

Eco-thinking and Informal Science Learning

Building a Journal for Everyone



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As founding co-editors, we welcome you to the launch of the *International Journal of Informal Science and Environmental Learning* (IJISEL). These are exciting times to begin a new journal that focuses on informal science and environmental learning. We share with you our aspiration to create an academic space that brings together the informal science and environmental education communities through an open-access platform - accessible to a diverse and international audience. In aiming to draw a collection of original research, the new journal will document and describe a diversity of research from around the globe. We will address this goal in two ways. First, the journal will reflect a diversity of voices/cultures conducting research across these global fields of inquiry. Second, the journal will further illuminate research diversity by highlighting an eclectic range of methodologies. From established to emergent methodologies we aim for papers to describe learning in science and environmental contexts in ways that push our collective thinking about what is possible.

In 2003, the Informal Science Education ad hoc committee of the National Research in Science Teaching stated that research focused on science learning outside the classroom needed to be fostered with a goal of developing, "... a more holistic, large-scale understanding of the entire learning process, both inside and outside of schooling environments" (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003, p. 109). Nearly 20 years later, this statement still continues to serve as a catalyst for current research in the ISEL community.

Over the past 30 years there has been a rapid growth of research that discreetly focuses on out-of-school learning as well as the growing body of literature that examines the connections between learning across formal and informal contexts. IJISEL grew out of this trend and the need to develop one resource devoted to bringing the fields of informal science learning and environmental learning in dialogue where authors may communicate their own work and engage with the work of others. While there are numerous journals publishing articles that emphasize informal science learning, IJISEL is unique in a) bringing informal science and environmental learning into conversations, b) centering a globality of scholarship and c) providing a space that is practice-oriented allowing for community and/or

youth-voiced articles to be featured.

We, the coeditors, intend to publish an array of articles from various professional perspectives, methodologies, and theoretical standpoints. IJISEL will include a broad range of topics, research methods and techniques, and locations (e.g. community-based contexts, museums, zoos, aquariums, outdoor, camps, parks). As longtime researchers and practitioners in these fields, we recognize that many innovations in formal science and environmental learning have emerged from research in informal learning/out-of-school settings, especially in community-based and culturally-resonant contexts. We will amplify this latter orientation to learning by publishing articles that emphasize indigenous/indigenizing, decolonial, and liberatory work, especially for the most marginalized learners. These emphases and practices will allow for a critical mass of authors to come together to promote, discuss, and analyze the emergent topics in ways that stimulates an exchange of new ideas and advances learning in these respective fields towards more equitable and justice-oriented frameworks and practices.

As we reflected on current socio-scientific issues (e.g., global pandemics, climate change), we revisited Dierking, Falk, Rennie, Anderson and Ellenbogen's 2003 informal science education policy statement published in the *Journal of Research in Science Education*. Their work established the presence of the field within the National Association of Researching Science Teaching. They advocated for research that considers the features of learning beyond the classroom, e.g. the cumulative, ecological, and sociocultural nature of informal and environmental science learning, the importance of context and place, sociocultural links to learning, and the product and process of learning. Since their recognition of the importance of learning outside the classroom, researchers have addressed the intersection of neurological, bio-cultural, and/or material aspects of learning; epistemological, ontological, and axiological considerations in learning; and research design. These new ideas and thoughts about decolonizing, indigenizing, and unsettling are pressing us to reexamine our teaching, learning and research. Our desire is that IJISEL will be a place to publish these ideas and experiences.

Similar to other venues, articles will go through a peer review process to ensure rigor and relevance. However, we are excited about features that will make our journal stand out from existing science education journals.. As a first example, we plan to initiate a practitioner section, Notes from Practice (NfP), that will emphasize research to practice. We will also have shorter practice-oriented pieces to accompany larger research articles. These articles will highlight the key points that are relevant to practitioners who design and facilitate informal and environmental learning experiences.

Lastly, we extend a special thank you to David Zandvliet at Simon Fraser University as his university provided us with the platform Open Journal Systems to launch the new journal. Additionally, as part of developing IJISEL we absorbed and extended the previous journal *Eco-thinking* with a desire to expand its scope to the informal science community. By launching a new journal under the IJISEL banner, we intend to broaden the scope of the original journal to include all forms of 'out of classroom' learning. The new name also reflects the strong overlap between environmental and informal science learning while offering an opportunity for these two communities to communicate. Additionally, we are delighted to work with Michel Lockhorst at DIO Press who has previously worked for other

publishers including Brill, Sense, and Springer. The new venture of DIO Press is very exciting and is pushing boundaries for what is possible in academic publishing. Additionally, Michel was instrumental in advocating for the publication of another journal: *Cultural Studies of Science Education*, a well-respected venue for socio-culturally centered science education research. Thank you Michel, for your support and your energetic ideas as we launch IJSEL.

We are very excited about this venture and grateful to have the support of many colleagues who are also key thinkers in informal science and environmental learning.

Meet the Editors (in alphabetical order):

Jennifer D. Adams is a Canada Research Chair and Associate Professor at the University of Calgary. She has research and teaching experiences across formal and informal settings at the secondary and postsecondary levels. Her work centers equity and fostering spaces of belonging and mattering for learners who have been historically marginalized from meaningful STEM learning experiences.

Patricia G. Patrick is an Associate Professor at Columbus State University and a Fulbright Scholar. She has 27 years of experience teaching in science education which includes 15 years researching learning outside the classroom. She authored the book *Zoo Talk* and is editor of the book *Preparing Informal Science Educators*.

David Zandvliet is a Professor at Simon Fraser University and holds the UNESCO Chair in Bio-Cultural Diversity and Education. He served as the founder and lead editor of *Eco-thinking* for 5 years. He has created a space for diverse and international authors to disseminate research and practice on environmental teaching and learning.

Articles in this Issue

This journal focuses on informal science and environmental learning and addresses the need for placing this work in a one location. The journal is timely as it will be a compilation of evolving perspectives on informal science and environmental learning. The compilation of articles for this inaugural issue represent research from five countries and celebrate diversity in research and methodologies. The work recognizes that environmental education and science education are tools we may use to address social justice and promote equality. Additionally, the articles reflect the diversity of methodologies—qualitative and quantitative methodologies. The articles are written by leaders in the field who are researchers and practitioners of informal science education and environmental education. The articles reflect empirical work supported by an understanding of the context of learning outside the classroom and underpin the need for work which supports growth between formal and informal learning spaces.

Ash & Race emphasize the importance of defining power and identity through discourse. Employing cultural historical activity theory, they explore the words shared during field-based preservice secondary science teacher professional development programs focused on environmental education. Their data insinuates tensions emerge in equity-based pedagogy, but they suggest equity may be achieved by providing resources based on need. While their findings are complex, the findings are a starting point for conversations that must take place in teacher develop-

ment programs and within environmental education.

Schneiderhan-Opel & Bogner followed 10th graders through a citizen science activity (Barcoding Fauna Bavarica project) to elaborate on the relationship between and interest in biology and environmental values and if interest in biology and environmental values were predictors of content knowledge. Organizing the relationships in this manner provide allowed the authors to provide schema of the mediators for biology interest and preservation. Their work acknowledges the positive role of environmental values and biology interest on environmental learning and underpins the relationship between learning inside and outside classrooms.

Traditional classroom educators teach using the fundamentals of epistemology, learning theories, and pedagogy. Ritchie & Morrison provide a study focused on adjusting our ideologies about learning by considering the values and practices of indigenous people—Māori, the Indigenous peoples of Aotearoa, New Zealand. They accomplish their work by grounding their methodology in local indigenous Māori theory and narrative. Their results indicate a close affiliation between student success in school and extended family support. Additionally, schools included Māori and Western knowledge domains and students were empowered to make decisions and identify their commitment to the environment. Ritchie & Morrison raise important implications for current and future pandemics. Indigenous knowledge and teaching must be imbedded as part of the formal classroom curriculum and educator practice.

Makerspaces are touted as resources for democratizing science education. In their article, Tan & Barton problematize this by utilizing the Rightful Presence framework for justice-oriented education to unpack the relationships between the materiality of making and the artifacts youth produce. The illustrative vignettes that they describe demonstrate how youth design and create artifacts that necessary for their and their communities' well-being and futurity.

As many ISE organizations have missions that include equity, Tran & Gupta urge institutions to go beyond simply forwarding statements. Rather, it is imperative that ISI staff engage in praxis of critical consciousness in ways that creates cultures of belonging. Building on a model from youth development scholars, Tran & Gupta forward an approach to professional learning for ISE staff that includes include humility, compassion, and belonging. These ideas must be embodied throughout the organization, from individual staff into the collective organization before they can be genuinely practiced. Without these components structural inequities will persist despite effort to do otherwise.

Reference

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Paths Toward Hybridity between Equity and Field-Based Environmental Education for Novice Science Teachers



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Paths Toward Hybridity between Equity and Field-Based Environmental Education for Novice Science Teachers

It has become increasingly critical that we no longer consider environmental and social justice issues separately. Well-researched examples of real-world paths toward hybridizing equity and field-based teaching in science education are rare, yet are especially important now, not only as we move towards anti-racist pedagogy, but also in response to the global pandemic and climate change. Cultural-Historical Activity Theory (CHAT) drives our analysis, with Structural Agency Dialectic (SAD) and Critical Theory (CT) providing additional lenses/foci to guide our data collection and analysis. To add to research on equitable field-based environmental education and to theorize it in newer ways, we trace the thematic markers as well as discursive traces that characterized the process of hybridizing in this research intervention. We focus on structural and agentic themes that advance or constrain movement towards hybridizing in an equitable field-based environmental education (FBEE) year-long, secondary science preservice science teacher (PST) professional development program. Data analysis focused on interviews, reflective journal and field notes, so as to capture emerging tensions directly through the PSTs' experiences, rather than program analysis. Three emergent contradictions emerged: (1) Negotiating the meaning of the term equity in theory and practice; (2) Unpacking the meaning of grit as a tool for individualism, and (3) Negotiating the meaning of resources as mediational means. This research adds to a larger movement towards fostering

equitable, accessible and anti-racist field-based environmental education.

Keywords: pre-service teacher professional development; field-based education; cultural historical activity theory; critical theory; equity

Introduction

Field-based teaching is an important pedagogical tool in environmental education. However, as the field remains a space of historic whiteness and exclusion (O'Brien et al., 2020; Morales et al., 2020; Finney, 2014), it is increasingly important to critically reflect on and conduct targeted research to expand field-based environmental education (FBEE) into a more equitable and inclusive space. Recognizing that FBEE and equity have arisen from different theoretical and epistemological foundations, our research centers on attempts to reconcile them to and locate potential overlap or 'hybrid' zones that allow both fields to be honored. Following Bhabha (1994), we define hybridity as "a metaphor for the space in which cultures meet...the possibility for creative forms ...produced on the boundaries of in-between forms of difference, in the intersections and overlaps..." (p. 1). We situate hybridity in the intersections and overlap between FBEE and equity, keeping in the forefront social, cultural and historical differences in origins, as potential areas of overlap.

More generally, we note that while there is much research exploring environmental/sustainable education professional development both in the U.S. and internationally (de Haan, 2006; Murphy et al. 2020; McDonald & Dominguez, 2010), examples of hybridizing equity and FBEE in pre-service professional development in science education are rare (Chinn, 2012; Monhardt & Orris, 2007), and the research that does exist is too often strategy rather than theory based (Carabajal, Marshall, & Atchison, 2017; Barrable & Larkin, 2020). In order to capture movement toward hybridity, we focus on structural and agentic thematic markers that appear to advance or constrain hybridity. This research is important as it begins to re-imagine FBEE, to extend its boundaries, challenge some beliefs and reposition FBEE within a more syncretic theoretical framework of equitable theory and practice.

We define field-based environmental education most simply as extending teaching outside the classroom into real-world settings, yet it is more than that (Lonergan & Andersen, 1988). We draw from Cole (2007), using an 'expansive view' of the environment/field, in which it becomes a place "rich with dynamic cultural, social, economic, political, historical contexts and perspectives that frame and construct the ecological processes within them" (p. 39). We define equity most simply as providing resources in proportion to need (redistributive) (Dawson, 2014), as opposed to seeking only equality, that is proving equal portions to all. Using this framework, we position "the use of multiple, diverse, and even conflicting mediational tools as promot(ing) the emergence...[of] expansive zones of development" (Gutierrez et al, 1999, pg. 286).

Moje et al. (2004), suggest that such expansive or hybrid zones can "serve as a navigational tool to help them [students and teachers, community members,

administrators, and so on] to understand conventions and practices of a new discourse community” (p.53) To do this, we follow discursive traces of emergent hybridity as PSTs attempt to negotiate common meaning as two very different disciplines overlap (Engeström, 1987; Sannino, & Sutter, 2011). To do this we must understand more clearly where equity and environmental theory and practice arise, that is, their philosophy, mediational means and expected outcomes.

In terms of equity, we note that within the US, for example, it has been strongly suggested that FBEE has been created by and offered to mostly middle-class, western European-Americans (Newsome, 2020; Taylor, 2019; Toomey, 2018), but also that those most affected by environmental /climate change (Taylor, 2019) will be those minoritized (Tolbert, 2015) and typically less economically secure populations (Mendelsohn et al., 2006). Critical theory (CT) provides us a lens for studying how to more broadly situate inequities at the intersection of race, gender and culture. Because it is easy to fall into the ritual of white (often male) middle class field/environmental education as the norm (B. Moore, 2013), we position this research intervention first, as equity work, and second, as environmental work, understanding that these two should be conjoined, but are not. We note that people of color are often subject to practices in FBEE that leads to othering and exclusion (Toomey, 2018). powell & Menendian (2017) define othering as, “as a set of dynamics, processes, and structures that engender marginality and persistent inequality across any of the full range of human differences based on group identities.” (pg.15). Unfortunately, such othering practices are often accepted as normative behavior.

Such othering fits well with how scholars have positioned FBEE increasingly within a neoliberal philosophy of consumerism, competition and individualism (Apple, 2017; Fletcher, 2016). As Carlone et al. (2016) argued we must “move beyond the neoliberal grip on knowledge production in field ecology, contesting prototypical scientific epistemologies that are reductionist, techno-rational, and perpetuate subject/object dualisms.” (p. 209). Neoliberalism also helps us to understand the roots of the individualism vs. collectivism divide as it has steadily pushed the education systems towards a market economy based in part on individual rights, commodification and consumerism. Thus, individualism is a hallmark of neoliberalism and is an important discursive marker in teacher professional development as teacher collective power is deliberately diminished, students are increasingly tested, and schools become businesses. (Tolbert, Spurgin & Ash, 2021).

Noting these and related tensions and wanting to move toward equitable FBEE, the research intervention project we describe here challenges such dominant and normed discourses by working with young socially conscious teachers in training at a progressive university system, and an emergent community of scholars whose stated goals include social justice. To contribute to this body of research, to theorize in new ways, and, perhaps, to shift the focus of future research, we trace the most salient discursive aspects, noting how structures enhance and/or constrain success (as measured by past and present practices, discursive and written products reflective of success or conflict) in year-long secondary science preservice teacher (PST) professional development program focused on equitable FBEE. Theoretically we rely on Cultural Historical Activity Theory (CHAT), the Structural Agency Dialectic (SAD), and Critical Theory (CT) to potentiate

the complex analysis required for discursively tracing contradictions embedded in the proposed hybridizing process. Following CHAT principles, we seek out contradictions as they emerge (Foot, 2014), exploring both individual and collective emergent themes. Taken together these three frameworks allow for a more nuanced and comprehensive analysis than either one could do on its own.

Theoretical Framework

Cultural historical activity theory (CHAT) is our overarching framework within which we situate the structure agency dialectic (SAD) and critical theory (CT). CHAT, both systemic and flexible, is a framework nuanced enough to capture multiple levels of activity, people, mediational means, rules, hierarchy, and community. CHAT is object oriented, invites contradictions, is historically based, dialectical and expansive. Structure and agency exist in a dialectical relationship as does all of CHAT. Structure and agency enhance and constrain each other, and are mutually constituted. We argue that SAD can help provide a more fine-grained analysis of PST agency or lack of it within the activity framework. CT provides a much-needed intersectional lens, drawing attention to the role power, race, identity, and gender have played in systems of education. As a combined conceptual frame, the tri-part frame supports research that is equity driven, destabilizes neoliberalism and dominant ideologies, engages in multi-sited analysis and uses an intersectional lens. We acknowledge the overlapping influences of power, identity, in order to dialectically explore how environmental education can be re-positioned for expansive, equitable community-focused teaching and learning.

Because CHAT is designed to embrace dialectical relationships, it welcomes and seeks out contradictions (e.g., for whom and by whom is FBEE designed; individualism vs. collectivism), presuming that contradictions actually drive and transform activity systems (Engeström, 1998; Foot, 2014) encouraging expansion toward aspects we may not have known before. This generative stance allows us to expect and thus make space for unanticipated outcomes. Thus, CHAT, having already used to analyze classrooms, companies and hospitals, functions as all-purpose systemic tool that accommodates interdisciplinarity works well with specific constructs such as the structure agency dialectic (SAD) and a variety of mediational means (for example, language, discourse, books, computers, open space, land, etc.) (Engeström, 1987; Langemeyer & Nissen, 2005). CHAT takes into account the varying components/nodes of an activity system, including the individual (subject- i.e., Pre-service Teachers), mediational means (tools- i.e., Resources of all kinds), object (motivation, outcome- i.e., Equitable FBEE), community (biology dept. county, education dept), rules (e.g. state mandates for credentialing) and division of labor (academic hierarchy, local school norms). We observed interacting systems, including a department of biology at a university, preservice science teachers in a teacher education program, the county office of education and/or the natural resource management team.

Here we focus primarily on mediational means naturally moving across such multiple systems, including money, expertise, tools such as hygrometers, land, cultural background, curriculum goals, lesson plans or experts. Gutierrez et al. (2009), argue that such mediational means or tools are both essential and changing parts of any activity. CHAT also provides a framework within which to study the

details of the structure agency dialectical (SAD) tension between individual PSTs and potential enhancing and/or constraining collective, structural forces (Buxton et al., 2015; Cole & Engeström, 1993; Varelas et al., 2015). SAD (Sewell, 1992) then, allows us to frame our thinking in terms of specific factors that both advance and constrain PSTs' direct experience of agency, but also whether and how they might position themselves as individual agents or part of a larger collective. Specifically speaking of agency, Sewell (1992) suggested it, "is the actor's capacity to reinterpret and mobilize an array of resources in terms of cultural schemas other than those that initially constituted the array" (p.17). By actor/subject, here we refer to the PSTs, but also note the surrounding community of mentors, researchers and university and county resources. Sewell (1992) further suggests evidence of agency, sometimes described as transformative agency when situated within CHAT, when people use tools in novel ways, or in places where they "don't belong." For all these reasons, mediational means then, are a central part of our work, relying on both typical and creative usage, which we can only recognize, if we are open to unknown outcomes (Engestrom, 1987). This bodes well for activity, interactions and mediational means seemingly outside of the 'norm' or 'settled expectations' (Bang et al, 2012; Bang et al., 2015; Moore, 2013), especially known when they work to transform previously 'known' situations or systems.

Gutierrez and Barton (2015) suggest that, "the structure–agency dialectic provides conceptual and analytic tools for re-reading and re-naming some of the enduring equity dilemmas faced in science teaching and learning, offering inroads to seemingly intractable problems" (p. 575). As we shall come to see, both agency and structure (and the inventive use of mediational means) are multi-layered, as are their interactions (Buxton et al., 2015; Varelas et al., 2015). Using SAD we recognize that PSTs can and do have and do gain agency (as well as identities as soon-to-be teachers) in the PST programs, yet, the possibilities are not unbounded. One such intractable problem may be how to hybridize equity issues with environmental concerns without losing nuance or depth of either discipline.

Critical Theory (CT) reaffirms our commitment to social justice, nondominant science ideologies, and praxis. As Mensah & Jackson (2018) highlight, in CT:

race matters, history matters, voice matters, interpretation matters, praxis matters ...because "it is not enough to simply produce knowledge, but to dedicate this work to the struggle for social justice" (Zamudio et al., 2010, p. 6). (pg. 7)

We keep these tenets central to intersectionally examine the role, power, race, and/or gender may have within the field-based emergent teachers activity system. This stance allows us not to be only critical of the system, but our own analysis. In FBEE, specifically, we aim to move the more common approach of socially critical theory (Walker, 1997) to a place of praxis and expansion, using CT address not just environmental justice but social and racial justice.

Methods

Context

The data from this research draws from the pilot year of a professional development program at a large west coast university, co-sponsored by the Education Department (the Master of Arts/Credential (MA/C) Program), the Biology Department, the Natural Reserve System of the University system, and the local County Office of Education (COE). This local consortium emerged due to a shared commitment to advancing diversity and equity in environmental education through field-based pedagogy, evidenced by the following descriptions: (1) The MA/C program is an intense one-year program with a focus on social justice and educational equity; (2) The Biology Department offers the most field courses in the university system, and: (3) The local COE has one of the few environmental literacy coordinators in the state. This unique partnership was rather novel, its pilot years meant to create a model for a potential university system wide professional development program for teacher education.

The FBEE program focused on the efficacy of a new field-based environmental pedagogy intervention designed to address the dearth of diversity of backgrounds and perspectives in the environmental science sector, advancing a specific and targeted equity approach. Collective activity included the integration of FBEE content into two of the science student teachers' courses, quarterly Saturday workshops, and implementation of program strategies in participating in PST/CT classrooms through the development of lesson plans. The pilot year of this emerging collaboration faced challenges as it progressed as the partners were new to each other, the program was situated across multiple schools and districts operating under state credentialing guidelines, and the budget for the program was limited and temporary.

Participants

All secondary science MA/C students were invited to participate in the 2018-19 academic year. Applicants were asked to reflect on the program goals, as well as their ability to commit to the time required to participate. From a cohort of fourteen mixed science (chemistry, physics, biology, etc.) credentials, five participants applied and were selected, largely those credentialing in biology. There were three male, Sandy, Skip and Hilago, and two female participants, Cheyanne and Maggie (see Table 1). All PSTs but one (Skip) were paired with cooperating teachers (CTs) with varying experience with field-based/environmental pedagogy. Students in the MA/C program are assigned two placements, one at the middle school level and another at the high school level, the second one longer than the other. These pairings came with the second placement CTs. Participating CTs and PSTs were each paid a stipend for their participation.

Data Collection and Analysis

Data collected from the participating PSTs included pre/post interviews, quarterly

reflective journals, ethnographic field notes of workshops, associated MA/C student coursework (including research papers and lesson plans), surveys, and reflective presentations on their program experience. Data was collected by Race, as Ash was an instructor in the program and could not ethically view the data until the participants had completed their course with her. Interviews were audio-recorded and transcribed through a web-based service (temi.com). The data analysis focused primarily on interviews, supplemented with the reflective journals and written course work. Iterative rounds of coding initially identified larger tensions/themes, which were then refined into specific codes at three levels of analysis: the professional development program, the PST placement contexts, and individual PSTs. Data was critically reviewed and re-reviewed by the authors together and separately. We utilize discourse tracing, as described by LeGreco & Tracy (2009):

Discourse tracing provides new methodological resources for gathering and analyzing data associated with case studies, especially those focused on issues of change...it builds from a critical and poststructural epistemology that celebrates the importance of power, multiple levels of discourse, practice, and participant voice...Moreover, this approach can result in rigorous naturalistic generalization (Stake & Trumbull, 1982)...

We traced the contradictions/tensions we noted during PST ‘work’ within the newly expanding space as discursive markers/traces, using these to identify the emerging hybrid themes. These traces allowed us to glimpse change in views over time, especially in terms of criticality and inconsistencies. Hybrid then was represented by the disparate and unifying discursive traces signaling overlap or merging of pre-existing differences in practice or worldview. By comparison, we could also note where and for whom this did not occur.

For example, for the PSTs, discursive traces uncovered previously less-understood inconsistencies/contradictions, such as differing views of PST and student access and key mediational means/ program resources that might scaffold success. The data presented here is drawn from all participants, but focuses on two PSTs, self-represented as a queer Latino male, Sandy, and a Caucasian cis-woman, Cheyanne (see Table 1). Although all five in the research cohort represented the process of hybridization to varying degrees and in quite different ways, we selected these two because of their degree of engagement with the program and the criticality they brought to their reflections of the program.

Findings

The goal of the intervention was: 1. locating thematic markers, 2. following discursive traces during negotiation of themes, 3. noting how these constrain movement towards hybridizing equity and FBEE. Overall, we took into account three-levels of analysis; the overall program, the CT/PST dyad pairings, and individual PSTs. We concentrated on specific areas requiring significant negotiation both in oral, written, real-time and overtime form: (1) Negotiating the meaning of equity; (2) Identifying discursive traces of appropriating a grit/individualistic stance and (3) Situating and negotiating resources, which we have positioned as mediational means.

Negotiating a Joint Meaning of Equity

We immediately noticed a disjuncture concerning the actual meanings of the word equity (often seen as equal, diversity, inclusion, social justice, etc.) at both individual and collective levels across all partners. Different versions of the meaning of equity appeared early and quietly but persisted throughout the first year. The meanings and the differences between some of the most commonly used terms (equity, equality, diversity, etc.) were not made explicit at first, partially because this was not originally seen as an area needing elaborate negotiation. People spoke in generalities, until it became clearer that participants did not mean the same thing. As participants' ideas changed it was not surprising that the meaning of the program itself (based on equitable FBEE) needed re-negotiation. As with past environmental alliances, some meanings and beliefs had to be established within the actual work or practice of the community (Kempton & Holland, 2003) in both the field and classroom.

