in which education and the whole human experience are examined, and in which multiple global perspectives are considered (Ardoin et al., 2013); there also remain concerns about the field's insularity and lack of impact (Ardoin et al., 2013). Additionally, the question of the suitability of research stances and methods with the goals of the field persists (Robottom & Hart, 1993): How are we able to deeply understand the many permutations of people, society, and ecology without using lenses that different worldviews provide? How do we explicitly develop and bring those researchers to the table if as a field, we do not hold an expansive inclusivity?

While the initial focus of research in science education was quite distinct from that at the core of EER, with much less emphasis on promoting specific curricula in schools and more on understanding how students learned in classrooms, the shifts that have occurred and which been documented, particularly over the past two decades, have in many cases been quite similar. Science education researchers in the mid to late 1970s were trying to make sense of how learners in school settings were developing understandings of specific kinds of scientific concepts and processes. They were attracted to the power of two theories in particular which could account for the sense-making (or lack of sense-making) that they were observing. These were

cognitive constructivist theory as developed by Jean Piaget, and social constructivism, which originated from the work of Lev Vygotsky. (For a fuller description of this work, see, for example, Liu & Chen, 2010, and Wadsworth, 1996). The influence of these two theories on the development and influence of conceptual change theory (CCT) was significant as well (Duit, Treagust, and Widodo, 2008), and the influence of CCT on research in science education cannot be underestimated.

Conceptual change theory was a driver of SER which persisted into the 1990s, and only experienced a decline in the past two decades, as reflected by the number of papers published in leading SER journals such as *Science Education, JRST, International Journal of Science Education*. (See, for example, work by Lin et al., 2019). This decline appeared at about the same time that increasing attention was being paid to the influence of race, gender, and context, and more broadly to issues of equity, diversity and inclusion as they relate to both the preparation and practice of teachers and to the access learners have to resources critical for learning (See, for example, Tsai & Lydia Wen, 2005). One exception to this trend is what appears to be a slight increase in the number of papers in U.S.-centric journals which, in the past decade, have focused on teacher practices, and this may be related to the traction gained by the introduction and adoption of the Next Generation Science Standards (NGSS), as U.S.-based researchers try to determine how NGSS-aligned practices are enacted and how to support their enactment. (See Karampelas, 2021.)

Across the past two decades, we not only see a shift in research focus, but also an increase in the diversity of theoretical frameworks used as lenses on research questions posed (e.g., post-structuralism, critical feminism), in the methodologies employed (e.g., participatory DBR), and in the nationality of authors. This is true of journals based in the U.S. (e.g., Lin et al., 2019) as well as elsewhere in the world (e.g., Skamp's, 2020 investigation of publications in the *Australasian Journal of Science Education*).

Stemming from its emergence as a field of practice, EE pushes back against current paths of environmental problems and calls for a new path; it is counter-hegemonic to varying extents. And while the stimulus for more visible SER work was in part the product of the space race of the mid-20th century, the centering of science/society-related social justice issues has grown in recent decades (e.g., Zeidler et al., 2005). To be generative in this way, researchers in both fields must continue to examine real-world problems in a way that interrogates social mores and relationships of power that have resulted in current environmental issues in order to bring us to an understanding of how these and emergent issues can be successfully addressed. To do this in a way that allows for further study and knowledge-building, it is vital that the theoretical underpinnings are robust, that researchers are clear-eyed about what their worldview affords and misses, and that the research builds on existing research and opens doors for new inquiry.

7.2 | Imperative 2: The continued growth of EER and SER are dependent upon continued critical conversation

In the Anthropocene, the proposed era marked by human impact on the earth's geology and ecosystem (Crutzen & Stoermer, 2000) we must deal with not only continued and accelerating environmental degradation and climatic change, but with worsening social and economic inequality. These dual crises require an educated, caring, and active citizenry. Both SER and EER have strengths they can lend to the work that must be done to reach the goal of understanding how people learn about complex socioscientific problems, and how science and environmental education

students and educators can work to address them. What structures already exist within these two disciplines which might enable the work necessary for this goal to be achieved? How do we as researchers in the two communities ensure that the research we do supports a just, sustainable future? This shared space of social inequity in the Anthropocene may serve as a boundary encounter (Wenger, 1998)—an event that provides connections between COP—around which the two communities can collaborate and mature. By bringing to bear the perspectives and practices generated in each community and diverse theories and onto-epistemologies, both communities can change their work. But this requires critical, reflective conversation within and between the two disciplines.