The mismatch of meanings emerged most clearly in the quarterly workshops, when all the partner communities met. The natural science faculty's (who offered the first workshops) interpretation of diversity or equality centered on offering the same kinds of activities they had used with university students, to the PSTs, who were then expected to use them with their minoritized middle and high school students. This equal/same lesson for all approach is a classic view of equality; everyone gets the same. PSTs, on the other hand, having been imbued with a social justice and equity stance in their MA/C program immediately recognized the conflict between the 'same lesson approach' and their current understanding of equity. Cheyanne said:

A lot of the kids that they're (university science professors) working with, it's not equitable...Let's talk about K-12 when we're working with kids of all levels, all backgrounds. That's where the conversation on equity needs to be happening.

Maggie said something similar, "It (workshop) didn't address the idea of equity and bringing students who wouldn't already have that experience into it (the field)." Cheyanne and Maggie recognized that using the same pedagogical approach for college students with K-12 students doesn't take into account the additional and sometimes unknown challenges equitable FBEE engenders. In short, it is not equitable according to their definition. But it did conform to other professionals' views of equality.

Sandy also commented on the mismatch between the workshop presentations and the program goals of equitable FBEE. Reflecting on the program, he said:

No. I think that [equity] is what the cooperating teachers (CTs) and the student teachers (PSTs) wanted. I think everyone associated with the master's program, that's what they wanted. But the people that we brought in weren't addressing those issues. And I think just re-aligning what the overarching goal is for everyone, including participants [and] guest speakers about why we are speaking at this specific workshop would be better and put everyone on the same page.

Sandy stated the contradiction quick clearly. By this we mean the power inequalities of student and program designers set up an inequitable situation for them and by proxy their future students. Using SAD, we can argue both Cheyanne's, Maggie's and Sandy's recognition of a mismatch or in CHAT terms a contradiction in collective meanings of the term equity appeared to have motivated increased agency on their part in the face of structural programmatic constraints. Within CHAT such contradictions are valued and are said to drive systems to expand and transform, so that the final product cannot be entirely predicted in advance. This particular contradiction motivated them to advocate for change, which eventuated in a new format the next year, especially in terms of negotiating the meaning of the term equity early and often.

In a separate academic program component, Sandy wrote a research paper titled "Accessibility for Marginalized Folx in Outdoor Education." He specifically addressed the lack of accessibility for people like him,

...it kind of fueled my frustrations with [the program], kind of made me realize that I can't be this passive person in a community that needs active voices.

Sandy wanted equitable approaches to FBEE programs for marginalized folx like him, and personally motivated to change the program. When the FBEE program did not provide that, he announced in this research paper that he planned to be more agentic. One product of his increasing agency was an emerging hybrid stance which, among other actions, rejected the common diversity language of 'equal for all'. Instead, his new posture announced an expansive view of what heretofore has passed for normal in his own training, as an undergrad in this same university with some of these same professors. The hybridity in this case resides in the fact that he was pushing beyond the boundaries of so-called 'normal' EE in that university.

Sandy and Hilago both recognized the tension between diversity and representation both within and outside their MA/C program. Sandy noted the lack of diversity in program leadership, "There isn't any people of color (POC) representation other than one Education Faculty." Hilago noticed that the lack of people of color as guests in the workshops, "...just having different people of color come in as well. I felt like it would've been helpful." While not surprising, given the historic whiteness of teaching and FBEE, CT reminds us that critical voice is essential for change to happen, especially if that voice comes from a less powerful position. Both students were POC themselves and proactive in different ways. In an 'end of the program' debrief, all PSTs commented on the lack of explicit/concrete focus on an equity aspect of field-based learning, asking, for example, "Who are we serving?" and "How do you do field-based learning with students/schools who lack the resources to go beyond the school grounds?" Thus, despite the sentiments coming from many PSTs as we saw, the larger burden of critiquing inequities in practice and diversity fell on the POCs in the group.

Unpacking the Meaning of Grit as a Tool for Individualism

Grit, a term popularized by TED talks and books (Ducksworth, 2016), has roots in the American "pull yourself up by the bootstraps," strongly individualistic norms emphasized since the 1960's by neoliberalism proponents that emphasize globalization, competition, consumerism and of course, individualism (Apple,

2017; Tan & Barton, 2008). While the concept of grit itself is not problematic, those who use it place the emphasis on individual agency, failing to recognize larger systemic barriers and challenges teachers and their students face. As one conservationist suggested:

Many folks in the conservation / ecology circles I move in will refer to getting reluctant students into the field as a “forced march”. I’ve said it myself many times without thinking much about where that phrase comes from or how it might be received. Lots to unpack and retire in that language.

The language of grit and unlimited agency has become so normalized that teachers, scientists and environmentalists use it without reflection on alternative meanings. For example, language like “forced march” can be extremely damaging for Indigenous or Black students, whose ancestors were forced to march to reservations or on chain gangs, often to their deaths.

Gutierrez et al. (2009) argued that literacy must be remediated; we suggest FBEE requires similar linguistic remediation. Take this comment by Sandy, who focused determinedly on equity and social justice in his approach to FBEE:

I asked, what if the kid doesn’t want to do this? And then the instructor said ...well, you just gotta make them do it...And that really put me off because that was really big, pull yourself up by the bootstraps kind of thing. Force kids into doing something until they like it or until they’re successful. And I’m like, no.

Scribner & Cole (1973) said, “searching for specific ‘incapacities’ and ‘deficiencies’ are socially mischievous detours” (pg. 558). By this we mean looking for deficits and providing assumed corrective methods, as noted above, ‘make them do it’ is not consistent within equitable social, field-based practices.

Situating Resources as Negotiated Mediation Means

The contradictory translations and meanings of the term resources was not obvious at the beginning of the FBEE program, as meaning was undifferentiated in important ways. Again, discursive traces led us to this theme. We have situated resources (within a CHAT framework) as mediational means or tools for achieving desired objects (outcomes). In the case of FBEE work, any perceived mediational means (and there was a wide range) can take multiple forms, as can the perceived motivation for any particular outcome (help society, save money, etc.). An equitable stance concerns distributing resources according to need and not necessarily in equal measure. It appears that PST participants and leaders interpreted ‘resource’ through two lenses, (1) similar to equity, we trace the interpretations of what the word resources actually meant; and (2) implementation in practice, that is, how resources were identified, distributed, and used. The meaning of both these categories shifted over time, and meanings of resources varied at the different levels of analysis.

Not surprisingly, PSTs interpreted resources as the things they need to make FBEE teaching practice work. Some leaders viewed them as land, money, and lessons, others as an equitable stance and desire for social justice. This contradiction was revealed over time. From a programmatic perspective resources included tangible items, such as transportation to sites away from school, and the

less tangible as well, such as degrees of mentoring by CTs. As seen in the two concept maps, representing PSTs past experience with FBEE (Figure 1), Cheyanne and Sandy entered the program with differing expertise and views of resources. The primary difference, beyond specific contexts for work, was Sandy's strong reference to structural constraints for equity, including lack of resources.

Cheyanne located her goals on one side and experience on the other (Figure 1.A), explaining the positions and providing strong evidence of experiences and subsequent questions. She synthesized her past experience but also what she wanted in the future. Cheyanne was placed in her student teaching in a 6th grade middle school science classroom; unlike other PSTs, she was paired with the same CT the entire year. Her mentor/CT was a veteran teacher with many years of experience incorporating FBEE teaching into the classroom. Cheyanne recognized the impact of this:

My CT is a big part of my "Goals of ..." side of my concept map because she consistently brings the field into her classroom. I think this is a very sustainable approach to FBEE learning. ... all classrooms have the ability to make their classroom a field, where students can operate as field scientists.

The scaffolding from her CT significantly broadened her understanding of FBEE. The combination of past experiences and the current scaffolding from her CT helped to shape her understanding of resources, especially in regard to equity when students cannot go on actual field trips due to a variety of reasons (access, money, pandemics). Such an expansion of perceived and real resources (i.e., her CT) marked Cheyanne's ability to move towards equitable FBEE in her current and future work. We see this later in her job selection, as she states in an interview discussing why she chose a job in an urban area instead of a nature-rich one,

... it just kind of smacked me between the eyes. thinking of all of these ideas of how to do (FBEE) in urban areas, that I want to take the skills that I have of creating lessons and curriculum and take them to a place where it needs it the most.

Sandy positioned his concept map around his role as an educator doing FBEE. Focusing less on past experiences, he emphasized emerging tensions novice educators, such as himself, must navigate. These included systemic barriers and the role of social justice. His question, "How do I do all of this at the same time?" reflects both conflict and desire to do things differently (Figure 1.B). Unlike Cheyanne, who completed her concept map near the start of the program, Sandy created his concept map about two months later:

I feel as though [program] has these ideas of helping a certain audience of students. Students who come from impoverished and underfunded schools and communities, especially students in grades 6-12. However, most of the resources and tools that we have been working on are not necessarily helpful to the goals made for this program.

This stated tension between program goals and possible success of implementation forced us to step back and systemically analyze the inequity in the essential resources provided to the PSTs. For many program leaders, despite best intentions for equity, resources were often seen as generic field-based pedagogical tools, with little thought given to the specific level of instruction. Frankly, our view of what resources could be expanded a good deal during this study. Sandy,

Cheyenne's and the other PSTs critical reflection revealed a programmatic lack of differentiation in negotiating and managing teacher resources for working with POC in EE.

Similarly, regarding placement-level resources, unlike Cheyanne, Sandy was placed with a CT with less FBEE experience, in a high school ninth grade science classroom with significant departmental and structural constraints, including unit timing, curricular alignment and hesitation from other teachers to alter the curriculum. These constraints limited his agency, as he notes, "The program hates when I say this but I'm just a student teacher and I'm also like, don't say too much or else you lose out on a job opportunity." This reflects the limited agency that PSTs often have in their classroom placements (Tolbert, Spurgin & Ash, 2021). Limited agency and lack of equitable FBEE and CT resources hindered Sandy's ability to create and implement fully equitable field-based lessons in his placement.

Discussion

Using CHAT, SAD and CT, we analyzed the incipient contradictions, challenges, affordances, as well as some outcomes, as PSTs moved toward hybridity in a historically white exclusionary field. One goal of creating equitable FBEE was understanding how teachers can understand equitable field-based pedagogy using a rich set of mediational means. We noticed movement toward hybridity or, as we suggest 'expansive zones of development', in different overt forms, yet still grounded in theory, using similar (and different) mediational means. We see that subjects/PSTs used mediational means towards achieving objects (outcomes). The subjects Sandy and Cheyanne had similar (workshops, classes, cohort) and sometimes dissimilar (CT, lesson plans) mediational means. Their community of practice largely overlapped except for the classroom experiences with students and CTs. While each had located an expansive zone within which to work toward equitable FBEE, in actual practice, because of structural constraints, their goals were not realized equally. Cheyanne experienced more degrees of freedom than Sandy, while Sandy advocated for a good deal more agency within the program.

Both left the program and took new jobs in challenging urban environments focused on equity concerns. For Cheyanne, the program provided rich resources and mentorship that impacted her confidence and appropriation of program goals, impacting her agency. She was confident of her ability to implement field-based teaching in her future urban placement in the face of significant structural constraints. Sandy recognized the systemic inequity that persisted even in a program focused on equitable approaches, as he shifted to critical advocate. He viewed the program with a critical stance, recognizing the persistence of whiteness, inequitable resources, and problematic ideologies that exist overall in FBEE. His new job placed him on the frontlines of such work. This critical lens worked toward pushing program organizers to recognize their own role in perpetuating whiteness in the field. The subsequent year of the program incorporated his and Cheyanne's, and other PST's suggestions.

Just as CHAT welcomes contradictions, SAD is centered on one, and in this case, the dynamic dialectic between teachers' individual agency and institutional/structural constraints. We recognize teachers can and do express agency as they can, also noting the forces working against them on a local and global scale,

especially the overemphasis on individualism that neoliberalism promotes (Apple, 2017). With this mindset, the blame for failure as well as the reward for success can be artificially located in the individual, rather than in the structures that position, enable, and/or constrain the individual (Gorski, 2009; Valencia, 1997). As the research in this intervention is aimed at re-mediating the collective understanding of equitable FBEE, it is expected that many more hybrid or expansive spaces would emerge to challenge dominant individualistic narratives. For example, this process of hybridity created a space for our PSTs to push against the individualistic grit, “make them do it” narrative that has existed in FBEE.

At the program level, the FBEE program aimed to provide collective and equitable resources, both intellectual constructs and the material ‘stuff’ of teacher’s work. Within the larger systems of activity of this research intervention (county, university, classroom, field), there were attempts to provide and connect resources beyond the individual teachers and classroom level. This proved to be challenging. The hybrid, expansive spaces created by the PSTs showcased how some mediational means moved the system towards more equitable FBEE. This negotiation provided valuable insight into how to improve future iterations of the system, but also the fault lines we noted. For example, Sandy’s critical stance and Hilago’s comments nudged the leadership to include more voices and perspectives of people of color in the next year of programming.

Limitations

We recognize this study is a U.S. specific example. However, there are numerous CHAT- based teacher professional development research studies, especially in Europe (Ellis et al., 2010). We hope the theoretical grounding and conceptual framework will provide a useful lens across all environmental education spaces, especially for those seeking to critically examine their practices. We also know this is a limited data set from only one year of a pre-service teacher professional development program. While we took measures to triangulate our data, we recognize our findings may not be generalizable and may be subject to researcher bias. We also note our roles in the program as a potential source of bias, Ash as a lead founder of the program, and Race is a graduate student researcher with a background in field ecology.

Conclusion

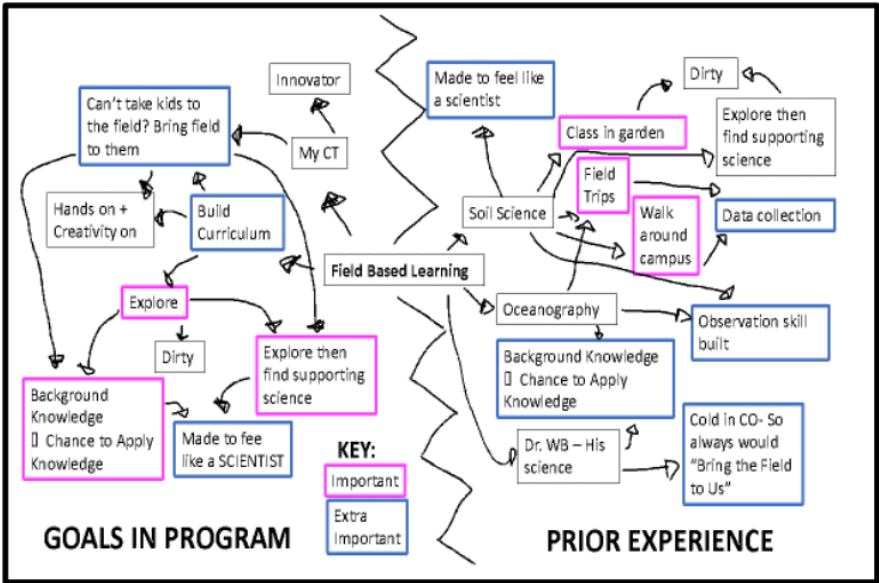
The field of environmental education (EE) is rife with contradictions, structural constraints, emerging consumerism and sometimes unbridled individualism (Fletcher, 2016). EE, in fact, appears to be a perfect area of study for the type of analysis we have suggested. We have argued that cultural-historical activity theory (Engeström, 1987; Engström & Sannino, 2011) with attention to the structure agency dialectic and centered through a critical theory lens, provides the tools for uncovering and fully examining systemic analysis of contradictory relationships. We have offered three dialectical areas, views of equity vs. equality; deficit (grit) vs. resource views; and conflicting meaning of resources, which we positioned as mediational means, and as the levers for transformation (Foot, 2009).

In the age of COVID-19, it has become increasingly evident that we can no longer consider environmental and social justice issues separately. The data presented here highlights tensions that emerge when attempting to incorporate equity-based pedagogy in science teacher preparation. Equity is achieved through providing resources according to need rather than equally. As recognized by the participating pre-service teachers, it appears that this particular intervention only partially met that goal, as it did not entirely translate to equitable FBEE.

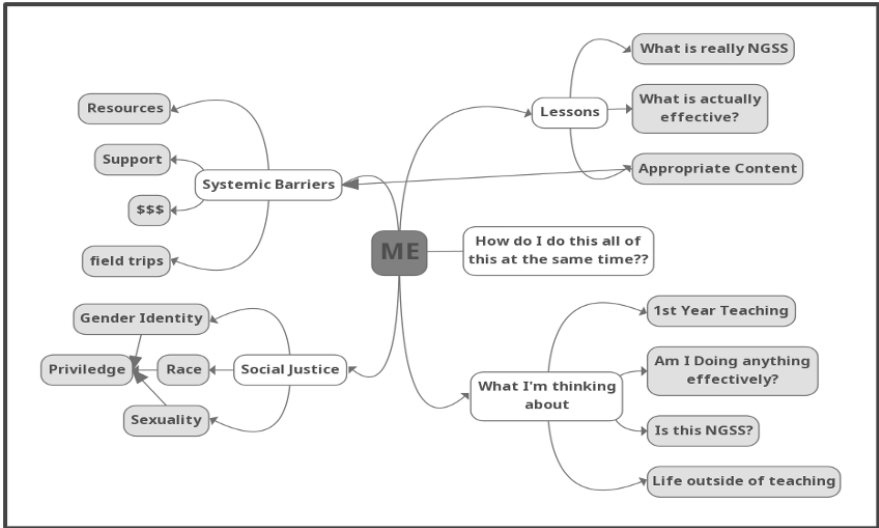
Environmental and field-based education need greater critical examination as we move towards designing equitable, anti-racist, hybrid spaces. This reflection was supported as the pre-service teachers were given space to reflexively negotiate, and then shift, their previous understandings of FBEE to more equitable FBEE. This retrofitting of newer views of equity into previous understanding of FBEE created visible contradictions which allowed the pre-service teachers to move with agency through the professional development program, voicing concerns and suggestions.

Figure 1

Focal Pre-Service Teacher’s Concept Maps



(A)Cheyanne’s Concept Map



(B) Sandy's Concept Map

Table 1.

Program Pre-service Teacher Information

Name	Undergrad	Interest in Science	Teaching Philosophy	Thoughts on Field-based Education	Placement/CT
Sandy	Public University in CA Major: EEB Cal Teach	As a way to help community; Ecology interest sparked by Pokémon	Help develop a good society; Being authentic	Authentic engagement with content; learn respect for nature; grounding	High School; Novice Teacher with minimal experience in FBEE
Cheyenne	Private Christian College in CA Major: Education Minor: Environmental Science	Grew up in area with access to natural spaces	Developing Positive Character Traits and Respect	Invaluable; Develop richer connection to place	Middle School; CT with many years of experience teaching and an expert in utilizing FBEE in classroom

Table 2.

Focal Pre-service Teacher Extended Background Information References

Name	Demographics	Placement
Maggie	Female; Caucasian	11-12th Grade AP Environmental Studies
Cheyenne	Female; Caucasian	6th Grade Science
Skip	Male; Caucasian	N/A (was not paired with CT associated with program)
Hilago	Male; Latino	6th Grade Science
Sandy	Male; Latino	9th Grade Biology

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Symbiosis Between EE and SE



The Combined Effect of Environmental Values and Fascination with Biology on Biodiversity-Related Learning

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Symbiosis between EE and SE: the combined effect of environmental values and fascination with biology on biodiversity-related learning

Cognitive learning in ‘green’ education modules feeds its success from a host of predictor variables. In our present study, we focused on the relation between environmental attitude sets and fascination with biology and their impact on biodiversity-related learning within a sample of 205 Bavarian 10th graders (Mage = 15.3, SD = ±0.64). We engaged the participants in an innovative environmental learning module situated in biology lessons and including student-centered, hands-on learning experiences, such as, for instance, a species identification exercise, interactive multimedia-based elearning activities, or a role-play to explore a future scenario for sustainable forestry. Central element of our module was a citizen science activity in which students collected forest soil samples that contributed to the DNA barcoding project Barcoding Fauna Bavarica, which aims to complete a comprehensive

inventory of biodiversity at the state and national level. Using a pre-post-retention-test design (T0, T1, T2), we monitored cognitive achievement, environmental values, and fascination with biology by applying a module-dependent knowledge test, the 2-MEV scale and the Fascination with Science scale. Pro-environmental values (preservation, PRE) showed a strong positive correlation with fascination with biology (FB), whereas preferences of nature utilization (UTL) revealed the reverse trend. The effects of PRE attitudes and FB on biodiversity-related learning were analyzed via structural equation modeling (SEM): both variables positively predicted cognitive learning achieved through module participation. The results underline the relevance of developing a symbiotic relationship between environmental education (EE) and science education (SE), which is up to now underresearched and underrepresented in practice.

Keywords: fascination; environmental attitudes; environmental values; 2-MEV; biodiversity education; citizen science

Introduction

Exploitative use of natural resources, environmental pollution, climate change and insertion of invasive species have led to irrevocable habitat destruction and severe biodiversity loss (Díaz et al., 2006). The main drivers of environmental degradation are the demands and consumer behavior of a steadily growing world population (Kitzes et al., 2016). Efforts to halt further human-driven biodiversity decline and to minimize the human impact on the environment, therefore, rely heavily on public involvement and commitment to sustainable consumption. The reduction of global biodiversity loss cannot be solely achieved through political top-down decisions. Education provides the basis for preparing young adults for conscious consumer decisions as well as an active and responsible citizenship (Grace, 2006). The overarching goals of environmental education (EE) and education for sustainable development (ESD) approaches are to foster informed decision making in socio-ecological issues, problem-solving skills as well as sustainable, eco-friendly and pro-environmental ('green') behavior (Lee & Grace, 2010; McKeown & Hopkins, 2005). In formal education, both approaches are implemented in science education, primarily in biology and geography classes.

Knowledge-Acquisition in Relation to Environmental Attitudes

Environmental education research primarily focuses on factors that have been identified as highly important for achieving the goals of environmental education programs: environmental knowledge and attitudes and their relation to eco-friendly behavior. Limited or missing knowledge has been repeatedly described as a crucial obstacle to pro-environmental behavior (Gifford, 2011) and studies point towards a positive association between environmental knowledge and behavior (e.g. Frick et al., 2004; Kaiser & Fuhrer, 2003). Bord et al. (2000), for example, determined an in-depth understanding of the main drivers of global climate change as an major prerequisite for the development of ecofriendly behavior towards a mitigation of climate change. Even though knowledge might not be the major

influencing variable, it still plays an important role for 'going green', i.e. to engage in eco-friendly behavior (Moss et al., 2017).

The acquisition of knowledge and individual pro-environmental attitudes are regarded as key indicators for successful environmental education approaches (e.g. Fančovičová & Prokop, 2011). While a lasting change in environmental values (in terms of attitude-sets) requires longer-term or repeated participation in educational programs, cognitive achievement can already be affected by short-term environmental learning modules (Bogner, 1998). Using a pre-, post and retention test design, Schumm and Bogner (2016a) monitored adolescents' knowledge acquisition within a three-lesson classroom-module about renewable energies and reported a short-term as well as a long-term knowledge gain six weeks after participation. Similarly, within a one-day education program about honeybees, Schönfelder and Bogner (2017) reported a gain in students' environmentally relevant knowledge on the conservational issues. Moreover, Thorn and Bogner (2018) examined cognitive learning within an adolescent 10th grade sample participating in a three-lesson, inquiry-based program on the topic of the forest ecosystem and confirmed that the short-term intervention effectively fostered students' long-term knowledge acquisition after six months. Finally, what is more, even a one-year period proved to keep an acquired knowledge gain when 6th graders follow an outreach bionics module within a zoological garden (Marth & Bogner, 2017).

In all these studies, students' environmental learning was positively related to pro-environmental values. Numerous further correlative studies have proven a relation between knowledge acquisition and environmental values within the context of environmental education programs (e.g., Fremerey & Bogner, 2015). Pro-environmental values are considered as an important predictor and trigger of 'green' behavior (Roczen et al., 2014). The investigation of the environmental knowledge acquisition and environmental values, their relation, and the underlying interrelations with other factors are therefore of high importance for successful environmental education approaches. In our present study we focused on motivational abilities as well as environmental values and their role for biodiversity-related learning.

An instrument that is regarded to monitor environmental attitude sets reliably and validly, is the 2-MEV scale (MEV: Two Major Environmental Values; Bogner & Wiseman, 1999). Both environmental values are based on two underlying higher-order factors: preservation and utilization. As higher-order factors, they are defined as values, consisting of a set of primary factors, defined as attitude sets (Bogner & Wiseman, 2006). preservation represents an ecocentric perspective that assigns an inherent value to nature worthy of protection. In contrast, utilization reflects a rather anthropocentric view in which nature is regarded as an exploitable resource exclusively valued on the basis of its benefit to human welfare. The particular advantage of the 2-MEV lies not only in its confirmation by various bi-national studies (e.g.; DE-DK: Bogner & Wiseman, 1997; DE-CH: Bogner & Wiseman, 1998; DE-FR: Bogner & Wiseman, 2002) or internal cross validation studies (e.g. Wiseman et al., 2012) but also in its repeated independent confirmation by different groups (Borchers et al., 2014; Braun et al., 2018; Johnson & Manoli, 2010; Milfont & Duckitt, 2004).

Motivational Abilities: Fascination with Science

In a recent study, Schönfelder and Bogner (2020) have investigated the relationship between environmental values and general science motivation. The study sheds light on a so far unconsidered relationship between the two variables. Especially intrinsic science motivation turned out to be a strong predictor of pro-environmental attitudes. In general, motivational abilities play a major role in educational contexts and have been shown to determine, among other factors, students' effort, engagement, learning success and self-monitoring (Schunk & Zimmerman, 2012). In the context of science education, studies are indicating a decline in students' motivation towards scientific topics (Potvin & Hasni, 2014). Accordingly, ongoing research efforts are focused on the relation between motivation and learning, how to foster motivation for science in educational settings and how to appropriately measure motivational abilities. A fairly new approach is the description and investigation of the construct fascination with science. Bonnette et al. (2019) referred to fascination with science as to be in love with science by summarizing three motivational aspects under the concept of fascination: curiosity, interest, and mastery goal orientation. Similarly, Otto et al. (2020) included the concepts participation, interest and excitement, and identification with the scientific enterprise in the construct of fascination. These concepts are subject of intensive psychological and educational research and will only be described very briefly here.

Markey and Loewenstein (2014) defined curiosity as “a desire for specific information in the absence of extrinsic reward”. According to their definition, curiosity emerges when a person encounters a specific information or knowledge gap, which he or she wants to bridge. In contrast to the concept of curiosity, they define an interest as a desire to expand one's general knowledge about an object or to engage in an activity. Although, interest is a content-specific motivational state, its development does not necessarily require a person to encounter a specific gap of knowledge or information. Following the person-object-theory of interest, which is widely used in educational research, an interest arises from an interaction between a person and their environment (Krapp, 1993). Two forms of interest have been of particular importance for science education research: situational interest, which represents a temporary psychological state and individual interest, which means a permanent motivational disposition (Hidi & Renninger, 2006). Repeated preoccupation with the object or re-engagement with the activity can induce a deepening and development of situational interest into persistent individual interest. Mastery goal orientation in science describes the pursuit to gain scientific knowledge and to achieve mastery of scientific skills (Elliot & McGregor, 2001). The goal of science mastery in and beyond school is closely related to the identification with the nature of the scientific enterprise (Carey & Smith, 1993). Comprehension of the way scientific knowledge is acquired and understanding how scientific methods are used is, in turn, a key aspect of scientific literacy (Dass, 2005).

In the present study, we measured fascination with biology (fascination with biology) using a subscale of the recently developed Fascination with Science Scale by Otto et al. (2020). The instrument conceptually draws upon the Campbell paradigm (Kaiser & Wilson, 2019) as a new variation of the tripartite model of

attitudes (Rosenberg & Hovland, 1960), which proposes an attitude to be based on three dimensions: an affective, a cognitive and a behavioral component. The affective dimension is characterized by positive feelings and emotions towards a subject area, here science in general or certain scientific fields (Otto et al., 2020). The learning topic “aquatic ecosystems”, for example, is supposed to trigger positive emotional reactions in a person who is fascinated with biology and who would enjoy learning more about marine wildlife. The cognitive component is reflected in willingness to solve even complex scientific problems as well as to develop necessary skills, knowledge, and competences. The behavioral dimension manifests itself in the repeated and voluntary exercise of extracurricular activities and experiences. For example, students fascinated with biology will frequently watch TV documentaries about animal behavior or observe garden birds. Like environmental values, fascination is a latent construct, which is not directly observable but becomes measurable based on its three dimensions (Otto et al., 2020).

Purpose

In recent correlative studies, we have already identified a positive relation between pro-environmental attitudes and knowledge and have provided first insights into the relation between fascination with biology and cognitive learning (Schneiderhan-Opel & Bogner, 2020b, 2020c). The present study aimed to shed light on an expected relation between both variables and their combined effect on environmental learning. We examined the following research questions and hypotheses:

RQ 1: To what extent is fascination with biology with biology related to environmental values?

H1: preservation attitudes and fascination with biology are positively correlated.

H2: utilization attitudes and fascination with biology are negatively correlated.

RQ 2: Do fascination with biology and environmental values have a relevant impact on content knowledge acquisition?

H3: preservation and fascination with biology are positive predictors of knowledge at all three test times.

Methodology

Sample and Research Design

Our sample consisted of 205 tenth graders from 14 secondary school classes of seven grammar schools (German ‘Gymnasium’; note that Gymnasium students

receive a university entrance qualification) in Bavaria, Southern Germany (Mage = 15.3, SD = ± 0.64 ; 46.8% female). In accordance with the national guidelines, participation required parents' written consent and we guaranteed anonymity as well as confidentiality of the data. The study was approved by the Bavarian State Ministry of Education and Cultural Affairs (StMUK; reference number X.7-BO5106/160/12).

Our study followed a quasi-experimental research design. Students completed a pre-, post- and follow-up questionnaire (T0: one or two weeks before project participation, T1: directly after the lesson, T2: six weeks after participation) distributed in a paper-and-pencil version. Module participation as well as the evaluation took place during regular school hours.

Content and Design of the Educational Module

Within the framework of the present study, we developed and evaluated an educational module on the topic of biodiversity at the example of the forest ecosystem. The overall goal of our intervention, called FutureForest, was twofold. First, we intended to increase environmentally relevant knowledge on the topic of biodiversity and second, the module aimed to raise awareness for environmental conservation. The module took 180 min and was held during four regular biology lessons. It was divided into four sub-modules that covered different aspects of the issue:

1. Sub-module one focused on the ecosystem services of forests that contribute to human wellbeing (supporting, cultural, provisioning, and regulating services, e.g., sequestration of carbon and provision of oxygen). The students worked with an interactive website.
2. Sub-module two dealt with the method of DNA barcoding for species identification and demonstrated how environmental monitoring relates to biodiversity conservation. The participants worked with an interactive, digital learning tool.
3. Sub-module three focused on the relevance of a diverse composition of forest soil organisms for forest ecosystem functioning. Students observed organisms under the microscope and trained their species determination skills with a simple identification key.
4. Sub-module four dealt with the human-induced impact on forests and biodiversity, e.g., the cultivation of monocultures or the consequences of climate change. The participants were involved in a role-play that included the perspectives of different stakeholders on organic forest conversion.

Our approach followed the self-determination theory (Deci et al., 1991). Consequently, the participants completed the sub-modules autonomously in small groups of three to four students. The groups completed the whole module self-responsibly within a given time frame. They were provided with all the necessary material and each student got a workbook that contained information texts and task descriptions. Only the final wrap-up phase was teacher-guided. Here, the students were able to compare their results and to improve them where applicable

(for a detailed description of the modules' tasks see Schneiderhan-Opel & Bogner, 2020a)

In addition to the activities in the classroom, we involved the students in a collaborative citizen science project. They collected forest soil samples for our project partner at the Bavarian State Collection of Zoology. To ensure correct sampling, the students were instructed by their teachers. Additionally, they were provided with a protocol that contained necessary tasks and information on how to take the sample, how to collect the GPS location data of the sampling site and how to prevent the sample from drying out. The scientists received the samples together with the protocols, which provided necessary information on the sampling site (e.g., plant and tree composition of the respective forest). The soil organisms extracted from the samples were determined through DNA barcoding, which is a method for species identification through the use of species-specific genetic markers, the so-called DNA Barcodes (Hebert et al., 2003). To determine an unknown specimen, its genetic marker is amplified and subsequently compared to reference species within a database. Thus, the determination process heavily relies on the establishment of reference databases that contain information on morphologically and genetically determined species. The data collected by the participants supported the work of the scientists at the Bavarian State Collection of Zoology, who aim to further expand the national DNA barcoding database and to identify previously unknown species within the framework of their project *Barcoding Fauna Bavarica*.

Instruments

Knowledge was measured at all test times using a program-specific multiple-choice test, which comprised 25 items on the lesson content. Each item had four possible answers, only one of which was correct. For statistical analyses, correct answers were coded as "1" and incorrect answers as "0". In the post- and retention test, we reordered the items randomly to prevent response bias.

To measure the environmental values, we used the 2-MEV scale as outlined in Bogner (2018), which measured the two higher order factors utilization, and preservation by 13 items. The items required approval of rejection on a 5-point Likert-Scale ranging from 1 "strongly disagree" to 5 "strongly agree".

To measure fascination with biology, we used a subscale of the Fascination with Science scale by Otto, et al. (2020). The scale has its roots in the Campbell-paradigm, which "describes individual behavior as a function of a person's attitude level and the costs of the specific behavior involved" (Kaiser et al., 2010). In consequence, the more difficult a statement a person agrees with, the higher is their fascination level. The scale is comprised of 84 items related to seven scientific fields: science in general, biology, chemistry, physics, astronomy, geology, and technology. Each of these subscales consists of 12 items covering the three attitudinal dimensions behavior, cognition, and affection. We applied 12 items referring to the field of biology. The items were measured on a 5-point Likert-type scale ranging from 1 "strongly disagree" to 5 "strongly agree" for affective and cognitive items and covering 1 "never" to 5 "very often" for behavioral items.

Statistical Analyses and procedure

For reliability analysis of the ad-hoc knowledge test, Cronbach's alpha was calculated. Except for T0, internal consistency was acceptable (T0: $\alpha = 0.654$; T1: $\alpha = 0.745$; T2: $\alpha = 0.796$). Item difficulties between 0.15 and 0.96 represent a suitable range between easy and difficult questions. An insignificant Shapiro-Wilk test ($p = 0.31$) confirmed normal distribution of the item difficulties.

In accordance with Otto et al. (2020), we analyzed the quality of the Fascination with Biology Scale by using the Rasch model approach (for an overview of how to use Rasch analysis in science education research see Boone, 2016). Rasch analysis is based on the assumption that the probability of a respondent correctly answering an item depends on the difference between the person's ability (measured by the number of correctly answered items) and the item difficulty (measured by the number of respondents who gave a correct answer) (Bond & Fox, 2010). We used data of all three testing points (T0, T1, T2), with $N = 736$ for the calibration procedure. The Likert-Type answers were dichotomized (agree, strongly agree = 1; partially agree, disagree, strongly disagree = 0; often, very often = 1; sometimes, seldom, never = 0). The item separation reliability was $ri = 1.0$; $SD = 2.26$. The person separation reliability was $rp = 0.69$; $SD = 1.53$.

Person separation indicates how efficiently a set of items is able to separate those persons measured. Item separation indicates how well a sample of people is able to separate those items used in the test. Where these statistics are expressed as reliabilities, they range from 0.0 to 1.0. The higher the value the better the separation that exists and the more precise the measurement (Wright & Stone, 1999, p. 151).

For further evaluating of the instrument quality, we used the item fit statistics (Boone, 2016). They indicate how well the observed data fits to the predicted Rasch model (Bond & Fox, 2010). Items show infit mean square values (wMNSQ) in the range between $wMNSQ = 0.79$ and $wMNSQ = 1.18$ with a mean value of $MNSQ = 0.98$ and $SD = 0.13$. The infits lie within the acceptable limits between 0.70 and 1.30 (Bond & Fox, 2010). 25 students scored 0 and seven students reached the maximum score. There are no maximum or zero score items. Item difficulties show a suitable range from $\delta = -2.92$ to $\delta = 3.71$ with $SD = 2.27$. Confirming the results of Otto et al. (2020), items belonging to the behavioral dimension are the most difficult whereas the easiest items belong to the cognitive dimension.

We examined the relation between environmental values and fascination with biology via correlation analysis. Second, we performed confirmatory factor analyses (CFA) to assess the discriminant validity of the scales. We proceeded with analyzing the effects of environmental attitude-sets and fascination with biology on biodiversity-related learning by means of structural equation modeling (SEM). We decided to test two alternative models to investigate the relation of fascination with biology and preservation and their combined impact on cognitive achievement. In a first model (A), we measured the predictive ability of fascination with biology on preservation and the impact of their relation on knowledge acquisition at all three test times. In a second model (B), we tested the opposite scenario: the predictive ability of preservation on fascination with biology and the mediated impact on students' cognitive performance. We evaluated the model fit with the

following conventionally used indices (Kline, 2016): relative Chi-square (χ^2/df), comparative fit index (CFI), root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR). A good fit is indicated by $\chi^2/df < 2$, $RMSEA < 0.07$, $SRMR < 0.08$, and $CFI > 0.9$ (for an overview on structural equation modeling fit indices see Hooper et al., 2008). Due to non-normality of the data, we used robust procedures (spearman-rho coefficient for correlation analyses and maximum-likelihood estimator for model calculations). We used IBM SPSS 24 for descriptive statistics and correlation analyses, IBM SPSS AMOS for the CFA and SEM and ACER ConQuest 3 for Rasch analysis.

Results

Descriptive Statistics and Correlation Analysis

Preservation showed a strong positive correlation with fascination with biology ($r_s = 0.436$, $p \leq 0.001$), whereas preferences of nature utilization revealed the reverse trend ($r_s = -0.313$, $p \leq 0.001$). Gender showed a negative correlation with utilization but positive correlations with preservation as well as fascination with biology. Knowledge variables did not correlate with gender. At all test times, knowledge was positively related to both preservation and fascination with biology. The latter consistently showed higher effect sizes, which increased from pre-test to retention test. utilization correlated negatively with knowledge, with decreasing effect sizes from T0 to T2. As expected, the knowledge variables were positively correlated throughout all test times. All bivariate Spearman-rho correlation coefficients are depicted in Table 1.

Table 1:

Descriptive statistics and bivariate Spearman-rho correlations between the variables. * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. KN = knowledge, UTL = utilization, PRE= preservation, FB = fascination with biology, SD = standard deviation.

variable	1. gender	2. KN T0	3. KN T1	4. KN T2	5. UTL	6. PRE	7. FB
1. gender	-	0.076	0.104	0.135	-0.244***	0.355***	0.244***
2. KN T0	0.076	-	0.592***	0.540***	-0.254***	0.198**	0.275***
3. KN T1	0.104	0.592***	-	0.658***	-0.218**	0.265***	0.318***
4. KN T2	0.135	0.540***	0.658***	-	-0.179*	0.267***	0.416***
5. UTL	-0.244***	-0.254***	-0.218**	-0.179*	-	-0.381***	-0.313***
6. PRE	0.355***	0.198**	0.265***	0.267**	-0.381***	-	0.436***
7. FB	0.244***	0.275***	0.318***	0.416***	-0.313***	0.436***	-
number of items	-	25	25	25	7	6	12
mean	-	11.48	15.21	14.13	1.81	3.70	3.10
SD	-	3.45	3.66	4.41	0.43	0.56	0.58

Confirmatory Factor Analysis Results

The estimated CFA of the fascination with biology scale showed overall good model fit ($\chi^2 = 93.39$, $df = 45$, $\chi^2/df = 2.08$, $p > 0.001$, CFI = 0.93, RMSEA = 0.07, SRMR = 0.07). There was a strong positive relation between the affective and the cognitive ($r = 0.73$, $p < 0.001$) as well as the affective and the behavioral factor ($r = 0.67$, $p < 0.001$). The cognitive and behavioral factor were not significantly correlated ($r = 0.17$).

The CFA of the 2-MEV data verifies the two-dimensional factor structure of the instrument (Fig. 2.). Chi-Square is low relative to the degrees of freedom and with an insignificant p-value ($\chi^2 = 82.56$, $df = 64$, $\chi^2/df = 1.29$, $p = 0.059$). The CFI with 0.91 is acceptable and the RMSEA with 0.038 as well as the SRMR value with 0.06 lie below the acceptable thresholds of RMSEA < 0.07 and SRMR < 0.08 . We additionally conducted an exploratory factor analysis in SPSS. Among the factor solutions, the varimax-rotated two-factor solution yielded the most interpretable solution with overall good factor loadings above the threshold of 0.3. Kaiser-Meyer-Olkin measure was 0.7 with a significant Bartlett's test ($p > 0.001$) and eigenvalues were above 1.

Figure 1.

CFA of the fascination with biology scale. Model fit indices: $\chi^2/df = 2.08$, CFI = 0.93, RMSEA = 0.07, SRMR = 0.07.

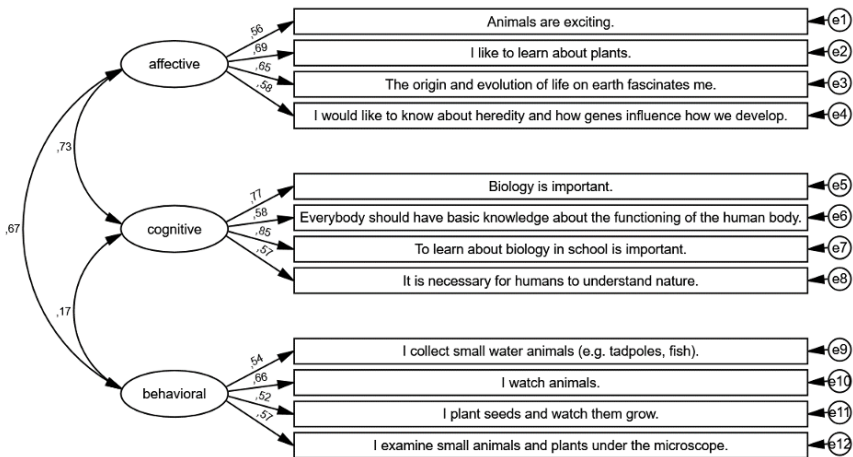
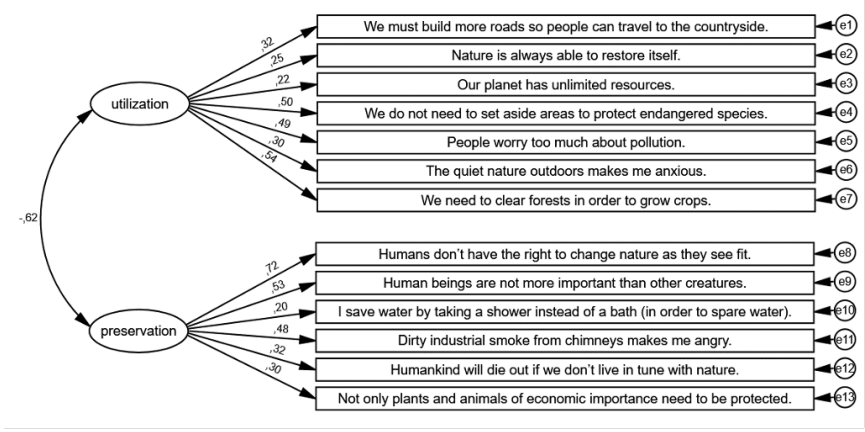


Figure 2.

CFA of the 2-MEV. Model fit indices: $\chi^2/df = 1.29$, CFI = 0.91, RMSEA = 0.038, SRMR = 0.06.

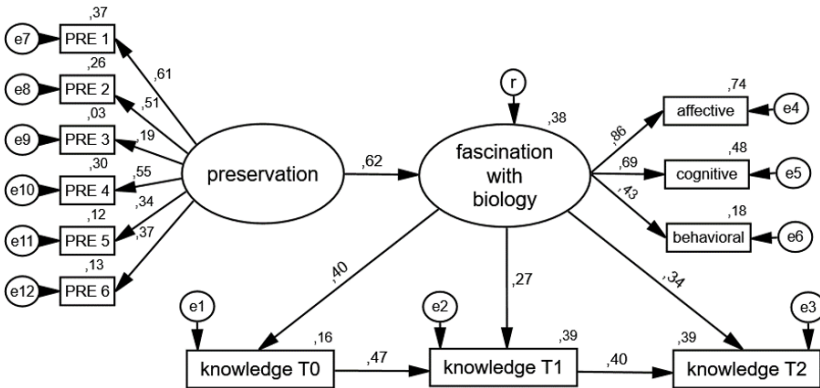


Structural Equation Modeling

Due to the negative correlation between utilization and preservation and their opposite association with fascination with biology and knowledge, we only inserted preservation to avoid suppression effects (Kline, 2016). The results of the two structural equation models and model fit indices are shown in Figure 3 and Figure 4.

Figure 3.

Model A: fascination as the mediator $\chi^2/df = 1.53$, CFI = 0.94, RMSEA = 0.051, SRMR = 0.05.

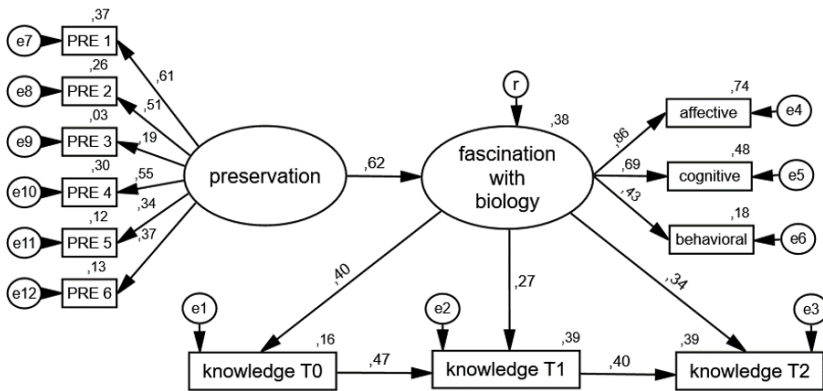


In model A, preservation was a positive predictor of fascination with biology ($\beta = 0.62$, $p \leq 0.001$). In relation with preservation, fascination with biology was a positive predictor of knowledge at all three test times ($\beta_{T0} = 0.40$, $p \leq 0.001$; $\beta_{T1} = 0.27$, $p \leq 0.001$; $\beta_{T2} = 0.34$, $p \leq 0.001$) and explained 16% of the variance in pre-knowledge at T0. 39% of the shared variance in post-knowledge was predicted by fascination with biology and pre-knowledge. Accordingly, 39% of the variance in knowledge retention was explained by fascination with biology with biology and the previous cognitive performance.

In our model B, fascination with biology was a positive predictor of preservation ($\beta = 0.72$, $p \leq 0.001$). preservation, in turn, positively predicted knowledge ($\beta_{T0} = 0.44$, $p \leq 0.001$, $\beta_{T1} = 0.29$, $p \leq 0.001$; $\beta_{T2} = 0.40$, $p \leq 0.001$) and explained 19% in the variance of pre-knowledge. Both, pre-knowledge at T0 and preservation explained 40% in the variance of knowledge at T1. 42% of the variance in retention knowledge was explained by preservation and knowledge at T0 and T1.

Figure 4.

Model B: preservation as the mediator variable. $\chi^2/df = 1.66$, CFI = 0.93, RMSEA = 0.057, SRMR = 0.06.



Discussion

The main outcome of our study is the positive relation between environmental values and fascination with biology and their combined impact on environmental learning. The positive relationship between preservation and fascination with biology is in line with recent research on the relation between environmental values and general science motivation (Schönfelder & Bogner, 2020) and we will discuss our findings especially regarding the largely unconsidered potential of a mutualistic relationship between science education and environmental learning (Gough, 2002).

Measuring Environmental Values and Fascination with Biology

As stated above, the factor structure of the 2-MEV has been repeatedly and independently confirmed (for an overview see Bogner, 2018). Initially developed for

measuring German adolescent secondary school students' environmental preferences, the model proved its reliability and validity within samples of different age groups as well as for various countries. To our knowledge, up to now, the 2-MEV has been successfully applied in 33 languages. Starting in the late 1990s with a high number of items, the item set was successively reduced to a 14-item battery validly reproducing the two-factor structure (Bogner, 2018). Even a reduction to 12 (Schneller et al., 2015) or 10 items (Schönfelder & Bogner, 2020), still leads to the expected factor structure. Shorter scales offer a clear advantage for the evaluation of education programs: in most cases, the research questions require the application of several instruments but, at the same time, it is necessary to take into account that the participants' attention span is not unlimited. In the present study, we, thus, decided on using the short version of the 2-MEV scale (as displayed in Bogner, 2018).

An estimation of our 2-MEV data led to an acceptable CFA model with overall good model fit indices passing the criteria defined. However, as our sample size was limited to 205, we preferred to additionally conduct an explanatory factor analysis to assure the factor structure. Kaiser's criteria, the scree-plot, eigenvalues above 1 and factor loadings above 0.3 give empirical justification for maintaining the two-factor solution of the 2-MEV (Field, 2009). In accordance with previous studies, the CFA and the correlation analysis revealed a significant negative relation between the higher-order factors preservation and utilization (e.g. Milfont & Duckitt, 2004; Schneller et al., 2015; Schönfelder & Bogner, 2020).

The results of the Rasch analysis and the CFA prove the reliability of the fascination with biology scale. Our results confirm the scale as a ready-to-use instrument to measure the fascination with biology (Otto et al., 2020). Overall, item difficulties showed a suitable range between easy and difficult items ($\delta = -2.92$ to $\delta = 3.71$). Behavioral items were most difficult whereas cognitive items were fairly easy. The item separation reliability of $r = 1.0$ verifies the item hierarchy (construct validity). In comparison, the person separation reliability of $r = 0.69$ as well as the number of 25 zero and seven maximum scores indicates, that the test did not sensitively enough distinguish between very high and low performing students. One reason could be the low item number since we did only apply eight items for the scientific field biology. Increasing the number of items for the specific science subject areas would most probably enhance the ability of the test to classify different levels of fascination. Additionally, our confirmatory factor analysis results of the fascination with biology items are in line with two recent studies that report a three-factor structure for the fascination with the field science in general, biology and technology (e.g. Baierl & Bogner, 2020). Comparable to their results, we found the strongest correlation between the affective and the cognitive domain of fascination and a less but still strong effect between the factors affect and behavior. While they found a small but significant correlation between the factors behavior and cognition, our results show no statistically significant relation. We agree with the assumption of Baierl & Bogner (2020) that this finding is probably related to an attitude-behavior gap. The positive intentions represented by the cognitive and affective domain are not necessarily translated into actions or behaviors. Further, the behavior items are the most difficult items. High approval ratings to those items represent high fascination because the greater the actual effort or cost the greater is the estimated fascination (Otto et al., 2020).