While some scholars push back at the cohabitation of schooling and EE and find it problematic (Gruenewald & Manteaw, 2007; Stevenson, 2007), there can be a valuable two-way conversation between the fields. There is a broad record of SER research using sociocultural perspectives on the learning of PK-12 students that overlaps with and strengthens key tenets of EE such as environmental identity, learning in everyday life, and the role of more knowledgeable peers (e.g. Kempton & Holland, 2003). There is also a deep reservoir of scholarship applying perspectives familiar from critical environmental studies to learning and education systems (e.g., Bang & Marin, 2015). Critical scholarship, in our analysis, includes that which seeks to understand the relationship of the human and the more than human; which creates education that is transformative; and which encourages activist research that seeks to disrupt systems that fail to support social and environmental health. By calling on relevant work within the formal and informal education realms, research in each field can be more robust and inclusive, and can facilitate conversation which acts as a boundary encounter between both disciplines. We also would argue that in order for critical conversations to gain a "life" marked by greater visibility and intellectual energy, scholarship in these two fields needs to be represented more significantly in well-respected and mainstream journals in each of these fields. We would argue from our analysis that this goal has not yet been met, as more theoretically inclusive papers (e.g. scholarship representing non-dominant epistemologies) appear in journals such as *Cultural Studies in Science Education* or *Canadian Journal of Environmental Education*.

7.3 | Imperative 3: Both EER and SER communities must take on an approach that elevates the complexity of teaching and learning to make space for multiple onto-epistemologies

As we work towards a just and sustainable society, we must understand not just what works but why it works. Without a theoretical base to help frame our research, it functions instead as program evaluation. There is no question that evaluation is vital to the field of EE. However, without a theoretical framework to make sense of the findings in diverse contexts, without reflection on what the theory and methodology afford and constrain, it becomes more difficult to apply them to a broader narrative and to contribute to deeper understanding. By understanding the *why* of a phenomenon or question, we can apply acquired knowledge to new contexts and improve our overall efforts. To achieve this, we need to heed Kincheloe's (2001) concept of interdisciplinary bricolage, which we named earlier in this piece - using not just multiple methodologies, but multiple theoretical perspectives, and onto-epistemologies to remove the blind spots that result from a single worldview and potentially obscure mechanisms within these systems. Promising methodologies to be borrowed from broader education research and which we note that science education researchers have taken up in often powerful ways are design-based

research (DBR,Barab & Squire, 2004; Sandoval & Bell, 2004) and design-based implementation research (DBIR, Fishman et al., 2013; Penuel et al., 2011). Both were designed with the goal of bridging theory and practice and involve the close study of problems of educational practice in an iterative, theory-informed manner that brings together multiple stakeholders (researchers, educators, students, community) in a learning system. By collaborating closely with educators and communities in designing and analyzing learning contexts, DBR researchers systematically look at what multiple stakeholders bring to the table and engage with them to examine and measure impact. The emphasis on theory-informed practice and practice-informed theory aligns well with EE and EER's early and continuing emphasis on practice and its evolution to praxis and reflects a shift in the learning sciences research in science education.. Because DBR investigates learning in complex, real-world contexts, it is designed to consider multiple variables (Barab & Squire, 2004; Sandoval & Bell, 2004) such as the classroom climate, outcomes, and layered systems (classroom, district), just as the environmental issues EER is concerned with are multi-layered and interactive. The close collaboration between researchers and stakeholders also illuminates the many-faceted impacts of changes in complex systems, and can be extrapolated to conceptions of both human and non-human components of social-ecological systems. More recently, some scholars have made use of a participatory design-based research (PDR) approach (see, for example, Bang & Vossoughi, 2016) which, while it shares some of the same foundations and characteristics with DBR and DBIR, as well as with research-practice partnerships, also has its roots in aspects of critical theory and methodology and has educational justice as a core value and social change as an explicit goal. As such, it is an outstanding example of the kind of hybrid approach suited not only to acknowledge but to address the complexity of teaching and learning issues as they "play out" differently for individuals and groups in different contexts.

8 | WHERE DO WE GO FROM HERE?

In examining these imperatives, we find ourselves facing the following challenge: How do we cultivate boundary encounters between the SER and EER communities that foster: (1) critical thought and praxis; (2) reflective research with a strong theoretical base; and (3) the stitching of scholarship into the existing and future (more inclusive) fabric of EE knowledge production? Whatever strategic plans we employ to meet this challenge will take work at both individual and systems levels. Here we highlight two strategic paths for such work: implementation of changes in graduate student preparation and the reconstruction of our role and the scope of our scholarly work.