Relation between environmental values and fascination (H1 & H2)

Fostering pro-environmental values is one of the major aims of ESD (Rieckmann et al., 2017). It is therefore of high importance for the development of educational measures to investigate relevant factors influencing environmental values. In our present study, we focused on fascination with biology. Since assessing fascination with scientific fields is a new approach to measure motivational abilities related to science, most assumptions are drawn from related research on interest and motivation.

Preservation is clearly positively related to fascination: the higher the pro-environmental value score, the higher is the fascination with biology and vice versa. Further, in our model A, preservation showed a strong, positive impact on fascination with biology ($\beta = 0.62$) and in model B, fascination with biology revealed a positive effect on preservation ($\beta = 0.72$). Learners with high pro-environmental preferences seem to be more interested in biology, more willing and motivated to learn subject-specific content and methods and more open to identify with the nature of the scientific enterprise. Conversely, our findings indicate that higher fascination levels will positively affect pro-environmental attitudes, i.e., students' preferences and willingness to protect the environment. Comparable results have been found for the relation between environmental attitudes and motivational abilities or concepts that are comprised by fascination, e.g., interest. In two correlational studies with Finnish secondary school students, interest in environmental issues has shown to be positively correlated with pro-environmental, biocentric attitudes and attitudes towards sustainability (Uitto et al., 2011; Uitto & Saloranta, 2010). Le Hebel et al. (2014) measured adolescents' environmental values and their interest in learning socio-scientific topics, e.g. the greenhouse effect. Students with higher pro-environmental attitudes showed greater willingness to learn. Additionally, in an adult sample and within a structural equation modeling approach, interest in scientific issues positively predicted attitudes towards sustainability (Wang et al., 2020). Further, in a study of Schönfelder and Bogner (2020) biocentric attitudes had a positive impact on general science motivation and vice versa. The observed interconnection between environmental values and motivational abilities is of high relevance for educators, in this case especially biology teachers. From our results we conclude that students holding low pro-environmental attitudes will not be enthusiastic about learning biology or willing to master scientific skills. On the other hand, students with low fascination, i.e., with low interest in biological topics and curiosity to learn more about biology or willingness for science mastery, will have less intentions to preserve the environment. This interdependence indicates that fascination with biology is conducive for the development of pro-environmental values and vice versa, preservation attitudes can be beneficial for generating fascination. This would also mean that the manifestation of the motivational abilities curiosity, interest, and science mastery can positively contribute to the promotion of pro-environmental attitudes. During the last decades, we encounter an ongoing decline in students' interest in STEM (Osborne & Dillon, 2008). At the same time, we observe an increase in environmental concern (Gough, 2002), which became visible very recently in the global Fridays For Future movement. As proposed by Dillon (2012), "focusing on issues of health and the environment might motivate more students to appreciate the value of science and to consider studying it for

longer either at school or elsewhere". From our findings, we support the call for developing stronger synergies between EE/ESD approaches and formal science education (Schönfelder & Bogner, 2020). The probability for students to develop pro-environmental attitudes increases if they are fascinated with biology. Taking the other perspective, interest, curiosity, and mastery goals are thus most probably required for the development of intentions to protect the environment. The interconnection found between fascination with biology and environmental values suggests that biology lessons in formal education provide a suitable platform for EE/ESD approaches and consequently for simultaneously fostering environmental values and fascination.

Combined Impact on Environmental Knowledge (H3)

Fascination and preservation attitudes positively predicted pre-knowledge and cognitive learning achieved through module participation. In Model A, fascination with biology mediated by preservation, positively predicted knowledge at all three test times with medium effect sizes. fascination with biology had the highest impact on pre-knowledge scores, the second highest effect on retention knowledge scores and the least impact on post-knowledge directly after module participation. From the second perspective in Model B reveals a similar picture. Mediated by fascination with biology, preservation predicted cognitive achievement with medium effect sizes and the highest impact on pre-knowledge scores. These findings confirm correlative analyses for the relation between environmental values and knowledge as well as fascination with biology and knowledge (e.g. Schneiderhan-Opel & Bogner, 2020b, 2020c).

We see two possible reasons for the highest influence of fascination on students' pre-knowledge scores. First, as indicated above, learners already holding higher fascination levels and pro-environmental values have probably already benefitted from former science lessons and were able to successfully gain respective knowledge. This conclusion is supported by the fact that the participating 10th graders have already attended biology lessons on environmental topics in previous school years. Secondly, students with pro-environmental attitudes and high fascination scores may have achieved higher pre-knowledge scores due to frequent nature experiences or practice of extra-curricular activities as well as informal learning opportunities related to environmental learning. In terms of environmental values, this assumption is supported by Le Hebel et al. (2014), who report a positive correlation between learners' extracurricular activities and their preservation attitudes. Thus, students with high preservation attitudes do more likely deal with science-related activities outside the classroom and they will most probably gain respective pre-knowledge. Regarding the influence of fascination with biology, findings of Uitto et al. (2006) on the positive correlation between interest in biology and students' nature experience confirm our assumption. Frequent exposure to nature presumably enhances learners' fascination with biology. In a study of Prokop et al. (2007), a one-day field trip increased students' knowledge and positively affected learners' attitudes towards biology and nature as well as their intention towards choosing a future biologist career.

Additionally, we assume that students scoring high on preservation will outperform students with low pro-environmental preferences leading to a performance

gap. This assumption has also been made for the impact of science motivation on environmental knowledge acquisition and is supported by our results on fascination (Schumm & Bogner, 2016b). The differences in knowledge between learners with high or low fascination with biology and preservation attitudes, respectively, may increase over time and become obvious in the long-term view. When it comes to new environmental topics during their school career, low performing students will lack the pre-knowledge required for cumulative learning. Students with low motivation to learn biological or environmental topics will not successfully acquire knowledge as well as scientific skills and will, thus, lack scientific and environmental literacy (Bryan et al., 2011). In the future those students will most probably not persist in science and will not choose a scientific career. The connection between fascination and environmental values found in this study might further increase this effect leading to less environmentally responsible citizens.

Conclusion

In view of combating major global environmental challenges, it has never been more important to develop successful EE and ESD approaches. Our study contributes to this need by supporting EE/ESD practitioners and science teachers. To our knowledge, this is the first study investigating the relation between environmental values and fascination with biology and their combined impact on environmental content knowledge. Keeping in mind the multitude of variables that intervene with cognitive achievement (pre-conceptions, emotions, creativity, etc.), both fascination as well as positive environmental values need specific attention when planning and implementing successful EE/ESD modules. Students with preferences to nature protection and higher levels of fascination with the subject biology will benefit the most from such approaches. The aim must therefore be to foster pro-environmental values as well as the intrinsic motivation towards science.

However, further investigation of the unresearched and under-pursued relationship between environmental education and science education is needed (Dillon, 2012). Given a positive relation between environmental values, fascination with biology and cognitive learning, we support the demand for greater synergy between EE/ESD and formal science education (Gough, 2002). As a prerequisite for this, further analysis and understanding of the interdependence between motivational abilities and environmental values are needed to enable the development of successful EE/ESD approaches within formal science education. Studies with different age groups should simultaneously assess motivational abilities and environmental attitudes to broaden the results of the present study. If science education and environmental education form a symbiotic relationship, they can mutually benefit from each other. Simultaneously fostering interest towards science as well as providing the required knowledge and skills can set the course to become responsible citizens who take action for nature protection.

Ethics and Consent

The proposed study and consent processes have been approved by the Bavarian Ministry of Education (StMUK; X.7-BO5106/160/12).

Participating schools were informed about the research conducted and all par-

ticipants and legal guardians provided written consent to participate in this study. Data privacy laws were respected because the data was recorded pseudo-anonymously: only a specific identification code, based on sex, birth month and year allowed conclusions on sex and age. Withdrawal from participation was possible at any time.

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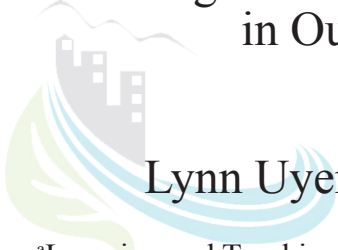
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Rebuilding Our Teams to Be Critically Conscious in Our Educational Work



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Rebuilding Our Teams to Be Critically Conscious in Our Educational Work

It is never easy to realize that, despite good intentions, one's efforts to be helpful may cause more harm. That is, in part, the reckoning the ISE field must address as we emerge from the global pandemic striving to do and be better. While there are instances and examples of educational work that exemplify our vision for equity, access, and inclusion, for the most part, ISE practice continues to operate within paradigms from the larger systems of society that perpetuate inequalities. We argue work towards the just and egalitarian goals in ISE organization's equity and access statements fall short without the organization's staff (the humans who do the work) engaging in critical consciousness together. Building on a model from youth

development scholars, we advocate for the need to include humility, compassion, and belonging in critical consciousness. Without these components, unconscious biases shade people's abilities to see the strengths in those different from them, to offer care to everyone (especially people who have been pushed into the margins), and to work towards ensuring everyone is rightfully welcomed, just as they are. Importantly, we must embody these ideas with our staff and in our work culture before we can genuinely practice them for our audiences. Doing so requires a mindset towards professional learning and reflective practice, and then intentionally designing and refining structures to support learning from individual staff into the collective organization.

Keywords: professional learning; reflective practice; critical consciousness; belonging; humility; compassion

Introduction

Setting the Context

The informal science education (ISE) field has been engaging in efforts to address equity and inclusion for several decades. Scholars (e.g., Dawson, 2014a; Feinstein & Meshoulam, 2014) offer evidence of particular practices and insights for ways to advance the work in our designed settings (e.g., science centers, zoos, aquariums; referred to here as ISE organizations). These works take a critical stance on the hopeful narrative the ISE field crafted at its nascency, as we strived to legitimize ourselves alongside learning science in formal, school environments (National Research Council, 2009). We believed ISE organizations to be places that could serve all people of the community, especially those who have been marginalized, through engaging and accessible programs and exhibits. Referencing the US National Research Council's first comprehensive scholarly review, Feinstein and Meshoulam (2014, p. 269) called attention to the argument that:

... museums and science centers may be better at eliciting positive emotional responses to science, better at demonstrating the relevance of science to everyday life, better at embodying the nature of science, and better at positioning science as something that young people can do. They even suggest that informal science education can bring science to a broader audience, helping to address the persistent inequities of science education.

The argument at the time was based on mounting evidence that supporting science learning and engagement was not the exclusive purview of schools, and that the significant influence of ISE organizations needed to be recognized and understood.

Indeed, the free-choice nature of experiences outside of school are valuable for social, emotional, and motivational reasons. Equity-focused scholars urge us to be more critical of the reality of these contributions. Using visitor demographics, they point out visitors to such cultural organizations were predominantly White, middle class (Dawson, 2014a; Farrell & Medvedeva, 2010). Other research and evaluation efforts shine light on the ways in which the design of these designed

settings uphold the values, ways of knowing, and languages of the dominant culture, making ISE organizations potentially unwelcoming and inaccessible to marginalized communities (Ash, 2004; Dawson, 2014b; Garibay, 2009), and especially for Black populations (Martinez, 2020). Programs in such learning spaces are often designed to attract the elite (Chaffee & Gupta, 2018), or perhaps designed with a deficit-approach that positioned visitors as void of capital and opportunity (Habig et al., 2021). In other words, we are potentially widening disparities in science education by enriching those who are already enriched or problematizing those who are othered. As Feinstein and Meshoulam put it, “unless the situation changes, museums and science centers could even worsen the inequities of science education, rather than improving them” (2014, p. 369).

These are prescient words considering the current global situation. The COVID-19 pandemic has impacted the ISE field in devastating ways. When the doors closed to the public in March 2020, so too did the revenues. An estimated one-third of ISE organizations may remain closed permanently (American Alliance of Museums (AAM), 2020; Collins et al., 2020). Among those who can reopen, staff size and composition has changed, as layoffs and furloughs led to loss in talent. Moreover, due to concerns over virus transmission, the ways people move through spaces and physically interact with each other and things in their surroundings has changed. “Hands-on” science cannot be done in the ways they always have without some modifications, at least within the immediate future. Amidst global interruption from these closures, the murder of George Floyd, an unarmed Black man, while in police custody on May 25th propelled the dialogue about the pervasiveness of systemic racism and anti-Blackness into the mainstream. This incident is not the first to be publicized. But with no place to go and a constant stream of social media, people could not hide from the images of violence and inequities that marginalized groups, and particularly the Black community, have endured for centuries. More people are finally talking about racism, anti-Blackness, and systemic oppression at their dinner tables and in their (video) conference rooms; conversations that we, as a nation, have been taught to avoid. All this to say, the situation has changed, albeit likely not in the way Feinstein and Meshoulam had in mind.

From these tragedies is the opportunity to rebuild teams in ways that put ISE organizations (and the field more broadly) in a better position to address the issues of equality and justice in science education. There cannot be a return to the “normal” that advantaged a select segment of our society and marginalized so many others. Normal is “the usual, average, or typical state or condition” (New Oxford American); it is what we have become accustomed to in this moment, in this place. What is normal here today (e.g., smartphones, composting) is not normal everywhere or a few years ago. Normal can be designed. Recent fieldwide inquiries suggest cultural institutions place high value in doing work in diversity, equity, access and inclusion (DEIA), though many do not have a clear plan or know how to begin (AAM, 2018; Garibay & Olson, 2020). It is important to recognize there is no single solution to fix a problem within a system. People’s tendency towards a centralized mindset (Resnick, 1996) leads to the erroneous assumption that “this one thing” will fix the problem of racism or social inequality. The system could be society; it can also be an organization and the delicate network of departments that collectively create the identity of that organization. In this article, we look at the part in the system where we have knowledge, experience, and influence, and begin

there to make changes. We specifically focus on ISE professionals whose job roles involve creating, offering, and supporting learning experiences for audiences (i.e., primarily education departments and educators, but not exclusively).

To begin, we consider the proposed framework for equity in ISE organizations that Dawson (2014a) articulates. Her thinking is inspiring. We argue, however, all of that change is not possible if the humans doing the work are not critically conscious. Next, we describe our theoretical framework in considering the relationship between staff and organizations, and how we think about this relationship for making systems-level change. In the second half of the paper, we offer two propositions (on professional learning and critical consciousness) for rebuilding education teams to enable ISE organizations to work towards the visions of equity and justice.

Framing the Argument

Emily Dawson (2014a) has a call to action for those of us who lead and work in ISE organizations. She asks us to think deeply about the socio-cultural practices and ways of thinking that shape our institution's engagement with audiences through exhibits and programs. She points out working towards DEIA is challenged, in part, because our practice tends to operate within existing paradigms that favor dominant groups. We are enacting assimilation practices. Dawson describes interlocking constructs to reshape an ISE organization's approach to DEIA work: infrastructure access, literacy, and community acceptance.

Infrastructure access refers to whether people can access ISE spaces and experiences. Barriers to access can be visible (e.g., wheelchair ramps, reachable by public transportation) and invisible (e.g., awareness of the institution, unappealing marketing, and staff demographics that do not represent the community). ISE organizations knowingly or unknowingly hold the power for who is welcomed or not (ibid, p. 214). While there are good examples, the reality is that organizations still maintain power when calling the meetings and setting the agendas for collaborative work with communities (Bandelli & Konijn, 2013). With patterns of participation and access to ISE venues consistently narrow (white, middle class, cisgender), organizations are potentially reproducing the disadvantages that exist in the social systems in which they are a part. So, how do we break this cycle?

Literacy examines the rules of engagement when people access ISE spaces; put differently, can people use what they have accessed. There are power dynamics in our designs, such as assumptions about fundamental literacy, scientific background knowledge, or ways of knowing. Learning experiences in ISE organizations often favor English language practices and Western representations of science and people in both exhibits and signage. The physical spaces are structured in ways that exclude people with disabilities. Thus, contrary to Frank Oppenheimer's (1975, p. 11) now infamous statement, "no one ever flunks a museum," our ISE practices can result in people from some communities feeling like they "flunked" (Dawson, 2014b; Martinez, 2020). We add that organizations double down on these exclusionary practices through the ways that educators are prepared and supported to do their work. For instance, youth floor facilitator programs are training grounds

for science communicators (Gupta & Negron, 2017) wherein diverse young people learn how to engage visitors in conversations about science. However, oftentimes, these programs focus on science content and facilitation practices that perpetuate dominant ways of knowing and speaking, even as youth are taught to engage with cultural competence. *This situation begs the question, how can we re-balance the power dynamics to disrupt narrow forms of literacy and re-imagine the processes that have historically privileged certain communities and left out the majority of people?*

Community acceptance inquires whether people are made to feel they belong in the ISE spaces, and how the organization is situated in its local community. This construct pushes staff to take responsibility for practices and mindsets that unintentionally exclude or position audiences at a deficit. There is need to shift towards asset-based schemas that leverage the cultural wealth and capital marginalized communities possess through their lived experiences (Yosso, 2005). *So, how do we value and celebrate differences without fetishizing and essentializing groups?*

Dawson's review provides examples across the field for each of these constructs where organizations, programs, and individuals are addressing social inequities in their work. Indeed, there are instances from which to learn. Knowing all the thought, planning, and resources put into designing ISE spaces and experiences, we are confident that the prevailing persistence of inequalities in ISE practice is not due to intentions to exclude. We argue they continue, in part, through staff's lack of critical consciousness when designing and engaging with the public.

Theoretical Underpinnings

We posit that changes towards DEIA in ISE practice fall short without the organization's staff (the humans who do the work) engaging in critical consciousness together. The work culture to enable developing critical consciousness requires a mindset towards professional learning and reflective practice. To understand this argument, it is helpful to articulate how we build on Sewell's (1992) theorizing of structure and agency. Structures include the resources, tools, ways of thinking, and rules of engagement in different aspects of society, such as an ISE organization or our field. Structures facilitate and organize social activities and interactions. They contribute to what becomes the "culture." Structures can be visible/invisible and formal/informal.

Each staff individually contributes to the organization's mission, and many individuals comprise the collective that constitute the organization. Individuals carry with them the socio-cultural and political views, histories, beliefs, philosophies, styles, knowledge, abilities, and skills from their lived experiences. They bring these characteristics of themselves and the structures that shaped them into the organization as they work. The organization also has its history and structures (e.g., ways of working with partners, approaches to designing exhibits and programs, protocols for proposal writing and fundraising) that come from the collective over time. Since humans have agency and individuals make up the collective, each of us is supposed to be able to influence the organization's structures and transform

the culture of the collective. But that does not always happen. The structures of the individual might or might not align with those of the organization, resulting in tension and exclusion among those with less agency when organizational structures do not value their voices. Due to their social position (Kezar & Lester, 2010) from their job role, gender, race/ethnicity, sexual orientation, etc., some individuals have more agency than others (Sewell, 1992).

With care and attention, we believe structures can be designed to ensure all staff have agency within the organization, not just those in particular groups. Since each ISE organization is part of society, we are hopeful these local transformations can mediate changes in societal structures. Building on this theoretical perspective, in the next section, we offer two propositions for rebuilding education teams to enable and empower educators and organizations to engage in equity work.

Two Propositions for Rebuilding Our Field

Proposition 1: Professional Learning Is Foundational for Organizational Transformation

Rebuilding our teams need to be grounded in professional learning and reflective practice, rather than current models and mindsets for training and development that position staff as lacking and cultivate the mentality of “fixing” and “being fixed” (Tran et al., 2019). This shifted perspective moves our focus away from treating learning opportunities for staff as transactional. Calculating whether this amount of investment in staff will yield that amount of return in their work is a futile exercise. Humans are not robots. Efforts to identify direct correlation between staff development and organizational performance has fallen out of favor, in recognition of this futility (Fuller & Unwin, 2004). Understandably, the desire for improved performance from investments in staff remains. While it is valuable for learning acquired by individuals to transfer to the organization, it is important to recognize that learning is done by humans, not organizations as entities. Learning gains by individuals benefit the entity when people can apply what they learned into how they do their work; the organization “learns” when people transform or create new structures for doing and thinking about their work. Consequently, organizational learning falls short if the individual’s learning is not attended to appropriately.

By professional learning, we mean practitioners’ ongoing learning about their practice in order to develop their expertise and skills; it is valuable for improving practice regardless of the profession (Webster-Wright, 2009). It places professionals in the role of learners, learning about their own practice. As a corollary, reflective practice is integral to professional learning (Tran, 2019) because reflective practice is the process of learning from one’s work experience (Dewey, 1933; Schön, 1983). The educators themselves are hungry for deepening their practice. In a recent survey of 400 educators across a spectrum of ISE organizations, 80% of respondents expressed interest in learning more about how to actively engage with visitors (Ennes et al., 2020). The field has been trending towards these foundations over the past decade (Martin et al., 2019), though progress is slow.

The Workplace as A Place of Learning

Truly anchoring in professional learning involves positioning the ISE workplace as a place of learning for the people who work there (Martin, 2019). This shift can be a challenge because the key objective of a workplace is not learning, but rather successful delivery of their goods and/or services (Fuller & Unwin, 2004). Even in education-focused organizations, like museums and universities, where goods and services pertain to “learning,” that learning is for their patrons not their employees. But, learning happens for employees because humans are social organisms who learn as we participate in social activities (Brown et al., 1989; Lave & Wenger, 1991). Work is a prominent social activity throughout our lifetime, especially in adulthood. Places of work are places of learning, regardless of whether workers and managers consider the workplace as such. As we participate in our social activities, humans learn by imitation, collaboration, and instruction (Bransford et al., 2000; Vygotsky, 1978; Wood et al., 1976); in work environments, the places where learning happens have been described as informal, incidental, and formal (Elkjaer & Wahlgren, 2005; Marsick & Watkins, 2001).

Thus, as we anchor education teams in professional learning, we must apply onto ourselves, the robust understanding of learning that we use with our learners (National Academies of Sciences, 2018). That is, learning: is a lifelong process, does not just occur in formal settings, builds on what we know, requires us to dialogue about our thinking, involves space to reflect and wonder, and relies on motivation and emotional engagement. Reflection is an integral part of learning. It involves knowing one’s thinking and how to regulate it. Doing so enables a person to detect inconsistencies of thought and identify connections between areas of conceptual understanding. Reflective practice is engaging in the metacognitive aspects of professional learning. It is influenced by a person’s motivation, focuses on understanding and solving problems within one’s practice, making change from what is learned, and is deliberately learned over time within a community (Tran, 2019).

A Framework for Structuring Professional Learning from Individual to Organizational

In positioning the workplace as a learning environment, professional learning becomes a shared responsibility and opportunity for everyone. However, when it is everyone’s responsibility, there is risk that, in practice, no one is responsible. Merely acknowledging that learning at work happens as people participate in doing work can possibly make it difficult for both workers and managers to hold one another accountable for opportunities and gains. In other words, structures are necessary to ensure the informal, incidental, and formal learning that staff engage in at work does not remain compartmentalized, solitary, and invisible. Particularly among those with less agency due to their social position.

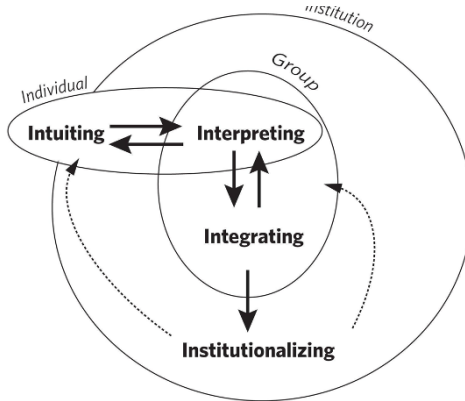
Crossan, Lane, and White (1999) offer a multi-level framework to conceptualize links across the three levels of interaction within organizations (individuals, groups, and the organization) based on four social and psychological processes (intuiting, interpreting, integrating, and institutionalizing). These processes inform each other

to lead to organizational learning. Intuiting is “the preconscious recognition of the pattern and/or possibilities inherent in a personal stream of experience” (p. 525) that happens individually; it affects others if they interact with the individual. Interpreting is the process of explaining ideas and experiences to oneself and others, which can occur at both the individual and group levels. Integrating is the process through which a shared understanding is developed among individuals and coordinated action is taken through mutual adjustment, and this process takes place at the group and organizational levels. Institutionalizing occurs at the organizational level when routinized actions transpire or become part of the taken-for-granted patterns.

It is possible to use this framework in the architecture for rebuilding departments, as well as designing programs for staff learning (Figure 1). Protocols, tools, and routines for these processes are needed for transparency and consistency. We offer our own experience creating and disseminating the Reflecting on Practice program (Tran & Halversen, 2021), and implementing it at the American Museum of Natural History (AMNH) specifically (Tran et al., 2019) to illuminate this possibility.

Figure 1.

Application of Crossan, Lane, and White’s (1999) multi-level framework for organizational learning in Reflecting on Practice



The Youth Initiatives (YI) group that Gupta directs made a collective commitment to learn together using the Reflecting on Practice program to strengthen their sense of community (Tran et al., 2019). The program comprises a suite of routines, activities, and readings (the structures) that push individual staff to express their intuitions and interpretations of learning and teaching for colleagues to consider. The readings are information, arguments, and ideals from the research literature that members take in, ponder, and interpret for their own and shared use. These structures from the program enable individuals to make their practice public, thus pushing the exchange of ideas, values, and experiences between the individual and collective. Meanings are negotiated as the staff interpret their thinking and actions together. The structures become normalized and get integrated by the group as “the way they do things.” Members of the group facilitate movement of their new habits and meanings across the institution as they interact with other groups within

the organization.

YI is one group nested within a larger group (Education Department) that also sits alongside other large groups within the organization (AMNH). As members of YI move across these arbitrary boundaries that organize work, they bring with them the structures from Reflecting on Practice and their shifted ways of thinking and doing. Members of YI contribute to transforming the Education group and AMNH in a cohesive way, while also being shaped by these interactions because the movement is two-ways. YI continues to evolve, and the group is not without its flaws. However, the structures that facilitate the social and psychological processes for professional growth and learning have also helped cultivate trust and connections that enabled members to have tough conversations, especially during a crisis such as a pandemic, knowing that members care for each other's well-being.

Proposition 2: Reflective Practice with Critical Consciousness Includes Humility, Compassion, And Belonging

Rebuilding our teams on the foundations of professional learning and reflective practice makes space for the mindset and culture that is needed for engaging in the ongoing and difficult work towards equality and justice. Current myopic focus on “outreach to underrepresented communities” as the common approach to doing work in equity and inclusion leads us to overlook that educators are members of the same inequitable societies as their learners. Every staff is a member of their society. Even if they are not the targets of exclusionary policies and behaviors, they are affected by them vicariously, by shaping the stereotypes and assumptions educators hold about groups of learners. The human brain is a social organ and is shaped by the social interactions in our culture (Park & Huang, 2010). We learn from the society in which we live to avoid what we feel threatens us and approach what we feel is rewarding (Barrett, 2006; Rock, 2008). We form stereotypes and prejudices of people different from us based on language and images from our surroundings, not just from our direct experiences (or lack thereof). Educators' unawareness of this influence is what is most detrimental because, despite their best intentions, educators can perpetuate the existing harm that marginalizes people. For instance, while educators might aim to build on the strengths of all of their learners, they do not “see” everyone's strengths and instead (unknowingly) privilege certain learners at the expense of others. It is difficult to unlearn our implicit biases built over years of socialization in an inequitable society (Lai et al., 2016); however, people can learn to regulate their behavior against their bias through recognition and intention (Mendoza et al., 2010).

Having critical consciousness (both learners and educators) can help to get us there. Critical consciousness is the ability to recognize and analyze systems of inequality and the commitment to take action against these systems (Freire, 1970, 1974). Developing critical consciousness is foundational in multicultural education and critical pedagogy (Gay, 2018; Ladson-Billings, 1995; Muhammad, 2020; Nieto & Bode, 2018). Ladson-Billings (1995, p. 474) argues for culturally relevant educators to enact three propositions in their pedagogy where students must: experience academic success; demonstrate cultural competence, and;

understand and critique the existing social order. To do so, she (2006) points out the educator needs to be cognizant of social inequities and their causes. Gay (2018, p. 43) specifies culturally responsive teachers are emancipatory and liberating from oppressive educational practices and ideologies as they lift “the veil of presumed absolute authority from conceptions of scholarly truth typically taught in schools.” Nieto and Bode (2018) explain, social justice in education involves pushing against the misconceptions and stereotypes that lead to and perpetuate inequities and discrimination based on social and human differences, like race, class, gender, ability, etc. It involves cultivating learning environments and designing learning experiences that encourages learners to be critical thinkers and conscious of the sociopolitical context in which they live. Despite its presence in teacher education thought and scholarship, inclusion of critical consciousness in coursework remains limited (Gorski & Dalton, 2020). Teachers often have persistent faulty and simplistic understanding of multicultural education and critical pedagogy that contributes to marginalizing the use of these pedagogies in the education system (Sleeter, 2012). We argue the lack of developing their critical consciousness can result in educators and educational practices celebrating diversity and essentializing culture without deeper interrogation into social inequities and making change.

The ISE field does not have any professional education requirements, and research on educators’ equity-focused practice is scarce (if at all). Unless individuals pursued critical studies themselves (formally or informally), it is not surprising many ISE professionals have not considered systems of inequalities in our society. Without critical consciousness, ISE professionals inadvertently maintain the erroneous narrative that “science is neutral,” “education is apolitical,” and “informal science education can right the inequities that schools create.” At worse, they can become dysconscious, “an uncritical habit of mind (including perceptions, attitudes, assumptions, and beliefs) that justifies inequities and exploitation by accepting the existing order of things as given” (King, 1991, p. 135). For decades, the ISE field, through exhibits and program experiences, has strived to challenge the transmission model of learning and teaching that treat learners as empty vessels to be filled. This model not only does not reflect how people learn, but it also enables dominant oppressive structures to be maintained (Freire, 2018). Unfortunately, we fail to push against this model for ourselves when we emphasize efforts to “train staff.”

Enacting Critical Consciousness

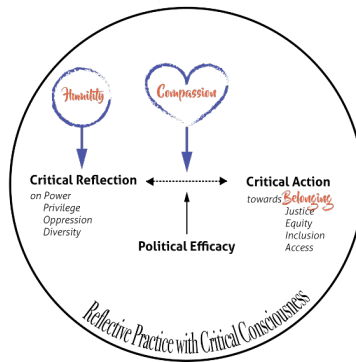
To guide efforts towards enacting reflective practice with critical consciousness, we build on a framework from youth development. Watts, Diemer, and Voight (2011) describe critical consciousness as having three key components. **Critical reflection** refers to a social analysis and moral rejection of societal inequities, such as social, economic, racial/ethnic, and gender inequities that constrain well-being and human agency. Those who are critically reflective view social problems and inequalities in systemic terms. **Critical action** refers to individual or collective action taken to change aspects of society that are perceived to be unjust, such as institutional policies and practices. This is a broad view of activism that includes participation in activities such as voting, community organizing, and peaceful protests. Watts, et al. add the concept of **political efficacy** from political science

because, sometimes, people do not take action. Instead, they become “armchair activists.” Political efficacy is the perceived capacity to effect social and political change by individual and/or collective activism. People will be much more likely to engage in critical action if they feel their actions lead to change.

Figure 2 depicts how we visualize Watts, et al.’s model and add to it, as we consider engaging in reflective practice with critical consciousness in our work. We place power, privilege, oppression, and diversity as concepts on which to reflect critically and belonging, justice, equity, inclusion, and access being efforts to take actions toward. Additionally, we identify the significant role of humility in critical reflection, and how compassion can also push us towards taking critical action. We elaborate further on Figure 2 and how the components apply to ISE practice.

Figure 2.

Building on Watts, Diemer, and Voight’s (2011) components of critical consciousness with humility, compassion and belonging.



Critical Reflection

Critical consciousness begins with critical reflection, which is a fundamental part of reflective practice. It is helpful to understand that reflection, critical reflection, and reflective practice are all related concepts (Larrivee, 2000), though they are not mutually exclusive (Fook, 2015). ISE professionals can reflect on what they do, but not make any changes in their thinking or habit from those reflections; in such cases, they are not engaging in reflective practice (Tran, 2019). Educators can engage in reflective practice, but not interrogate “beliefs, assumptions, and expectations and make visible [their] personal reflexive loops” (Larrivee, 2000, p. 296); thus, they are not engaging in critical reflection. Finally, educators can focus critical reflection on themselves (Mezirow, 1998), and remain unaware and inconsiderate of how power operates to perpetuate privilege and oppression in our social systems (Brookfield, 2009). Engaging in reflective practice with critical consciousness requires ISE professionals, within their professional communities, to be mindful of the sociopolitical context and intentional in how they leverage their power.

Power, Privilege, and Oppression in our Diverse Society

ISE professionals cannot enact change towards equity in their work if they do not notice the existence of inequities entrenched in the policies and patterns of education, and how they affect and are affected by these social structures. What this implies is the need for critical reflection to involve recognizing how **power** exists and works in society and education. Power is a feature of social relations in which people have *relative control or influence over outcomes*, for themselves and others (Fiske & Berdahl, 2007; Lammers et al., 2009). It can be a social force (Fiske, 1993; Keltner et al., 2003) and personal agency (Van Dijke & Poppe, 2006). Power can be acquired from privilege because individuals are accorded unearned special advantage through membership in a dominant social group (Bailey, 1998). Importantly, privilege is built into societal structures and so exists at the level of social group (e.g., race, gender, sexual orientation); it is not something a person *takes* or has the option *not* to take, regardless of their intentions (Johnson, 2005; powell, 2012). Power can also be gained from a person's social position within shifting networks of relationships: manager/worker in work environments; adult/child in family units; and constructed hierarchies from social groups. Oppression is the unjust or cruel exercise of power and privilege by a dominant group over others to maintain its domination; it exists on multiple levels — individual, interpersonal, institutional, systemic (Hanna et al., 2000).

Power is not inherently good or bad, though it can be used for benevolent and malicious purposes (Lammers et al., 2009; Sassenberg et al., 2012; Scholl et al., 2018). People can perceive social power as an *opportunity* to advance their own self-interests and emphasize independence. People can also think of power as *responsibility* for the well-being of others and recognize interdependence. People can use their power, knowingly or inadvertently, to keep laws, policies, and “normative” practices in place that repress groups of people and subjugate them to the dominant group (David, 2013; Feagin, 2013; Jones, 1997). People can also leverage their power to change the structures that oppress groups of people. While the choice on how we use our power may not always be easy because it could involve relinquishing control or sharing resources, many people do have a choice.

The dynamics of power and privilege in society that result in oppression also exist in education systems in schools and ISE organizations. Modern society is multicultural and pluralistic, that is, it is diverse. It is necessary for staff to question why doing outreach to “reach diverse audiences” is problematic without examining the extent to which their spaces and practices are inclusive and cultivate a sense of belonging among the diversity of people in their local community. For a field that is dominated by middle-class, cisgender cultural norms and personnel, and where 98% identify as white (Ennes et al., 2020), it is necessary for all staff to be critically reflective of their social identities and positions so they can recognize and change structures in their work to rebalance power dynamics towards the just and egalitarian outcomes they seek.

Humility. Engaging in reflective practice with critical consciousness involves normalizing ongoing critical dialogue among colleagues during their daily work where and when things happen, not relegating them to occasional, training meetings led by outside experts. The significance of dialogue in critical reflection

is well-known. We add the need to be attentive to our cultural humility. Humility is a characteristic within each person (intrapersonal) and emerges when we interact with people (interpersonal) (Owens et al., 2013; Van Tongeren et al., 2019). Intrapersonally, humility involves the degree to which a person seems to have a relatively accurate view of self (Tangney, 2000). This aspect of humility can show up as the ability to acknowledge and own one's limitations and recognize the fallibility of one's beliefs and thinking. It is not simply being modest but includes a willingness to seek and consider feedback. It is not having low self-esteem or being meek and self-deprecating, but instead, having a more accurate view of one's assets and flaws. Interpersonally, humility involves the degree to which a person has an orientation towards the needs and well-being of others (Davis et al., 2013), thus having relatively low self-focus. This aspect of humility can be indicated through restraint of the ego (not being narcissistic) and respectful interpersonal interaction (not being braggadocious).

Importantly, having humility means being teachable (Owens et al., 2013); that is, being open to new ideas and contradictory information, and wanting to learn with and from others because one genuinely believes what others have to share is inherently meaningful and valuable. People can express humility about their own cultural beliefs, values, and attitudes (Van Tongeren et al., 2019). It is having an awareness of the limitations of one's own cultural worldview while curbing the tendency to view one's own values and ways as superior. It is also a genuine willingness to learn the cultural orientation of other people.

Expressing humility in our critical reflection urges us all to be open to learning from one another because we value each other, and simultaneously pushes us to seek feedback on our own thinking and actions as we work to be more accurate in our understanding of ourselves, and the power and privilege we hold. We cannot truly engage in reflective practice without humility, and it needs to be practiced as a part of the broader system. This also means there needs to be differentiated and diversity-sensitive communal structures to support staff of color to practice cultural humility (Moon & Sandage, 2019). The predominantly white educational ISE workforce cannot achieve cultural humility without confronting their own white identities.

Critical Action

Critical consciousness works towards taking critical action to bring forth social change for just and egalitarian outcomes articulated in equity, inclusion, and access statements (AAM, 2018; Garibay & Olson, 2020). Critical action can be both individual and collective. For educational practice in ISE, we echo Dawson's (2014a) well-articulated equity and access framework. At the organizational level, specific actions can involve changes in hiring practices, governance, infrastructure, and funding. For education teams and educators, it can involve changing how learning experiences are designed, and the ways educators interact with learners and one another. For this discussion, we add the need to address efforts towards belonging because all DEIA efforts fall short without it.

Belonging. Belonging is being and feeling that one is a welcomed and rightful member of a group. It is multi-dimensional, and "encompasses citizenship,

nationhood, gender, ethnicity, and emotional dimensions of status or attachment” (Antonsich, 2010, p. 647). Belonging involves perceiving and experiencing interpersonal bonds with people in a group, as indicated by stability in the relationship, concern for one another, and continuation of the relationship into the foreseeable future (Baumeister & Leary, 1995). Social interactions and relationships like these are so fundamentally important to every human being that the pain from a social experience (e.g., breaking up with a partner, being rejected) activates the same regions of our brain as the affective distress from a physical experience (e.g., a broken arm, torn muscle) (Eisenberger, 2012; Eisenberger & Lieberman, 2004). Personal (feeling of being “at home”) and public (socio-spatial inclusion/exclusion) sentiments of belonging are intertwined. For instance, the lack of wheelchair ramps or English only exhibit labels exclude people in public spaces, which in turn affects their personal sense of feeling “at home” in these places. The absence of this sense of belonging is not exclusion, but a sense of loneliness, isolation, alienation, and displacement that can lead to motivational and mental health problems.

“The right to belong is prior to all other distributive decisions since it is members who make those decisions” (powell & Menendian, 2017). In other words, members within a group (in this case, ISE professionals) are the decision-makers to redistribute resources, make spaces accessible, ensure practices are equitable, and strive for diversity. ISE professionals must inherently believe all people belong, not simply tolerate and respect differences, in order to genuinely ensure that all people feel welcome and have the right to co-create and make demands of the group. It is important to understand that “any dominant ... group tends to fill the notion of belonging with a rhetoric of sameness, which clearly prevents any recognition of difference” (Antonsich, 2010, p. 650). Then, the requisite for belonging means to assimilate to the language, culture, values, behavior, religion, etc. of the dominant group (Yuval-Davis, 2006). This condition is a false notion of belonging. Dawson’s review points out how our (historical and current) practices actually embody this flawed thinking.

As we rebuild our teams, we need to adopt more inclusive forms of belonging (Antonsich, 2010; powell & Menendian, 2017) and make deliberate efforts to ensure groups that have been excluded know and feel they belong without flattening differences that naturally exist between people. It involves co-creating structures wherein staff can feel comfortable bringing their voice, pointing out tensions with the intention of improving the system, and engaging in actions that support the learning culture. We must do this amongst ourselves in order to be able apply this understanding towards our audiences. Expanding identities (e.g., what it means to be a woman) and narratives (e.g., multiple stories and voices) widen the narrowed conceptions of people that we have been socialized into forming. Focusing efforts to build bonds within social networks and bridges across social divides can cultivate different forms of social capital that distribute educational resources equitably (Murray et al., 2020). Reviewing policy and practices to ensure structures are in place that normalizes pluralism can broaden who belongs. These efforts push us all to express our humility and learn; doing so, allows for power to be shared with those who are typically suppressed and underscore their actions, voices and ideas.

The assumption is that engaging in critical reflection urges people (particularly from oppressed social groups) to take critical action; and as they take action to enact change, they loop back to reflect deeper and more critically (depicted in Figure 2 as the two headed arrow). But sometimes, people do not take action (the shaft of the two-headed arrow is dashed). Within their articulation of critical consciousness, Watts, et al. (2011) consider political efficacy as influencing whether people engage in critical action (the solid arrow pushing on the dashed two-headed arrow). Political efficacy can be internal referring to people's beliefs about their capacity as political actors, and external referring to their beliefs that government structures and officials are responsive to their interests. Politics need not be exclusive to government; it can be found within organizations. In the workplace, this concept can be analogous to staff believing they can affect organizational change to confront and oppose dominant norms that maintain structures that cause harm, and belief that management is responsive to their interests for social change.

Compassion. To Watts, et al.'s model, we add compassion as another influential driver towards critical action. Compassion is a fundamental aspect of multicultural education (Gay, 2018; Nieto & Bode, 2018), with emphasis being on ways culturally responsive educators express their compassion by caring for the intellectual and emotional well-being of students of color. Caring relationships is a fundamental human need. Positive and secure attachments with caregivers and people in our communities stimulate production of neural growth hormones that, in higher levels, can buffer critical regions of the brain against stress, and enhance learning (Esch & Stefano, 2005; Feldman, 2017). They also stimulate more receptors for these neurochemicals to be formed in many regions of the brain, which in turn allow for dampening fear and anxiety while increasing attention, curiosity, and exploratory behavior. This caring framework in teaching, however, is predicated on the assumption that educators offer compassion for all their learners, not just those they (consciously or unconsciously) deem favorable. The hope is that, through critical reflection and awareness, educators will develop compassion for learners who are different from them, and then take critical action in their teaching practice. We push further into this aspiration by inquiring about the roots of compassion and how to practice it. Our belief being that staff who experience compassion in their workplace are more likely to extend it to others in their work.

Compassion involves having a sensitivity to suffering in self and others, and the motivation and commitment to try to alleviate or prevent it (Gilbert, 2015; Singer & Klimecki, 2014). It involves social cognitive processes in our brains to perceive the mental state of others and making inferences about human behavior (Lieberman, 2013). Compassion has two psychological aspects: (1) the intention and act of turning toward and engaging with suffering rather than avoiding or dissociating from it; and (2) the intention to acquire the wisdom to learn how to alleviate and prevent suffering and act on that wisdom (Gilbert, 2015, p. 241). In other words, compassion is being courageous to attend to someone's distress, being wise to learn the person's situation and how to help, and then being strong to take action, in spite of opposition, to mitigate and stop the pain from happening

again.

While being compassionate is being human, people do not offer compassion to everyone. There are other aspects of being human that that shade to whom we offer compassion (Gilbert, 2015; Gilbert & Mascaro, 2017), one of which is grounded in early human history and tribalism. The survival advantage to care for members of our ingroup means we are reflexively less likely to offer compassion towards those perceived as outgroups, especially outgroups that seem to be different, have been stigmatized, or socialized into us as being a threat. Despite changes in the ways that humans live and socialize, this allegiance towards ingroup members is still present in modern humans. Here, cultivating compassion dovetails with belonging. Expanding our notions of who belongs within our ingroup can contribute to extending our reflexes to offer compassion to those who seem to be different from us (Antonsich, 2010; powell & Menendian, 2017).

We draw on research from neuroscience to further clarify the significance of this connection. Social cognitive neuroscientists have identified the area in our brain that is activated when we think of others, suggesting that this region functions to monitor the intermingling of our own action with the actions of others (Amodio & Devine, 2006; Lieberman, 2013). This area of the brain is activated when we consider groups of people society has classified as human (e.g., middle-class, white Americans), but less so for groups social norms have dehumanized (e.g., people who are homeless, refugees) (Harris & Fiske, 2006). Put differently, it is difficult to think about the mental state of others, to consider them and their relationship with us, and offer compassion to them, if we unconsciously consider them as being less than human in the first place. An implication from this area of work involves re-humanizing marginalized individuals and groups of people so that we re-socialize ourselves to view them as worthy of empathy, compassion, and social engagement. In short, doing this work correctly means activating those areas of our brain that will be involved in helping us regulate our behavior against our implicit biases against certain groups of people and offer them compassion.

As we rebuild our teams, it is imperative that we practice compassion towards one another all across the organizational hierarchy. Compassion as a part of reflective practice with critical consciousness can nudge staff to understand the power structures that cause harm and suffering among marginalized communities in order to know better how to help, and then take action where they can prevent or mitigate the pain. Simultaneously, encouraging more inclusive forms of belonging works toward reshaping our conceptions of human differences and members of our ingroup, and enables staff to offer compassion to all, not just to those based on narrowed definitions of who belongs.

Final Thoughts

In this paper, we engaged in critical reflection to consider to how to take critical action to heed the inequities in ISE that scholars across the field have raised for many years. Absent critical consciousness in reflective practice on how educational work is done, good intentions to leverage the value of ISE spaces to cultivate joy, curiosity, and passion for science results in enriching the already enriched, problematizing the othered, and inadvertently advocating assimilation practices. We explained the need to include humility, compassion, and belonging in critical

consciousness. Without them, we cannot see the strengths in people different from us, genuinely offer care to everyone (especially people who have been pushed into the margins), and work towards ensuring everyone is rightfully welcomed, just as they are. Importantly, we must enact these ideas for each other and in our work culture before we can genuinely practice them for our audiences.

Doing so means anchoring ourselves in an ethos of professional learning that abandons the transactional and transmission models of training, and instead applies what we know about how humans learn onto ourselves. Structures can be designed to support this endeavor. It can be challenging, but it is doable as we work to rebuild and recover from the pandemic. In moments, one might wonder if the ideas and actions put forth in these propositions blur the boundaries of personal and professional life. Indeed, they do. The problems of social inequality and racism (and other forms of oppression) are systemic, meaning there is no single solution. Fortunately, the field does not start from scratch. There are individual staff within our organizations who have been working within this critical consciousness; it is time we join together to think, talk, and reflect critically. Decades of research and practice across many disciplines provide a wealth of insights on first steps and missteps. We know how humans learn, and the central role of reflection and dialogue in learning. We know compassion sparks learning, and humility keeps our minds and hearts open to be taught. It is time we apply this wealth of knowledge upon ourselves. More discourse, details, and practical ideas are needed. We hope that our thoughts spark imagination for new possibilities moving forward.

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Learning From Sustainability Enactment Grounded in Māori Worldviews Within Education Settings in Aotearoa New Zealand

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Learning from sustainability enactment grounded in Māori worldviews within education settings in Aotearoa New Zealand

Recent events have highlighted multiple crises of related to social justice, environmental sustainability, and the wider wellbeing of humanity. Education for sustainable development (ESD) has been a key plank of the United Nations' endeavours towards social, cultural, economic, and ecological justice. Indigenous peoples have served as guardians of biodiversity and have developed time-honoured values systems and practices that preserve environmental wellbeing. In this paper we report on a recent study in Aotearoa New Zealand that aimed to identify approaches that reflect the pedagogical principles of ESD, with a particular focus on incorporating values and practices of Māori, the Indigenous peoples of Aotearoa. Three education settings participated in this study: an Enviroschools kindergarten and primary school, and a wharekura, a Māori secondary school. The methodology was grounded in kaupapa Māori theory, qualitative and narrative. Findings highlighted ESD pedagogical principles of criticality, empowerment, and inter-disciplinarity as well as the embedding of te ao Māori (Māori worldviews) with a particular focus on kaitiakitanga (environmental stewardship) evident across the settings.

Keywords: Indigenous education; education for sustainable development (ESD); Māori education; Māori worldviews; sustainability education; environmental education; kaitiakitanga; Enviroschools

Introduction

This paper draws from a recent project conducted in Aotearoa (New Zealand). This introductory section outlines the rationale for the study, which situates the project as a local response to international obligations under the United Nations Sustainable Development Goals, with regard to Education for Sustainable Development (ESD) (UNESCO, 2020), alongside aspirations for educational equity for Indigenous peoples. Aotearoa (New Zealand) provides an interesting case study in this arena due to governmental commitments to upholding the aspirations of the 1840 Tiriti/Treaty of Waitangi, and thus to addressing the impacts of colonisation on the Indigenous Māori. It should also be noted that the recent global pandemic alongside the accelerating impacts of the climate emergency have heightened awareness of how such crises disproportionately impact those who are socio-economically marginalised such as Indigenous peoples (Curtice & Choo, 2020). A further rationale is the recognition that there is much that can be learnt from Indigenous peoples' onto-epistemologies with regard to sustainability (L. Williams, Bunda, Claxton, & MacKinnon, 2018).

The overarching aim of the project was to explore and illuminate educational approaches that benefit Indigenous students, whilst aligning with the United Nations Sustainable Development (SDG) Goals (United Nations, n.d.). Two SDGs particularly pertain to this study. Goal 4.5 aims that all nations deliver on the following aspiration: "By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations" (UNESCO, 2017b). Goal 4.7 requires of all countries that: 'By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development' (UNESCO, 2017a, p. 8) .

The study outlined in this article was part of a larger international project: 'Reorienting Education and Training Systems to Improve the Lives of Indigenous and Marginalized Youth' which is led by Prof. Charles Hopkins, of York University, Toronto, who is the UNESCO Chair in Reorienting Teacher Education to Address Sustainability (Hopkins, n.d.). More than 120 institutions from 40 countries/Indigenous territories participated in the wider project. An overarching understanding of the project is recognition of the need to collaboratively work with and learn from Indigenous and marginalized communities to address education shortcomings and meet SDG expectations. The intention was to generate academic research into how schools and education systems around the world are working to better meet local education needs of Indigenous children and young people and to develop recommendations to assist education leaders worldwide (Kohl & Hopkins, 2020).