In preparing future researchers at the graduate level, faculty have the responsibility to provide students with exposure to broad theoretical perspectives and experiences in comparing the implications and value of these various perspectives for their affordances and constraints; critical reflection is built through continued opportunities to practice and responsive and inclusive mentoring. As Pallas (2001) has written, an appreciation and understanding of multiple epistemologies will be easier to develop for students as *consumers* of research than as *producers* of research, because it is easy to become increasingly embedded in the epistemology of your research community. He provided several practical suggestions for increasing doctoral students' comfort with multiple epistemologies, such as ensuring that discussion of epistemology is infused in all doctoral classes, placing these discussions in a historical context and linking them to the practice of research, as well as creating social spaces where it is safe for novice

researchers to discuss and experiment with epistemologies. Pallas (2001) also articulated why it is easier to prepare a novice researcher or doctoral student to encounter epistemological diversity as a *consumer* of research than it is to prepare them to engage with it as a *producer* of research; this is because we become entrenched as we move more deeply into our theoretical and methodological niches. As scholars and as mentors, we face the challenge of resisting that entrenchment in order to expand our own and our students' exploration of multiple onto-epistemologies with the goal of supporting the production of useful and theoretically inclusive research.

This becomes an even more challenging goal for researchers who find themselves located in academic departments other than education. EE researchers, for example, work in an array of academic departments such as the natural and physical sciences, environmental studies, natural resources, sociology, or geography and bring with them diverse academic preparation and professional experiences (Ardoin, Clark, & Wocjik, 2016). Some SE researchers such as those working in discipline-based education research face similar challenges. Each brings with them the attendant canonical epistemologies, theories and norms. There must be time and space devoted to discussion of these issues head-on if students are expected to appreciate diverse ideas and if they are to develop into researchers who are able to work productively and inclusively within different theoretical ecologies and within multiple disciplines. In addition to theoretical breadth and critical reflection in our instruction, readings that explore research as well as social and ecological issues should be authored by diverse scholars. This diversity must go beyond simple representation and must present worldviews that challenge our own and those of our students. Past the graduate preparation stage, the field must continue to provide opportunities for researchers to develop these TI practices in multiple contexts. The NAAEE Research Symposium is an excellent example of such an effort, as does NARST's Abell Institute. Given the drive to include more global voices, we must also examine the role of high-quality distance learning so that scholars have access to opportunities previously unavailable to them because of cost, location, or visa issues (Niner & Wasserman, 2021).

As individual researchers, we also must take it upon ourselves to prepare for work that is critically reflective, that engenders praxis, and that incorporates many voices. One way to enact such preparation is to actively seek out diverse voices on our research topic. This can be as simple as including non-Western search terms (e.g. indigenous, critical race theory, decolonial) in literature searches or seeking out conferences and professional development activities that represent this work while taking a vulnerable and listening stance. This may be challenging because, as Ridgeway (2019) points out "equity scholars are a numerical minority, making it that much more difficult to bring their voices and concerns to the forefront of this field."

As we collaborate on research and weave our research into the existing body of scholarship, we need to address the important role that place plays in what and how we come to understand the world. We must also remember that citations of and partnerships with scholars of Color and those using non-Western theories matter. In recent studies (AlShebli et al., 2018; Freeman & Huang, 2014), for example, it was found that author cultural diversity increased the impact of science papers. These partnerships must also include strategic dissemination efforts, particularly presenting symposia at conferences, acquisition of interdisciplinary grants, coordinated communication with more public-facing institutions and media to ensure greater impact and the normalization of diverse partnerships. Other researchers have found that men are more frequently cited than women in the social sciences (Dion et al., 2018). Deficits in citation reflect the persistent stances that women's work is less central to a field, resulting in the continued positioning of men as "experts". Similar patterns can be found for Black authors (Ray, 2018).

Even if this lack of citation is unintentional, it reflects an insidious implicit bias and reflects an insidious implicit bias and can lead to a more systemic epistemic injustice (Zimmerman & Chinn,2020) that weakens research as a whole by reducing its inclusivity as we have described in this paper.

8.1 | EER and SER - moving forward together

When two fields come together, there is an imagining of the other, followed by a "settling in" period in which each group has to evaluate the norms that guide the work in each community and negotiate them to a common set to guide forward movement. We see TI as a common goal around which the two communities can come together, engage in discussion about similarities and differences, and work together to better understand learning and teaching. A productive and mutually beneficial relationship results only when the quality of work is acceptable to all members of that community. This requires either that the new group absorbs, whole cloth, the scholarly norms of the established group OR a new set of norms is developed and accepted by both groups. Such work between communities and across boundaries can be accomplished in several ways - through a boundary experience as described earlier in this paper, or around boundary objects (e.g. Akkerman & Bakker, 2011; Leigh Star, 2010). TI has the potential to be such a boundary object, helping to move forward a partnership with a new set of shared norms. As a field matures, the prevalent norms and theoretical frameworks shift - there are new theoretical stances and methodologies that become open to fields that are maturing in a generative way. This growth of voices and epistemologies that we advocate for in our argument for TI is necessary for EER and SER to grow in this generative way together, learning from and with each other. Scholars in both SER and EER will benefit, and TI needs to remain centered in our collective minds - alternative ways of stating a problem, alternative ways to interpret data, how we choose problems to study, how we invite others in to do that work, and who receives invitations to become a part of that intellectual community.

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