Colonisation of Aotearoa by the British, beginning in the early 1800s, had decimated iwi Māori (Māori tribes/populace) to the point that by the beginning of the 1900s they comprised only 5% of the population (Statistics New Zealand, 2000). Māori have since rebounded to be 16.5% of the current population (Stats NZ, 2019). Recent high levels of immigration have generated a situation whereby in early childhood education enrolments those of Pākehā (European) ancestry now account for 48%, whilst 24% identified as Māori, 16% as Asian, and 8% as from a Pacific Island background (Ministry of Education, 2018b). This signals a huge demographic shift from the previous position of dominance by Pākehā whereby twenty years ago they comprised a comfortable 80% of the overall populace (Statistics New Zealand, 2000).

Indigenous knowledges contain valuable resources for sustainability practices (Corntassel & Hardbarger, 2019; Tom, Sumida Huaman, & McCarty, 2019). Despite histories of colonisation and the ongoing forces of globalisation, Indigenous peoples continue to strive to maintain guardianship over their lands and the biodiversity that depends on this (Raygorodetsky, 2018). As the capacity for the exercise of this guardianship is removed, so too is the protection of both Indigenous languages, knowledges and the biodiversity with whom they have co-evolved for millennia (Gorenflo, Romaine, Mittermeier, & Walker-Painemilla, 2012).

The focus of the international project has been to explore inquiry-based pedagogies that are not only responsive to students' and their community's interests, but also aim to benefit Indigenous children and youth. The key concept of the study was to use student engagement with locally relevant sustainability issues to deliver the core knowledge, skills and values that will improve the well-being of the students and their community.

In relation to the objectives of the New Zealand National Commission for UNESCO, which funded this project¹, the local objective was to highlight ways in which innovative New Zealand approaches provide opportunities for Māori and other children to demonstrate global citizenship via participating in projects that focus on ESD approaches to social, cultural, linguistic, economic and ecological sustainability issues of relevance to their communities. A second objective was to enrich understandings of the world by drawing on the use of diverse forms of knowledge including scientific evidence and traditional knowledge.

Aotearoa (New Zealand) is recognised internationally for progressive social and education policies, and in particular our innovative curriculum and practice in relation to Māori education. The Aotearoa branch of the UNESCO international project involved the two lead researchers collaborating closely with teachers from a wharekura (kaupapa Māori, Māori language immersion secondary school) and an EnviroSchools kindergarten and school. The ESD approaches utilised in the education settings in this project drew upon both western and Māori knowledge bases including the work of local scientists and conservationists.

This article begins by outlining key aspects of Education for Sustainable Development (ESD). It then outlines some key understandings of te ao Māori (Māori worldviews) before describing some key innovative educational initiatives in Aotearoa that reflect a commitment to te ao Māori. This is followed by a contextual overview of the theoretical and methodological positioning of the study and the three research sites. This leads into findings from each setting, concluding

with a final discussion which considers implications of this study in this time of the global COVID-19 pandemic.

Education for Sustainable Development

Education for Sustainable Development (ESD) is one of the key mechanisms whereby the United Nations aims to implement a global transformation to sustainability values and practices. ESD is not a taught content or curriculum, but a philosophical and pedagogical approach that can be applied holistically across and throughout formal and informal educational programmes:

ESD aims at developing competencies that empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic and environmental impacts, from a local and a global perspective. Individuals should also be empowered to act in complex situations in a sustainable manner, which may require them to strike out in new directions; and to participate in socio-political processes, moving their societies towards sustainable development. (UNESCO, 2017a, p. 7)

ESD is a learner-centred, localised approach, which does not direct specific content, but has a collaborative, problem-solving orientation focussed on fostering the competencies that will enable the transformation towards sustainability that is currently required as all life on our planet is increasingly distressed by the impacts of climate change, biodiversity loss, and currently the covid-19 pandemic.

What ESD requires is a shift from teaching to learning. It asks for an action-oriented, transformative pedagogy, which supports self-directed learning, participation and collaboration, problem-orientation, inter- and transdisciplinarity and the linking of formal and informal learning. Only such pedagogical approaches make possible the development of the key competencies needed for promoting sustainable development. (UNESCO, 2017a, p. 7)

An informative overview of ESD is provided by UNESCO, which highlights the holistic and integrated view of education, underpinned by recognition of the integrated nature of planetary systems, and focussing on social, cultural and ecological sustainability aspirations:

ESD empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment. It achieves its purpose by transforming society.

Learning content: Integrating critical issues, such as climate change, biodiversity, disaster risk reduction (DRR), and sustainable consumption and production (SCP), into the curriculum.

Pedagogy and learning environments: Designing teaching and learning in an interactive, learner-centred way that enables exploratory, action oriented and

transformative learning. Rethinking learning environments

- physical as well as virtual and online
- to inspire learners to act for sustainability.

Societal transformation: Empowering learners of any age, in any education setting, to transform themselves and the society they live in.

Enabling a transition to greener economies and societies.

- Equipping learners with skills for ‘green jobs’.
- Motivating people to adopt sustainable lifestyles.

Empowering people to be ‘global citizens’ who engage and assume active roles, both locally and globally, to face and to resolve global challenges and ultimately to become proactive contributors to creating a more just, peaceful, tolerant, inclusive, secure and sustainable world.

Learning outcomes: Stimulating learning and promoting core competencies such as critical and systemic thinking, collaborative decision-making, and taking responsibility for present and future generations. (UNESCO, 2019, para. 1-5)

Many schools around the world that have embedded education for sustainability (ESD) pedagogical approaches throughout their policies, practice, and curricula have demonstrated overall improvements across a number of areas such as student academic achievement, intellectual engagement, creativity, critical thinking, adaptability, dropout reduction, and student-teacher relationships (Laurie, Nonoyama-Tarumi, McKeown, & Hopkins, 2016).

Te ao Māori – Māori Worldviews

Māori cosmologies highlight the inter-relatedness of all beings. In this cosmology, people and other living creatures are all descended from Papatūānuku (Earth Mother) and Ranginui (Sky Father), through one of their children, the Atua (Compartmental God) Tāne-Mahuta who oversees the forests. Numerous other Atua oversee various further domains, for example: Tangaroa is the Atua of the oceans; Tāwhiri-matea the winds and weather; Haumia-tiketike of uncultivated foods; and Rongo-mā-tāne of cultivated foods. Infused throughout and emanating from this cosmology are a range of te ao Māori values that underpin the collectivist ethic of reciprocity and enable both wellbeing and ultimately, survival. Values of whakapapa (genealogical interconnections), in the genealogically sourced interdependence with the natural world are also evident in the recognition of rivers and mountains are respected as ancestors. Recently, the Whanganui River has been recognised in law as ‘Te Awa Tupua’, which has been translated as ‘River with Ancestral Power’ (Salmond, 2014, p. 286)

Spiritual values of the life force of mauri and the spiritual interconnectedness

of wairuatanga underpin these relationships. The obligations of manaakitanga (the nurturing of relationships) and kaitiakitanga (environmental guardianship and stewardship) require the enactment of values of obligation and responsibility to others including the natural world (Bargh, 2019; Mead, 2003). Further core values of collectivism include whanaungatanga, kotahitanga, and aroha. Whanaungatanga expresses the interconnectedness with those with whom we are related, both immediate family and beyond. Kotahitanga describes a sense of unity and solidarity with the collective. Aroha has been explained by Māori educationalist Whaea Rangimārie Rose Pere as the commitment of people related through common ancestry; loyalty; obligation; an inbuilt support system; stability; self-sufficiency; and spiritual protection (Pere, 1982/1994, p. 23). People are obliged to restore spiritual balances via values of reciprocity which include utu (recompense, rebalancing), tapu (spiritually charged, restricted) and noa (free from restriction).

These core Māori cosmologies and values can be readily equated with western scientific understandings. In particular the notion of the necessary equilibrium of interconnected environmental systems can be highlighted from a Māori perspective. Tapsell and Dewes (2018) have explained that:

From a Māori world view the life-carrying properties of whenua [land] (water engagement with active soil) – from source to sea – only exist where the energy to create, disrupt or disintegrate is in balance. This energy cycle we call mauri sits at the heart of the ancient Takarangi double spiral, representing the universe. Within the embrace of Rangi [Sky Father] and Papa [Earth Mother] exist their three principal offspring who maintain our biosphere balance: Tāne Mahuta is the Atua or great ancestor attributed with guarding and producing terrestrial photosynthesis and animal life; Tangaroa is responsible for all oceanic photosynthesis and marine animal activity; while Tāwhirimātea is the Atua who provides atmospheric conditions that check and balance his two brothers. If the mauri of these primary drivers of planetary life is in balance, then so is our biosphere. (Tapsell & Dewes, 2018, p. 67)

For the purposes of our study and this paper, the Māori value of kaitiakitanga is a particular focus. This quote from 1874, only 34 years after the 1840 treaty allowing British settlement, expresses Māori concerns re the impacts on biodiversity of their reduced capacity to exercise kaitiakitanga:

E whakatika rawa ana au ki taua mahi tiaki ngaherehere. Na matou taua tikanga, no mua mai ano no o matou tupuna a tae noa mai ki tenei takiwa... He mea nui ki a matou o matou ngaherehere, he taonga no matou nga rakau ; nga rata, nga matai, nga miro, nga pukatea, nga kahikatea, nga rimu, nga totara, nga maire, me nga tini rakau e kainga aua e te tini o nga manu o te ngaherehere me nga karaka me nga kiekie hei kai ma nga tangata..., Inaianei kua kore te manu, kua mate kua ngaro te kaka me te kakariki...

I entirely approve of protecting and preserving forests. It has ever been considered an important matter amongst the Maoris, from the time of our ancestors down to the present time.... We consider our forests a rich possession, and our trees a valuable property, our rata trees, and our matai trees, our miro, pukatea, kahikatea, rimu, totara, maire, and all other kinds of trees upon which the birds of the forest feed, and

also the karaka and kiekie which produce food for man... In the present day the birds are but few, and the kaka and the kakariki have almost disappeared... ([Translation in the original source] *Te Waka o Te Iwi*, Vol 10, No. 19, 22 September 1874. (Benton, Frame, & Meredith, 2013, p. 107)

Whilst *kaitiakitanga* in the contemporary context is often used to refer to environmental resource management, in its traditional sense its meaning is more complex, and relates to the *rangatiratanga* (chiefly authority) to ensure the provision of wellbeing for the tribal collective and should be understood with regard to these wider obligations, which involve recognising and upholding spiritual interconnections and balances (Kawharu, 2000).

The capacity to exercise the obligation of *kaitiakitanga* remains a concern for many Māori individuals and tribes today. A recent report noted that:

Māori worldviews generally acknowledged the natural order of living things and the *kaitiakitanga* (stewardship) relationship to one another and to the environment. The overarching principle of balance underpinned all aspects of life and each person was an essential part of the collective. Māori worldviews are therefore ones of holism and physical and metaphysical realities where the past, the present and the future are forever interacting. The maintenance of the worldviews of life are dependent upon the maintenance of the culture and its many traditions, practices and rituals. (Joseph, Rakena, Jones, Sterling, & Rakena, 2019, p. 9)

Innovative Educational Models in Aotearoa (New Zealand)

In this section we overview several unique educational models from Aotearoa beginning a brief outline of Māori medium schooling, followed by an overview of Te Whāriki, the early childhood curriculum (Ministry of Education, 2017c), and concluding with a description of the *Enviroschools* programme, an initiative that sits outside of the Ministry of Education.

Māori education in Aotearoa

Prior to colonisation Māori had sophisticated knowledge transmission systems that included a strong focus on understanding the sustenance and protection of local ecologies including food sources, via both formal and informal education processes (Buck, 1950; Makereti [Maggie Papakura], 1938). From a young age, children participated in the daily activities of their community, often under the tutelage of elders. There were also particular *whare wānanga* (houses of learning) for various specialised knowledges and skills taught by *tohunga*, experts in that field.

Aotearoa was colonised comparatively late from the perspective of a historical lens. In 1840 the British persuaded Māori to sign a treaty, *Te Tiriti o Waitangi*, that allowed for British governance. However, the British immediately assumed that they had been granted 'sovereignty' as per the English language translation of the treaty. From that point onward, the Article Two protections promised to Māori of *tino rangatiratanga* (absolute authority) over Māori lands and everything of value to Māori (such as their language, values and cultural practices) were ignored

by the settlers (Orange, 1987; Walker, 2004). A multitude of laws were passed that disenfranchised Māori and resulted in the loss of both lands and languages. Schools served as an instrument of colonisation, banning the use or teaching of te reo Māori (the Māori language). Currently one in five Māori report that they can speak their language (Statistics New Zealand, 2020).

Māori protest to the assumption of British sovereignty began immediately and continues to this day. As a result of Māori activism, te reo Māori, the Māori language, was recognised as the official language of Aotearoa in 1987. Māori immersion education models emerged during the 1980s. These include kōhanga reo, at the early childhood education level, kura kaupapa at primary school level, and wharekura at the secondary school level. The education in these settings is not only provided through the medium of the Māori language, but is also deeply imbued with Māori values, cultural practices, and traditional knowledges (Walker, 2016).

The recent Education and Training Act (2020) has stepped up government requirements for all education settings to demonstrate commitment to Te Tiriti o Waitangi. Schools are now required to ensure that “plans, policies, and local curriculum reflect local tikanga Māori [Māori values and practices], mātauranga Māori [Māori knowledge], and te ao Māori; and to take “all reasonable steps to make instruction available in tikanga Māori and te reo Māori” (New Zealand Parliament, 2020, section 9.1 (d)).

Te Whāriki: Early Childhood Curriculum and Early Childhood Research

Since its inception, the New Zealand early childhood curriculum, Te Whāriki, has reflected a strong focus on te ao Māori, which is an underpinning philosophy of the entire document (Ministry of Education, 1996, 2017b). One of the four key principles, Whakamana | Empowerment, states that “In an empowering environment, children have agency to create and act on their own ideas, develop knowledge and skills in areas that interest them and, increasingly, to make decisions and judgments on matters that relate to them” (Ministry of Education, 2017c p. 18). Under the strand Mana Whenua | Belonging:

Kaiako [teachers] are cognisant of the concept of tangata whenua [Indigenous people] and the relationship that Māori have to each other and to the land. This guides kaiako relationships with whānau, hapū and iwi [families, sub-tribes and tribes]. Kaiako share appropriate histories, kōrero [stories] and waiata [songs] with mokopuna [children/grandchildren] to enhance their identity and sense of belonging.

Kaiako support mokopuna to engage respectfully with and to have aroha [love/respect] for Papatūānuku [Earth Mother]. They encourage an understanding of kaitiakitanga [environmental guardianship] and the responsibilities of being a kaitiaki [guardian] by, for example, caring for rivers, native forest and birds. (p. 33)

Within the strand of Mana Aotūroa | Exploration, the curriculum states the expectation that:

Diverse ways of being and knowing frame the way respect for the environment is demonstrated. Kaiako develop understandings of how children and their whānau

make sense of the world and respect and appreciate the natural environment. Children may express their respect for the natural world in terms of respect for Papatūānuku, Ranginui [Sky Father] and atua Māori [Māori compartmental Gods]. Kaitiakitanga is integral to this. (p. 46)

Thus, the early childhood curriculum highlights that kaitiakitanga, actively caring for the earth, is integral to engaging with Māori cosmologies that are incorporated in the document. Previous research in ten different early childhood care and education settings across Aotearoa highlighted the engagement of tamariki in a te ao Māori focussed project of caring for ‘ourselves, others and the environment’, including Ranginui and Papatūānuku (Ritchie, Duhn, Rau, & Craw, 2010). That research indicated the importance of the involvement of families, communities, Elders, along with the empowered engagement of the children. With the guidance and facilitation of their teachers, young children demonstrated great resonance with Māori cosmology, empathising deeply with Ranginui and Papatūānuku, and the Atua, and upholding Māori values such as whanaungatanga, manaakitanga and kaitiakitanga (Barker, 2010; Ellwood, 2010).

Enviroschools and Te Ahu Tū Roa

The Enviroschools programme is unique to Aotearoa New Zealand and has emerged as an independent, not-for-profit community-based endeavour, despite the lack of government leadership and only minimal financial support (P. Williams, 2012). It began in 1993 and has included Māori perspectives as integral from the outset, under the leadership of a Māori community education organisation, Te Mauri Tau.

The Enviroschools kaupapa [philosophy] is:

creating a healthy, peaceful and sustainable world through facilitating action-learning; where inter-generations of people work with and learn from nature. It weaves in Māori perspectives, combining traditional wisdoms with new understandings. Importantly, our kaupapa reminds us to be in connection: to love, care for and respect ourselves, each other and our planet. (Enviroschools, n.d.)

In relation to Kaitiakitanga, the Enviroschools Kit states that:

Kaitiaki look after the physical and spiritual aspects of the natural world.

This means that the mauri (the life force or essence) of everything which makes up the environment is respected and protected. The mauri can be thought of as the force integrating and uniting the spiritual aspect and the physical aspect of a thing or being... Māori Marsden writes that: “All animate and other forms of life such as plants and trees owe their continued existence and health to mauri. When the mauri is strong, fauna and flora flourish. When it is depleted and weak those forms of life become sickly and weak”(Marsden, 2003).

In the forest, each bird within each species has its own mauri or life force. Each insect within each species has its own mauri. Each tree as an individual tree and

then collectively as a species has mauri. The bush or forest as a whole has a mauri comprising the collective mauri of all that is living within it. If the mauri of a forest is in good condition, birds will be drawn to live there and the people around that area will benefit from the healthy, vibrant forest and be able to feed themselves from it.... The spiritual kaitiaki, as guardians of such a bush area, take care of it, and ensure that it is healthy and its mauri is strong. Our actions can also help to enhance the well-being of the forest. We can commit to care for it physically (for example by fencing areas to protect them from grazing animals), and we can use practices such as karakia to combine and align our own creative energies with those of other force around us. (Toimata Foundation, 2018, p. 56)

The Enviroschools Kit explains Kaitiakitanga as follows:

People also have responsibilities to look after things. People can have an active role, while still honouring the spiritual kaitiaki of a place. In many cases, taking responsibility for a particular place or resource is a specific and special role which is handed down from one generation to another and carried by a particular person, whānau, hapū, or iwi [extended family, sub-tribe or tribe]. (Toimata Foundation, 2018, p. 55)

The Enviroschools programme is fostered by trained facilitators and engenders a whole of school or early childhood centre approach, incorporating te ao Māori [Māori world view] perspectives, and the notion of empowerment with a focus on sustainability within both school/centre and the wider community (Williams, 2012).

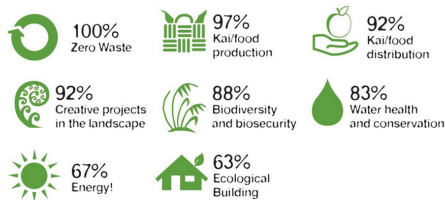
The 2017 Enviroschools National Census reports the following range of activities being undertaken by more than 1,100 Enviroschools representing 34% of schools and 6% of the large Early Childhood Education sector. This activity involves 152,000 children and young people actively participating as well as 15,700 school and centre staff.

Figure 1:

Enviroschools Census, from <https://enviroschools.org.nz/creating-change/growing-outcomes/>

All Enviroschools are engaging in a wide range of actions for sustainability

Environmental sustainability actions:



Cultural, Social and Economic sustainability actions:



* Percentages are the total % of participants who are taking one or more actions in the area

Source: 2017 Enviroschools Nationwide Census

Te Ahu Tū Roa is the reo Māori [Māori language immersion] sister organisation of Enviroschools, with both models being overseen by the overarching organisation, Toimata Foundation supported by Te Mauri Tau (Toimata Foundation, n.d.). Te Ahu Tū Roa operates in kōhanga reo, kura kaupapa and wharekura, that is Māori language education settings at the early childhood, primary school and high school levels. One of the objectives of Toimata Foundation is to “Further embrace and embed Māori knowledge, wisdoms and values into our work, and contribute actively to the revival of Te Reo Māori.

Whilst there has been little research conducted with Enviroschools or Te Ahu Tū Roa, the limited research on environmental education in New Zealand has acknowledged the leading role of Enviroschools (Bolstad, Joyce, & Hipkins, 2015; Eames, Cowie, & Bolstad, 2008; Tulloch, 2016).

An integrated, holistic approach to the teaching and learning of sustainability is advocated within the New Zealand School Curriculum (NZC), whereby children and young people are viewed as capable and having the right to share responsibilities of sustainability initiatives and decision-making (Ministry of Education, 2007). This idea is highlighted in the theme of sustainability within the NZC, whereby “learning of sustainability provides opportunities for students to make connections between learning areas, competencies, and values. It requires teaching and learning approaches that draw on all elements of effective pedagogy and focuses on empowering students to take action for a sustainable future” (Ministry of Education, 2020a, para 3).

Research Aims, Theoretical Grounding and Methodology

This project aimed to highlight how innovative New Zealand approaches provide opportunities for Māori and other children to demonstrate global citizenship via participating in projects that focus on ESD approaches to social, cultural, linguistic, economic and ecological sustainability issues of relevance to their communities. It also aimed to enrich students’ understandings of the world by drawing on the use of diverse forms of knowledge including Indigenous worldviews. The ESD approaches utilised in the education settings in this project therefore drew upon both western and Māori knowledge bases including the work of local scientists and conservationists.

The project was small scale, qualitative and narrative and was informed by kaupapa Māori theory (Pihama, 2010; G. H. Smith, 1997, 2003), pedagogies (Bishop, Ladwig, & Berryman, 2014; Pihama, Smith, Taki, & Lee, 2004) and methodologies (Bishop, 2005; L. T. Smith, 1999/2012).

Kaupapa Māori theory positions Māori worldviews, as outlined in an earlier section of this paper, as central, thus affirming and promoting “the validity and legitimacy of Māori language, knowledge and culture” (G. H. Smith, 2003, p. 11). Kaupapa Māori is a transformational response to colonised histories which operates beyond ‘decolonisation’ to generate a space of restoration of te ao Māori and te reo Māori (Māori worldviews and language) (M. Jackson, 2020; Mercier, 2020). In providing a culturally located and defined theoretical space, kaupapa Māori challenges the historical hegemony of western theories and research models (Pihama, 2010).

In keeping with kaupapa Māori understandings, the fostering of respectful relationships was central to the project (Bishop et al., 2014). It thus involved close collaboration with teachers in the three settings², Kōwhai Kindergarten, Kōwhai School and Te Wharekura o Tōtara. Research processes were co-designed with teachers, and understandings shared through regular meetings. Ethics approval for this study was given by Te Herenga Waka Victoria University of Wellington Human Research Ethics Committee.

Along with kaupapa Māori, critical ethnographic and narrative methodological approaches informed the data collection (Clandinin, 2007; Ritchie, 2017). Both researchers have extensive histories of working in te ao Māori education contexts³, and worked closely with the teachers in each setting, and with whānau [extended families] also in the wharekura. Data were gathered over a one year period from regular researcher observational visits; discussions with teachers and principal during visits and project meetings; pedagogical documentation gathered and analysed by teachers; children's narratives such as their videos prepared as part of their studies, a parent survey and interviews with whānau.

Findings

In this section we report on some of the learning experiences that focussed on sustainability kaupapa (focuses) with a particular focus on kaitiakitanga (as outlined in the section on te ao Māori constructs above) across the three different settings, beginning with Te Wharekura o Tōtara.

Kōwhai Kindergarten

The kindergarten caters for children aged 2-5 years, 62.5% of whom were of Pākehā (European) ancestry, 16.25% were Māori, with the remaining 21.25% of children being of Indian, Samoan, Chinese and other backgrounds, the diversity of the latter reflecting recent immigration growth in Aotearoa (Royal Society of New Zealand, 2013; Stats NZ, 2019). The kindergarten backs on to the grounds of Kōwhai School which is positioned next to a large wilderness area of Indigenous trees and streams. Both the kindergarten and school make regular trips into this area. Further, in keeping with the Enviroschools programme, there are regular 'Envirodays' which involve the entire school, joined by older kindergarten children, working collaboratively on outdoor projects for an entire day, such as tree planting, maintenance of school gardens and composting, all of which are led by children.

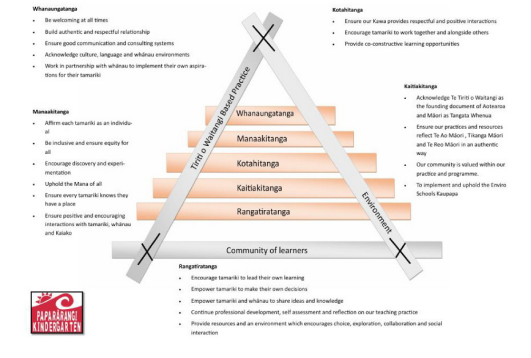
The Kōwhai Kindergarten philosophy is articulated as Te Kawa o te Māra Tamariki | Treaty of Respect, which has four over-arching kaupapa: Kaitiakitanga, Manaakitanga, Kotahitanga and Rangatiratanga (explained above). At the beginning of every school year, prior to Waitangi Day, the anniversary of the signing of the treaty, the teachers go over this Kawa with the children, discussing what each of these core kaupapa look like in practice. They gather together the children's own expressions of each, and then the children sign the treaty, showing their commitment to these understandings. They describe this process as 'a wonderful opportunity for Ngā Tamariki [The Children] to gain an insight into our founding document and its significance, empowering tamariki with Māori or non-

Māori whakapapa to gain a better understanding of the obligations of both parties encapsulated within Te Tiriti o Waitangi and the dual nationality of Aotearoa’.

Figure 2:

Kōwhhai Kindergarten Kawa

Philosophy in Action: SDG 4, 10



A teacher outlined some of their pedagogical approaches with regard to implementing their kawa:

Te Kawa o te Mara Tamariki is embedded in the mahi of our tamariki and is referenced and enacted daily in practice. At our whakataua to welcome new tamariki the children explain the kawa to their peers and give examples of how it looks in practice. We have four baskets and stones (taonga) that represent each part of the kawa on the wall near the mat area. Throughout the day tamariki and kaiako acknowledge when they see the kawa being used by giving a stamp to the child or children. At mat-time the children are asked if they have a stamp and they come up and explain which part of the kawa they upheld and what they did. They then put a taonga (stone) in the relevant basket. Whānau often tell us that their children use the kawa at home with their siblings and whanau as well.

Figure 3:

Te Kawa o te Māra Tamariki in action: Tiriti signing and Kawa wall display





The teachers note their use of supporting documents for the teaching profession such as ‘Our Code, Our Standards. Code of Professional Responsibility and Standards for the Teaching Profession’ (Education Council Aotearoa New Zealand, 2017). The latter requires the following commitment of all teachers in Aotearoa:

Figure 4:

Teaching Council Code #4 Commitment to Society, p. 12

 4. COMMITMENT TO SOCIETY
I will respect my trusted role in society and the influence I have in shaping futures by:
1. promoting and protecting the principles of human rights, sustainability and social justice
2. demonstrating a commitment to a Tiriti o Waitangi based Aotearoa New Zealand
3. fostering learners to be active participants in community life and engaged in issues important to the wellbeing of society.

As part of their ongoing internal review process, in recent years the kindergarten teachers have re-focused their understanding of the implications of Te Tiriti o Waitangi from the previous focus of the three ‘p’s of partnership, protection and participation, towards enactment of commitments under each of the articles of Te Tiriti (Boyd et al., 2017). One of the teachers, Elisabeth Lee, explains her treaty understandings in the following video: <https://vimeo.com/267351123>

In establishing the environment of Kōwhai Kindergarten teachers have deliberately fostered a tangible sense of wairuatanga, or spiritual interconnectedness:

Our physical environment also offers tamariki a tangible insight into the spiritual realm of Te Ao Māori. From conception to construction the tamariki have been actively involved in enhancing our physical environment by helping to create

representations of many of the atua in the Ranginui and Papatūānuku creation story. (Ranginui and Papatūānuku hold special significance for the tamariki - they will proudly tell you, “If you put Papa and Rangi together you get Kōwhai!”) A huge figure of Papatūānuku, clothed in flowers and ferns, welcomes all who visit, and Ranginui watches from above the sandpit. Rongo Ma-tāne protects our hua whenua [vegetable] gardens, Tangaroa swims with others in his watery kingdom (on a mural), Tūmatauenga guides our waka in the form of a tauihu [canoe prow], and tamariki find both representations of, and real creatures in Tāne Mahuta’s forest. Lastly, the ever present Tāwhirimātea announces his presence by making kinetic sculptures fly.

Figure 5:

A child in the waka (canoe) beside the mural of Tāwhirimātea at Kōwhai Kindergarten (included with permission)



The teachers of Kōwhai Kindergarten understand the importance of te reo Māori, the Māori language, as encapsulating Māori understandings, and as ‘a taonga [item of special value] that requires protection under Article Two’. They bexplain that ‘A couple of ways we do this is by interweaving Te Reo Maori throughout the day and curriculum areas’. The teaching team’s shared commitment to te reo Māori is evident in that they have together completed two Māori language courses and continue to work steadily at increasing their use of te reo throughout the programme, under the leadership of one of the teaching team. They continue to monitor their progress in this regard through its inclusion as a goal in their Strategic Teaching and Learning Plan, and their evaluations in relation to this goal. Their pedagogical documentation is punctuated with a wide range of relevant whakatauki [proverbs] (Rameka, 2016). Confidence in the teachers’ inclusive use of te reo is evidenced in the growing depth of reo utilised by both tamariki and whānau (children and families), and by the teachers’ increasing comfort in using te reo phrases without following these with a translation into English. Reflecting on

her evaluation of their integrated use of te reo, one of the teachers commented that it demonstrated ‘the modelling of Te Reo Māori as a living language for everyday use and they show that tangata [people] are getting used to hearing Te Reo Māori in everyday use within the kindergarten environment’ and that ‘whānau are noticing and appreciating’ the use of te reo ‘and the impact it is having on the learning of their tamaiti/tamariki [child/children]’.

The pedagogical documentation that the teachers produce reflects their commitment to te reo, as it is interwoven throughout. One particular strategy is their frequent use of whakatauki to introduce or end a document. Examples related to the environment include:

Toitū te marae a Tāne

Toitū te marae a Tangaroa

Toitū te iwi

If the world of Tāne endures [forests]

If the world Tangaroa endures [oceans]

The people will endure

And with regard to the Māori language:

Ko te reo te mauri o te mana Māori

The Māori language is the life-force of Māori

Ko tōku nui, tōku wehi, tōku whakatiketike, tōku reo

My language is my greatness, my inspiration, that which I hold precious

Kapa haka, Māori performing arts, are a strong focus at all three participating education settings in this study. Kapa haka embodies te ao Māori and is conducted in te reo Māori. Kōwhai Kindergarten conducts regular weekly kapa haka practices with the older age-group of children, and also perform at the school on a regular basis. The kindergarten’s head teacher explained that:

We have been doing kapa haka since 2008 when we had a Kapa Haka Leader, who would come in and take a weekly session. We used this knowledge to support the tamariki and continued to sing the songs throughout our daily sessions. He also provided his knowledge to support and deepen our understanding of Te Ao Māori often clarifying our understandings and what is best practice. Just over a year later, in 2010, he was unable to continue in his role as our leader and we then made the

decision to continue on our own and set the challenge of having a kapa haka concert for whānau as the motivation to continue. This is now a major yearly event for the kindergarten which the tamariki, whānau and school look forward too.

The kindergarten four-year-olds have an extensive repertoire which includes two waiata poi. Poi are balls attached to a woven cord, which are swung by both hands, rhythmically a precisely in accordance with specific actions to accompany a waiata (song). At a kapa haka performance by the kindergarten children to parents and senior school students at Kōwhai School, the kindergarten children were focussed and engaged throughout. At the end of the performance, the senior school students stood and reciprocated with a strong and convincing haka.

Kōwhai School

Kōwhai School caters for students from Years 1 to 6, that is, from approximate ages 5-10. In 2018 the demographics of the school population were New Zealand/European (50%), Māori (20%), Asian (14%), Indian (4%), Pasifika (4%) with the remaining 8% of students coming from more than ten other ethnic groups. This proportion of Māori students is higher than the national demographics of 16.5% (Stats NZ, 2019). The school demographics also reflect the situation whereby high levels of recent migration have generated a situation of superdiversity whereby 27.4% of citizens were not born in this country (Royal Society of New Zealand, 2013; Stats NZ, 2019).

The 2016 Education Review Office evaluative report on the school states that “The vision and valued outcomes defined by the school for all children are that they will be:

- resilient, empowered and confident students
- respectful of themselves, others and the environment
- able to relate well to others
- active seekers and users of knowledge.”

In consultation with parents, students and staff, the school had generated a vision statement entitled “Growing Adventurous Learners”.

The school Charter 2018-2021 contains the goal: ‘Celebrate the diversity of our community’ via the following sub-goals:

- * Cater effectively for learning differences.
- * Value language, culture and identity.
- * Integrate te reo me ngā Tikanga Māori [Māori language and culture] into teaching and learning.

Kōwhai School Charter 2018-2021 has a clearly stated commitment to the Treaty of Waitangi:

Treaty of Waitangi, Maori Dimensions and Cultural Diversity

In accordance with our Treaty of Waitangi Policy all staff will provide a programme that meets the needs of students and gives recognition to the needs of our Māori learners and values identity, language and culture. In order to support the acquisition of Te Reo Māori the school recently completed a year long professional development programme, aimed at increasing teacher confidence and knowledge, and therefore increasing student engagement and participation by Māori students in their learning. The cultural heritage of all students will be acknowledged and celebrated and aspects of the identities, cultures and languages represented incorporated into our school programmes.

Māori constructs are prominent in the school’s stated values (Figure 6):

Figure 6:

Kōwhai School Values

Values we encourage, explore and model: <small>(We look forward to working with Whānau to identify the most appropriate Te Reo Maori kupu, phrases and proverbs for our school)</small>				
Kotahitanga	Kaha/Whakamanawanui (?)	Manawanui	Kaitiakitanga	Manaakitanga/Whakaute
Community	Courage	Perseverance	Responsibility	Respect
We are proud of our school, ourselves and each other. We include others. We are accepting of differences and value diversity. We are cooperative. We learn from each other. We get on well with others. We share. We stand together. We work together as a team.	We give learning a go. We try new things. We have a go even when things are hard. We take responsible risks. We ask for and accept help. We are brave. We are open to new ideas. We are resilient. We know our strengths.	We keep trying even when things are tricky. We do the best we can. We understand it's okay to make mistakes while we're learning.	We are guardians of the environment. We help others. We are trusted to make good choices. We do the right thing even when no one is looking. We look after our belongings, other people's property and our school. We lead by example.	We care for ourselves, others and the environment. We treat others with kindness. We are welcoming. We are courteous. We are honest. We communicate affectively. We listen. We have good manners. We have empathy.

The entire senior school practice kapa haka regularly, the sessions fully led by the children, who participate with conviction and passion, supported by a teacher playing the guitar. At one of these sessions, the children introduced a new waiata, and after they had practiced it, the teacher suggested that they could further research the actions. She checked in with the children as to the correct command for returning poi, and asked ‘Who could show some leadership?’ At this particular time, the seniors were also practicing for forthcoming performances in a local festival, and at Wellington Airport during Māori Language Week.

Kōwhai School was a National Pilot School for Environmental Education and continues to have a strong focus on ecological sustainability whereby ‘all students are encouraged to respect and care for our environment’. They have previously gained two Bronze and a Silver Enviro-schools Award and in 2015 gained the top honour of attaining the Green/Gold Holistic Reflection Award. The school’s Charter 2018-2021 contains the strategic goal to: ‘Foster a healthy and active community who think and act sustainably’.

Te Wharekura o Tōtara

Te Wharekura o Tōtara, is a wharekura focussed on providing education for secondary school aged children via the Māori language and kaupapa Māori (Māori philosophy). The mission of Te Wharekura o Tōtara is to empower their students to achieve, contribute and lead in the advancement of Māori. There are 120 students on the school roll, 98% of whom are Māori. The teachers facilitate a project-based pedagogy that involves the meaningful integration of a wide range of subjects into ‘real-world’ projects, taking a strengths-based approach to build on students’ experiences and knowledge. A variety of different learning spaces enable collaborative learning across age-groups, supporting the whanaungatanga of older and younger students. Te Wharekura o Tōtara holds the view that learning occurs all the time, in many different locations and circumstances, not just at school. Accordingly, taking students out of school to specific locations appropriate to their particular learning activity is considered acceptable practice at Te Wharekura o Tōtara. Similarly, the contributions of community members, whānau [extended families], mentors and experts in their field are welcomed and appreciated and considered to enhance the learning experience of the students. Students at Te Wharekura o Tōtara engage in project-based learning across multiple ‘spaces and places’ of learning including community spaces.

Examples of educational engagements from the Te Wharekura o Tōtara data include both ecological and cultural sustainability kaupapa (projects). Students had participated in a programme ‘Paper4trees’ which is a waste minimisation and native tree planting programme for schools and early childhood education settings (Environmental Education for Resource Sustainability Trust, 2020). Each school is rewarded with one native tree/plant for every two cubic metres of paper and cardboard recycled. The native trees are sourced from 30 different native tree nurseries around the country to ensure that trees are sourced locally. After some discussion by the students, Te Wharekura o Tōtara organised a site visit to the nearby township of Whaingaroa | Raglan, to view and find out more about the ‘Xtreme zero waste’. Xtreme Zero Waste is an award-winning community enterprise established in 2000, which has generated jobs, education programmes and other services whilst diverting 71-79% of what used to go to landfill into recycling and re-purposing (J. Jackson, 2020; Xtreme Zero Waste Raglan, 2014). Whilst in Raglan, the students also visited a local Enviroschool where waste minimisation is entrenched and embedded into everything that they do. This time visiting the Raglan community transformed their understanding about climate change, locally, nationally and globally. One of the parents, Miriama⁴, said of her daughter, “Aroha’s age group is certainly leading the way.” She noted the problem-solving focus of the students at Te Wharekura o Tōtara. She also valued their gardening skills, whereby produce is then utilised in daily meals which are cooked at the school and that this shared consciousness in relation to the environment and climate change had influenced their practices at home.

A second kaitiakitanga kaupapa (project) conducted by the students at Te Wharekura o Tōtara focussed on the Maungatautari ecological island, which is a sanctuary mountain project that aims to protect the diversity of plant and animal species living on the mountain Maungatautari involving local community members including landowners, local iwi (tribes) and local residents. The project began

with a visit to the sanctuary on Maungatautari mountain. Many students did not have knowledge of the history of the land. Many had never been into Indigenous forest and did not know how to identify trees. Having this experience widened their knowledge base, deepened their commitment to be kaitiaki or guardians of Maungatautari and as a result the students want to go back to Maungatautari and continue to be active in its care. There was also huge whānau (family) interest in the project. “To me this signals success when whānau are interested and engaged in what their taiohi [young people] are learning.” According to the teacher who facilitated this kaupapa, her key learnings and shifts were related to skills of collaboration, leading a project, reflection on what is going right and what isn’t working and then changing what needs to be changed.

Kapa haka compositions and performance enable students to participate in a collective, disciplined learning environment. According to members of one whānau (family) whose children attend the wharekura, this involves “more than being a member of a group, it is about connections, being whānau, acknowledging whakapapa [genealogical connections], Te Reo Māori and Tikanga Māori”. Furthermore, “transformation through kapa haka” was identified as a key theme in the life of their whānau. They acknowledged Dr. Ngapo Wehi, (Ngāi Tūhoe, Te Whakatōhea, Ngāpuhi, Te Whānau-a-Apanui, Ngāti Kahu), as a highly respected kapa haka expert, whose statement, “Free the mind, be strong of spirit and you can achieve anything,” was quoted as the standard by which they measure their whānau wellness: “Excellence in performing arts was our motto. To achieve excellence meant a healthy mind, body and soul.” This whānau noted the role that kapa haka has played in restoring the Māori language along with pride in te ao Māori values and beliefs that had been impacted over the history of colonisation.

At Te Wharekura o Tōtara, kapa haka is a normalised part of the daily programme and is ingrained in the spirit of the school. This has opened up opportunities for the students to participate in pōwhiri (welcoming ceremonies), competitions and other events. The whānau (families) see kapa haka as “a powerful vessel, it is used to uphold our language, it is the strongest vessel which encourages change holistically. It gives us our place in the world”. It is therefore important to understand the potential of kapa haka in linguistic and cultural sustainability.

Kaitiakitanga Across the Three Education Settings

The Enviroschools programme suggests that in each school students will serve as the designated Enviro-Leaders. At Kōwhai School, these leaders are called the ‘Eco-Warriors’. Each term, that is four times per year, the school holds its Enviro-Day which is very much child-lead and also documented by the children, who contributed a large number of photos, video interviews, and curated videos for this project. The first video is one in which the Eco-Warriors introduce themselves, saying that ‘I’m an Eco-Warrior, because...’, ending their sentence with such statements as ‘I love nature and ecosystems’; ‘I love gardening’, ‘I love birds’, ‘I love plants’, and “I love to look after the environment’. Further elaborations include:

- we help the environment
- we grown plants

- we care about nature
- we can't let it go to waste
- we help plants grow and save them from predators
- I like birds and my favourite bird is probably the kakapo but the coolest bird is probably the saddleback
- nature can give us natural resources
- trees
- nature is beautiful and we can't let it go to waste. Will you help us?

In the range of various videos produced by the Eco-Warriors, various children interview one another about their Enviro-Day activities. These include gardening, composting, painting fences, creating a skink garden, enviro art designing murals, planting of trees in the school grounds, a trip to Otari-Wilton bush, preparations for a 'Sustainability Fair' comprising student generated projects, making bees wax lunch wrappers, sewing reusable bags, and offering workshops on water clarity, birds, animals and paper-brick-making. In another video, the Eco-Warriors ask one another about their favourite part of being an Eco-Warrior. Responses include: 'shaping the world', workshops, and sustainability. Notable is the detail that children are able to provide about their activities and projects, such as the layering of the compost. They also respond positively to questions such as 'How are you feeling?' and 'Are you happy that you are doing this for the nature and stuff?'

During a presentation by a marine ecologist, a guest speaker from Sustainable Coastlines, the children asked profoundly relevant questions and were also able to provide sophisticated and accurate answers to the questions posed by the guest speaker. This demonstrated the students' deep engagement with the kaupapa and their in-depth conservation knowledge.

Whilst planting native trees in the school grounds as one of the many activities during a Kōwhai School Enviro-day, the children spontaneously decided to do a karakia (spiritual invocation) after each tree was planted, holding hands in a circle around the seedling, and offering it their supportive, enthusiastic energy. Whilst the karakia were invented on the spot, and in English, the fact that the children decided this ritual was appropriate indicates their uptake of the importance of spiritual acknowledgement as part of the role as kaitiaki.

At Kōwhai Kindergarten, the engagement with caring for the environment began some years ago when the teachers adopted a place-based education approach (Penetito, 2009) which involves bringing in local history, community cultural life, connecting to the local geography and caring for the environment. This has been further enhanced since joining the Enviro-schools community. They see their commitment to kaitiakitanga as a Tiriti o Waitangi Article Two obligation:

We promote and encourage Article Two through the concept of kaitiakitanga in relation to whenua (land), tangata whenua (people) and taonga (treasures). Kaitiakitanga can be expressed as "the mutual nurturing and protection of people and their natural world.

We see part of our role as promoting and sharing our knowledge about Te Ao Māori concepts, including kaitiakitanga, with tamariki, whānau and the community. Preserving and valuing the land and all that is Māori (Te Ao Māori). Several years ago we were gifted the pepeha for our kindergarten by Mikaere Paki, our then cultural advisor, which acknowledges the land the kindergarten is on and is taught to all the tamariki supporting their understanding of/and connection to history of our place.

One of the other ways we are kaitiaki for taonga katoa is sharing and making real many pakiwaitara (historical stories).

An item in a local community newspaper item described how a four-year-old child from Kōwhai Kindergarten was very concerned on learning about the threatened status of the kiwi in Aotearoa (Department of Conservation, n.d.). With support of her family and the kindergarten teachers, she began fund-raising to donate money to an organisation that protects kiwi (<https://www.kiwisforkiwi.org/>).

In a survey of parents conducted by Kōwhai Kindergarten, teachers asked for any examples of kaitiakitanga that the children had shared with their families, and the following were some of the responses provided:

He is proud to talk about kaitiakitanga and references when we talk about looking after the world – i.e. rubbish, recycling, water care; also when he mentions that he has received praise for helping to look after kindy equipment.

Our little one talks about kaitiakitanga every week and how important it is to look after our environment and what she does at kindy and at home to demonstrate this e.g. water saving, rubbish collecting/recycling, care of the environment.

He works hard to be a kaitiaki, when he saw our neighbour squashing snails he asked if he could save them and take them home!

All the families who completed the survey were enthusiastic about and supportive of the pedagogical approaches that they were witnessing at the kindergarten.

Concluding Discussion

This section provides an overview of key findings from this study which aimed to illuminate ways in which a range of education settings utilised Māori constructs in enabling students to engage in pedagogies that reflected the notion of education for sustainable development (ESD), focusing on social, cultural, linguistic, economic and ecological sustainability issues within their localities. For Māori children and young people, the approaches outlined in this study are in alignment with the call from Emeritus Professor Sir Mason Durie and the Hui Taumata Mātauranga, and the alignment of subsequent government Māori education policy, for Māori to live well as Māori and as citizens of the world (Durie, 2003). This commitment is an expression of the obligations contained within the 1840 Te Tiriti o Waitangi seen for example, in Article Two concerns regarding protection of lands language.

Our data demonstrates that ESD approaches involving critical, empowering, action-oriented, transformative, problem-solving and transdisciplinary pedagogies, whilst not often expressly articulated as 'ESD' in educational

discourse in Aotearoa, are implicit in the educational paradigms from both the Auraki (mainstream) enviroschool and kindergarten, and the wharekura (kaupapa Māori secondary school) that were the focus of this study. Infusion of te ao Māori values such as kaitiakitanga were evident in all three research settings, a reflection of ‘culture’s contribution to sustainable development’ as per the UN’s Sustainable Development Goal 4.7 (UNESCO, 2017a, p. 8). ESD enactment was evident as a pedagogical process rather than as a discrete subject. This enactment of ESD was visible across many aspects, including: the empowerment of students, including those young children in the kindergarten setting; collaboration and shared responsibility; critical thinking; systems/holistic thinking; integration of both Māori and Western knowledge domains; commitment to intergenerational equity; and in the focus on place-based learning, locally grounded in their communities and in a commitment to care for their local environments and beyond. Dispositional outcomes for children include skills of critical thinking, collaborative problem-solving, leadership, confidence, along with a deep concern for others including the environment.

Whānau (extended family) support for their children’s endeavours is evident throughout the case studies. The parent survey from the kindergarten demonstrated widespread support for and commitment to te reo and te ao Māori within their children’s education, including from those families who are not Māori. Multiple sites of leadership are involved: including that of key teachers who have specialised focuses (such as Te Reo Māori, place-based pedagogy, global citizenship) along with the support of external Enviroschools facilitators, in-school Enviro lead teachers, in tandem with collective support from teachers and whānau, and leadership from tamariki, as seen in the Kōwhai school Eco-Warriors. All three settings demonstrated their enactment of commitments to the inclusion of te ao Māori and te reo Māori, as per the expectations of the New Zealand Ministry of Education (Ministry of Education, 2007, 2017a, 2017c). At Te Wharekura o Tōtara we saw the value of a school philosophy and pedagogies are deeply grounded in kaupapa Māori, that is Māori values, worldviews and philosophical approaches expressed through te reo Māori, the Māori language.

Addressing Racism in New Zealand Education

Recent developments in New Zealand education policy with regard to equity for Maori are noteworthy and align with ESD aspirations for social justice. They include a renewed Māori education policy, Ka Hikitia – Ka Hāpaitia (Ministry of Education, 2020b). This draws on a recent extensive nation-wide consultation with Māori (Ministry of Education, 2018a, 2019), and highlights the following:

Māori learners and whānau have identified racism as a major barrier in our education system. We will address this, provide equitable access to services, and in ways that promote fairness and are respectful and culturally appropriate so that Māori learners and their whānau have a strong sense of belonging. (Ministry of Education, 2020b, subsection 6)

The New Zealand Ministry of Education has recently launched a cross-sector programme, *Te Hurihanganui*, which aims to transform the national education sector, grounded in the following two key principles:

The transformative, critical, and social justice aspirations expressed in this key national education policy and programme provide fruitful opportunities to expand educational content and pedagogies in line with Māori aspirations, which include a commitment to kaitiakitanga, caring for the environment.

Implications for Covid-19 Times

As mentioned at the outset of this article, one of the key focuses of ESD is to empower learners “to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity” (UNESCO, 2019, para. 1). The COVID-19 global pandemic has given humanity cause to pause and reflect on our inter-relatedness and inter-dependence with nature, given the extreme vulnerability of humans to the impacts of the pandemic. The way human societies have increasingly encroached into wilderness areas, converting these for agricultural or urban purposes “is widely recognized to influence the risk and emergence of zoonotic disease in humans” (Gibb et al., 2020, p. 1). The key factors contributing to viruses crossing from wild-life into humans “are land-use change and climate change, both of which are hard to control. Our species has relentlessly expanded into previously wild spaces. Through intensive agriculture, habitat destruction, and rising temperatures, we have uprooted the planet’s animals, forcing them into new and narrower ranges that are on our own doorsteps. Humanity has squeezed the world’s wildlife in a crushing grip—and viruses have come bursting out” (Yong, 2020, para. 10). Transforming this exploitative attitude that perpetuates the relentless exploitation of wilderness spaces to one such as kaitiakitanga, could reduce such disrespectful destruction.

Large monolithic societies that have perpetuated the removal of Indigenous peoples from their lands, and thus reduced their capacity for guardianship, could also transform their approaches, by respecting not only Indigenous people’s guardianship but their long-standing knowledges of their particular ecologies. A recent example of cooperation between western scientists and Indigenous peoples is seen in the recent genome sequencing of the tuatara where Ngatiwai, the kaitiaki for this taonga species was fully involved in the research (Gemmell et al., 2020).

The inequitable individualistic models of education, economics and social policies that pervade western societies have also been called into question, as the pandemic has exacerbated the unequal outcomes in increasingly stratified societies. There is clearly serious concern with regard to “a national temperament that views health as a matter of personal responsibility rather than a collective good” (Yong, 2020, para. 29). Indigenous values of collectivity, as described above with regard to te ao Māori, prescribe a cohesiveness and collaboration that reduces the extremes of disadvantage, given the overall view that the wellbeing of the individual is dependent on that of the collective to which each belongs. One aspect of current social and economic systems is that as the wealth is increasingly concentrated in the hands of the few, to the disadvantage of the rest, it is often not acknowledged that this wealth has been built off the backs, the lands and labour of those who have been colonised and/or enslaved. In the United States, “Racist policies that have endured since the days of colonization and slavery left Indigenous and Black Americans especially vulnerable to COVID 19” (Yong,

2020, para. 4).

The largely unquestioned dominance of hypercapitalist economics that monetarises our planet's resources at the expense of the biosphere is clearly unsustainable. According to Jonathon Porritt "climate change is a civilisational issue, rather than an environmental issue, going right to the heart of today's growth-obsessed economy, challenging our very understanding of what we mean by progress" (as cited by Oram, 2020, para.10). Porritt views Covid as a wake-up call, whereby our planet has given us a strong warning which we ignore to our peril. The Covid pandemic "makes it significantly more likely we will do what needs to be done – as long as we put the climate emergency at the heart of our post-Covid recovery; we ensure science informs all future policy; we recognise ourselves once again as creatures of the Earth, governed by the laws of physics and the biological interdependencies of all living creatures"; and "we use the unprecedented shock of the pandemic to our way of life to rethink our basic values and, indeed, our ultimate purpose as human beings" (Porritt, 2020, as cited in Oram, 2020, para. 12).

We consider that the pedagogical approaches as outlined in this paper have potential to illuminate pathways for the urgent transformation that is required to protect the interdependent wellbeing of humans and planet, and that has been signalled in the United Nations' Sustainable Development Goals and prioritised in the work of the UN Network of teacher education institutions committed to reorientating teacher education towards sustainability (Hopkins, n.d.) Furthermore, the prioritisation and integration of Indigenous values within educational paradigms as outlined here, offer pathways towards restoration of ecological balances which provide a fundamental contribution towards safeguarding intergenerational planetary wellbeing.

Notes

1. We gratefully acknowledge the New Zealand National Commission of UNESCO for their contribution of funding towards this project.
2. School names are pseudonyms
3. Associate Professor Sandy Morrison affiliates to the tribes Ngāti Whakaue, Ngāti Maniapoto; Ngāti Rārua ki te Tau Ihu, and Ngāti Tama ki te Waipounamu. Associate Professor Jenny Ritchie is Pākehā (of European descent).
4. Pseudonyms are used for names.

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Making, Materiality & Power



*Establishing & Sustaining a Rightful Presence in STEM-rich Making with
Minoritized Youth*

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Making, Materiality & Power: Establishing & Sustaining a Rightful Presence in STEM-rich Making with Minoritized Youth

Engaging minoritized youth in making to produce 3D or digital artifacts using a
range of material tools in makerspaces have been deemed promising in democratizing
STEM education. We problematize this assumption through reframing what it would
mean for minoritized youth to author a Rightful Presence in STEM-rich making
(making that draws on and further builds STEM knowledge and practices). Drawing
on the Rightful Presence for justice-oriented teaching and learning framework and
on longitudinal critical participatory ethnography across four community-based
youth maker programs, this study unpacks the relationships between the materiality
of making and the artifacts youth produce. Using four illustrative vignettes, we
unpack how youth engaged in making to create artifacts necessary for their and their
communities' well-being, leveraging STEM-rich making toward a more rightful

presence now and in the future. The sociopolitical interactions between materiality and relationality in youth making programs are discussed.

Keywords: Makerspaces, Rightful Presence, Materiality, Youth, STEM-rich making

Making, Materiality & Power: Establishing & Sustaining a Rightful Presence in STEM-rich Making with Minoritized Youth

Introduction

Making and makerspaces have gained tremendous momentum in the last decade both in the United States (Martin, 2015) and globally (Sheffield et al, 2019) as a promising approach to foster creativity (Culpepper et al., 2020) and integrate STEM learning through material fabrication (Pepler et al., 2016). But why do youth engage in making and what and for whom, do they want to make? Consider what Ivy, a youth maker, said two years after she created a nameplate which has hung on the wall of the makerspace:

I think it was cool to see myself up there. It shows that you don't need to be an accomplished adult. Like kids did that. We did that. Kids of color and girls and like all of the people who grew up in their science classes, they didn't grow up seeing people like us. To have people see our names on the wall, on our nameplates, the projects we made, permanently hanging on the wall. That is inspiring!

Ivy's quote alludes to the meanings making holds for her: 1) Making is related to who youth see themselves to be; b) Making is related to her less than positive experiences in school science; c) What she makes is an extension of who she is and holds her hopes for a new social re-imagination, in concert with physical materials. In short, Ivy is acutely aware of the sociopolitical realities of her life as they imbricate with her making.

The maker movement has gained traction as a plausible panacea to democratize STEM learning experiences for all students (Martin, 2015). However, dominant maker culture is steeped in Patriarchy and White supremacy ideologies, (Brahms & Crowley, 2016; Authors, 2018), which work to reproduce structural and symbolic inequities via raced, classed and gendered hierarchies that have historically operated in STEM learning environments. Such ideologies project onto making meanings that further reify "coloniality's presence" (Domínguez, 2018) in the here-and-now and into the future, of making.

How do minoritized youth already engaging in STEM-rich making author a rightful presence in and through making, both in the here-and-now and hoped for futures? In this paper, we are particularly interested in how youth sustain a rightful presence through their engagement with the materiality of making, as evinced in, 1) how they make use of (or reject) what kinds of tools; 2) the kinds of material artifacts they create, why and for whom, in their community, and 3) the shift in both physical and social environments as a result of specific made artifacts, in

orienting both youth-makers and community towards new social futures. Two research questions guide this study:

1. In making for community, what kinds of artifacts do youth innovate to address what kinds of community issues, across which community spaces? What is youths' processes of making, in relation to what kinds of materials they choose to use and what they choose to make? How do these artifacts reflect youths' efforts in authoring a rightful presence in STEM-rich making?
2. How were made artifacts taken up by community members? What kinds of social interactions were fostered as a result, as related to youth seeding a rightful presence though making?

We draw on Rightful Presence for justice-oriented teaching and learning as a guiding theoretical framework and critical longitudinal ethnography as a methodology in this study.

Articulating the Problem-Space

Troubling the Dominant Culture of the Maker Movement

The maker movement has been riding a wave of immense momentum and popularity in the United States and across the globe (Martin, 2015). Often described as shop class 2.0, maker spaces are dedicated spaces housed with particular tools and technology ranging from low tech woodworking tools to high tech laser cutters and 3D printers. Makerspaces have also proliferated both in K-12 schools as well as in public domains, especially in libraries, museums and community centers.

Making has been touted as the next panacea to address all manner of schooling challenges, including “democratizing STEM education” (Martin, 2015), facilitating creativity (Peppler & Bender, 2013) and supporting interdisciplinary learning (Papavlasopoulou, et al., 2017). Indeed, the CEO of TechShop Mark Hatch asserted the transformative power of making when he stated, “anyone can make, anyone can change the world” (2014, p. 14).

While the promise of the maker movement to empower students in a multitude of ways in learning could be construed as inspiring, there remains the larger question, centered on issues of justice, of whose culture is being mirrored and reflected by the fast solidifying maker movement. A glimpse at the defining statistics characterizing the dominant Maker culture is sobering: 97% of Maker Faire (annual maker conventions both in the United States and globally, that feature makers across age groups, www.makerfaire.com) attendees have college degrees, 70% have graduate degrees; only 11% of the contributions to Make Magazine (the periodical credited with launching the Maker Movement) are female, and the median salary for those involved in the maker movement in the United States is \$103,000 (Brahms & Crowley, 2016). It appears therefore, that while the sentiment pronounced is that of ready access such that “anyone can make,” the regularities built into the dominant maker movement appear to filter out women and people-

of-color, perpetuating the same kinds of marginalizing practices that have yielded inequitable opportunities in STEM writ large (Calabrese Barton & Tan, 2018). In short, the culture mirrored in making and makerspaces overwhelmingly reflect White, male, middle-class norms (Buechley, 2013).

As Nascimento and Po'lvora (2016) caution, “[m]aker engagements with the world can easily embrace a sense of freedom and creativity to make whatever is wanted...with no major calls for changes in this situation, or even no concrete attention to its social conditions and consequences” (p. 6). When the maker culture reflects White male middle class norms akin to the dominant culture of science and engineering, we can expect similar gate-keeping boundaries that act to signal welcome to some (White) bodies while retarding the entry of others. The cultural and historical aspects of making across populations, space and time—including how, why, what, with what tools and resources that were used in making in communities --need to be acknowledged (e.g., Tzou et al, 2019; Cheah, 2009) and made visible, both to perturb dominant maker culture and to lay open the possibility that a culture specific to a makerspace situated in particular communities, can be collectively built to reflect the values of local stakeholders.

Material Culture in Making

In a makerspace, one is surrounded by stuff. Making is mediated by one’s embodied engagement with physical and digital materials. To become a maker, one has to put hand to stuff, to create something using available materials and tools. As such, there is a requisite process of learning making-related skills which encompass becoming familiar with both making tools and making materials. The field has been adept at documenting the range of materials leveraged in making (Kemp, 2013; Martin 2015; Kafai et al., 2017). The focus has been to identify and make visible what counts as making-related materials, in terms of raw materials as well as the tools involved. Making materials range from scrap/found objects for scrap building, hardware and carpentry projects (Kemp 2013), computer programs and 3D printers for digital fabrication (Martin 2015) and scientific tools (Kafai et al 2017), to maker-specific materials such as littleBits (www.littiebits.com), movable robots that could be programmed such as Ozobots (www.ozobot.com), complicated paper circuit projects (www.chibitronics.com) to e-textile related materials (e.g., www.sparkfun.com).

The field has been less adept at examining the relationality between making and materiality, or, the material culture in making. Material culture has been described as “the outward signs and symbols of particular ideas in the mind” (Schlereth 1992, 19). It is concerned with lensing artifacts created by humans as reflexive of “the beliefs of individuals who made, commissioned, purchased, or used them, and by extension the beliefs of the larger society to which they belonged” (Prown 1982, 1-2). Beyond objects themselves, material culture surveys the range of human and cultural expressions that both infuse and transcend material objects themselves (Bolin and Blandy 2003).

Further, material culture has been described as a “method of cultural inquiry employing physical objects as its primary data” (Schlereth 1985, p. 6). Relatedly, drawing on Appadurai’s book *The Social Life of Things* (1988), Miller posits that things, or objects, have trajectories “in their ability to move in and out of

different conditions of identification and alienation” (2005, 7). Youths’ contact with particular materials when making are therefore influenced by past histories of contact. Similar to Tzou et al., (2019), we see the “potentialities of materials” (311) as existing in relation “to our experiences, histories, and futures with them”. Barajas-Lopez and Bang (2018) noted that knowledge and power systems impact makers’ activities and experiences. To date, in the field of maker education research, with few exceptions (e.g., Barajas-Lopez & Bang 2018), there has been scant research on how materials, nested within particular material culture, lend directionality in “orienting” (Ahmed 2015) how and what youth makers make.

Theoretical Framework

Rightful Presence for Justice-Oriented Teaching & Learning

The Rightful Presence for justice-oriented teaching and learning framework proposes three tenets: 1) The necessity of allied political struggle to reauthor rights in disciplinary learning; 2) Claiming rightfulness through presence, by surfacing injustices; and 3) Collective disruption of guest/host relationalities (Calabrese Barton & Tan, 2020). Rightful Presence argues for the need to push beyond “equity as inclusion” where existing systemic structures remain unperturbed and existing norms and practices continue to reproduce subject guest-host positionalities. Equity as inclusion modes of interaction consign disempowered guests to depend on the powered hosts’ continued extension of hospitality and rights, at the pleasure of the host. In classrooms, teachers are the host who wield power, extending participation rights to students as they long as they toe the line as guests. We argue that such an approach acts to maintain and reproduce inequities because the boundaries gatekeeping what it means to “be included” remain unchallenged.

In the context of making where the dominant maker culture promotes particular kinds of making and particular kinds of tools discussed earlier, the rightful presence lens is helpful in focusing attention on how minoritized youth are engaging in what kinds of making in order to illuminate which sociopolitical struggles are currently troubling their young lives. Of particular relevance to making is also the suggestion that one way in which Rightful Presence can be claimed is by creating material artifacts to literally “claim space” (Calabrese Barton & Tan, 2020, p. 6) for the creators. Such a way of claiming space through material artifacts not only directly shapes the physical environment but also is generative of new social interactions tied to specific material artifacts that were nonexistent before.

The Intersection of Materiality and Rightful Presence in Making

A socio-material lens considers educational activities as hybrid ensembles of bodies, materials, ideas and symbols that actively interact, intersect, combine and recombine through various “patterns of assemblage” (Fenwick & Landri, 2012, p. 3). Unpacking the relationality between people and objects allow us to tease out, with more nuance, possible agentic roles that objects play in orienting human activity. We suggest that some objects in making are infused with particular meaning nested within larger systems of cultural-historical experiences, whose

meanings, and the effects these meanings may exert, gain mobilities as they are transported, housed in particular objects. In short, objects that are materials for making are mobile vectors of meanings that can act to erect “atmospheric walls” (Ahmed, 2014), reproducing unjust positionalities, or catalyze new social possibilities and futures. As vectors of meaning, materials carry both directionality and magnitude, which can work together to reproduce unjust positionalities or to seed transformative changes toward justice.

Socio-material studies in education have critiqued the normalized practice in education research of amplifying human agency while subordinating the impact of materiality (Fenwick, et al., 2011; Fenwick & Landri 2012; Sørensen 2009). This inattention to “what things do” (Verbeek, 2005) has led to what Miller (2005) described as “the humility of things” (p. 50), on the surface a descriptively benign term that in fact exerts significant force in the opposite direction, precisely because of things’ ability to appear innocuous. A seemingly anodyne presence keeps hidden how “stuff achieves its mastery of us precisely because we constantly fail to notice what it does” (Miller, 2005, p. 155). Ignoring the agency of things is unwise, as the orienting impact things have on people are “particularly effective during the early phases of socialization, where they stand as teachers, mentors and gurus, leading us to be examples of a specific society, class or gender more effectively than any explicit pedagogic exhortations” (Miller, 2005, p. 155).

Informed by the Rightful Presence for justice-oriented teaching and learning framework in conjunction with examining material culture and power in Making, we draw from longitudinal, critical participatory ethnographic work with youth engaged in STEM-rich making in community across two states. Looking across 6 years of community-based making experiences with youth, with four illustrative vignettes, we unpack: 1) how materiality related to making mattered in making injustice visible (Rightful Presence Tenet 2) in community; 2) the ways in which materiality work to oppress, how and in what ways; and the ways in which materiality work to seed and sustain a new making culture that deepen youth-makers’ rightful presence (Rightful Presence Tenets 1 and 3). We theorize and unpack, with illustrative case study data shared as vignettes, how youth engaged in the making process in community – from soliciting community input on what to make, to involving whom in the making process, to how, and by whom, the made artifact is to be put to use.

Methodology

We employed critical, longitudinal ethnography, across six years of partnering with youth-makers in community. Critical ethnography is particularly suited to our study as it values multiple perspective (Trueba, 1999) and foregrounds dialogic interactions between researchers and stakeholders. A critical ethnographic approach explicitly seeks to unpack and understand potentially oppressive relationships between structures and actors (Calabrese Barton, 2001). Engaging in critical longitudinal ethnography is also our response to the critique of a lack of an anthropological approach in education research (Ladson Billings, 2006), focused on sociocultural perspectives. To again a more authentic anthropological perspective in making sense of youths’ lived experiences in community settings, we embedded ourselves in those settings, both to gain legitimacy as members of

said settings, as well as to develop a robust understanding of the cultures therein. As we seek to become legitimized “outsider-insiders” to our community partners, we remain cognizant that our own positionings as adult researchers/teachers from local universities (one Asian, one White) would influence how we experience the norms as opposed to the youth. In sum, we have at least 500 contact hours with the youth across six school years of weekly interactions. Data sources include: 1) weekly, making session field notes, 2) biweekly conversation groups with youth about their making experiences, 3) artifact interviews with youth-makers after each made artifact, 4) informal conversations with club staff and parents, and 5) the youths’ made artifacts themselves, and when available, 6) how youths’ made artifacts were taken up by those for whom they made.

Data were analyzed in the grounded theory tradition, using a constant comparative approach (Straus & Corbin, 1998). First phase open coding involved surfacing a) critical episodes of youth making that featured particularly salient performances, in talk and actions that were further invoked by youth subsequently in time/space, we define salience by the reasons youth invoked for why they wanted to make specific things, and how they might go about doing so; b) the knowledge and practices youth drew upon during critical episodes, and c) relational dynamics that link knowledge and practices with regards to human resources and networks. Guided by our theoretical framework, we then engaged in subsequent axial coding to identify the axes of oppression, locate the nodes of intersection between materiality and rightful presence, and examine the impacts of such intersections on the dynamics on youths’ making processes and made artifacts. Across these phases, analysis was member checked with youth and club staff.

Context

All four youth making programs engage in STEM-rich Making (Bevan et al., 2015) that draws on “scientific and technical tools, processes and phenomena” (p. 99) during making processes. Each program is briefly described below.

Make Club and Green Club: Our work with upper elementary to middle school youth takes place in two making space programs across two states, both housed in Boys and Girls Clubs (BGC) in local cities. The BGCs are community-based clubs serving mostly youth from low-income backgrounds with after-school care and activities centered primarily on homework help, sports, and youth leadership development. Both clubs serve >90% African-American youth. We had worked with BGC staff to established STEM-rich making spaces in each of these clubs – Make Club and Green Club. Both making clubs run weekly for at least 90 minutes, with the focus of working alongside youth and community members to engage in what youth have come to describe as community-based “making that matters.” Both programs ran weekly during the academic school year. Youth participation typically endures at least past one full academic year, with 50% of youth staying for more than one year, until they “age out” of the program. We served as both maker-facilitators and researchers at these clubs.

Willow Newcomer STEM Club: We also work with middle and high school aged recently-resettled refugee youth at Willow Newcomer STEM Club, a weekly programming that run for at least 90 minutes. Similar to Make Club and Green Club,

Willow Club is focused on community-based making, with youth encouraged to engage in decision-making about what, why, for whom they want to make. Youth from a wide range of nationalities, speaking multiple languages, attend Willow Newcomer STEM Club.

Youth Advisory Council (YAC) Club at Science Museum: The YAC is a racially diverse group of about 20 youth, ages 9-16, who meet monthly to prototype, pilot, and revise science center spaces, exhibits, activities, and experiences. Since the YAC's initiation, the youth have undertaken several annual projects, such as designing a makerspace in the Center, developing new programs/activities for the makerspace, and examining/redesigning other areas of the Center.

Findings

We unpack youths' making experiences as undergirded by the intersections of materiality and authoring for rightful presence by sharing four illustrative vignettes to illustrate two main claims.

Claim #1: Youth created artifacts that were missing but that they deemed necessary for their own well-being as well as the well-being of specific community members they identified.

We arrived at this claim through investigating the following question-threads, as related to our first research question. Probing research question #1, we further ask:

1. Why do youth respond to, engage with, and re-mix particular materials in particular ways?
2. How do particular youth and materials interactions shape youths' making processes and what gets made?
3. What impact do youth and materials have on the emergent culture of youth-centered making spaces?

Vignette 1: Making and Maintaining a Little Free STEM Library

Fall and Samuel were two friends and members of Green Club who researched the complex terrain of library (in)accessibility for youth of color living in their low-income neighborhood, drawing also from their own embodied experiences. Barriers to library access for youth were due to interrelated reasons inherent in their everyday experiences as low-income youth living in their particular city and included 1) the lack of transportation, 2) the inability to apply for a library card because of the burden of proof of address, and 3) the inability to pay late fees, likely to be accumulated due to the lack of transportation. In their research, Fall and Samuel also learned about little free libraries –what they were and how they functioned in boosting reading through the circulation of free, donated books. As they explained:

At the Boys and Girls Club we do not have a library. At school, we hardly get any time to use the library and the school library does not have many books. It is also

hard for our parents to take us to the library. Lots of kids do not have library cards, either. Another thing we have been thinking about is that there are no books for us to read about science and engineering and how to do different projects at home. Even if we find a book we cannot always bring it home and we also cannot keep it for a long time at home. We were also thinking that along with the books on how to do science and makerspace projects at home lots of kids do not have the materials that they need to do the projects.

They included blinking LED lights around the library, powered initially by a hand crank generator and later by a solar panel, to call attention to the library, and to get kids curious about how it worked. Providing access to STEM books and resources was important to the youth as they knew that many youth in their school struggled with reading and had limited opportunities to learn STEM in school.

As the youth's comments suggest, the idea for the library emerged from their own experiences growing up in a low-resourced neighborhood and city. However, their project transformed in scope and direction as a result of how they sought to learn together across the design process about community access to books through their broad social network. As Samuel further explains:

When you are making your invention, first of all, you have to talk to people. You have to interview people in your community. You might know what the problems are, but you might not know how it matters to other people. We had our ideas, but our ideas weren't enough.

After they built the library itself, they asked adult mentors for book donations and made little electric art "maker kits" to include in the library so that other children "can do what we do at [making club]." The youth further solicited input on the types of books people wanted to see in the library, and whether their plans for book check out and return were clear and easy for community members. As Fall noted, "We have to have books with different reading levels and some with just pictures because even five-year-olds said they wanted to use the library." To facilitate mobility of their library, a feature they wanted as different from the regular models of little free STEM libraries which are often planted on one spot, Fall and Samuel's library featured wheels so that the library could be moved around the different rooms of the community center, including just outside the center so that youth need not enter the center to pick up a book or a maker kit (Figures 1-2).

Figure 1.

1a: Fall & Samuel with the body of the little Free STEM library they just completed; 1b: Samuel attaching a door they built to the library



Figure 2.

Fall & Samuel's explanation of further increasing visibility of the little Free STEM library through building a green lighting system

Making our library green!

- We are putting in a lighting system that is powered with GREEN Energy
- Phase 1: We are putting LED lighting around the library so that it will get everyone's attention
 - Powered by a hand crank → We think it is a great idea to get kids interested in doing STEM if they walk up to the library and say "Cool" as they power the lights themselves!
- Phase 2: Add a light inside the library
 - Powered by rechargeable batteries
 - We could build a solar panel docking station to recharge the batteries



Vignette 2: Sewing Soft-Toys and Light-Up Weekend Purses for Self and Younger Siblings

In a two-week, intensive making camp at the Willow newcomer youth center (total of 40 hours), 11 girls engaged in e-textile making and created light-up soft toys and light-up purses (Figures 3 - 4). The decision to engage in e-textile making for these specific purposes arose out of dialogue with youth and adult facilitators supporting the making camp. During the conversation, this group of mostly upper middle and high school girls brought up the latest "donation room" session they had, where youth were scheduled to visit the room at the center where the latest donations were sorted and organized, to pick items they might need. The lack of small purses and weekend bags were noted.

Sana asked if the camp activity could be about making small bags, what she described as "not big like school bags, small bags." Mani added "like you can use to go out, not to school." When asked if they meant handbags that women carried, they replied, "yes but not old and not big." Youth also wanted to spend part of the camp making "cute soft toys" for themselves, and their siblings because they had none. Toys were not allowed when it came to donations, due to a state law. As such, the children living in the residential complex where Willow Newcomer

STEM club is housed were generally lacking in toys, not just soft toys.

As the youth seemed to have a firm vision in mind of how they wanted their anticipated purses and soft toys to look, adult mentors asked about the kinds of materials—fabric, decorative fabric decals, trims, buttons and size of zippers, etc.—that the girls had in mind. Using the adult facilitator’s laptops, the girls searched for pictures of examples. Adult mentors then visited different craft stores to procure the materials the youth identified, for example, soft fabric in pastel shades, flower-shaped decals, lace-trim, and delicate plastic chains that might serve as purse straps. What transpired during the materials exploration conversation was what the girls did not want –school-bag and professional handbag type materials -stiff fabric, leather or faux leather, big buckles and thick straps.

During the camp, youth both hand-sewed and learned how to use the sewing machine to make their longed-for items. They had to learn how to sew workable circuits by hand, as metal-infused thread is brittle. Learning how to sew circuits was not easy, as threads could cross easily and break circuits. Despite frustrating moments where peers and adult mentors provided support, there were consistent moments of excitement as the artifacts took shape as the camp progressed. The youth complimented one another’s designs, how the purses were “so pretty”, how the soft toys were “so cute”, and “so huggable.” They imagined aloud how happy and excited their siblings would be, when presented with the soft toys. One of the youth, Anna, had to bring her almost two year old sister, Queenie, along as she was responsible for baby-sitting that week. Anna would converse with Queenie in their mother tongue, asking her what color fabric she liked, if Queenie wanted a tuft of hair on the soft toy that Anna was making for her.

On the last day of the camp, a younger cousin who was visiting one of the youth stopped by and looking at what was happening, requested her cousin, Sana, to make her a “soft toy purse.” Sana, with help from Anna, first made a soft toy and then sewed a delicate ribbon as a strap around the soft toy, so her cousin could wear it like a purse (Figure 4d). At the end of the one-week camp, each youth left with one purse and one or two soft-toys, one for themselves, the other for a sibling.

Figure 3.

Light-up weekend purses: 3a: Anna modeling her light-up purse, 3b: The collection of purses made by youth, 3c & d: close-up of two purses made by youth



Figure 4.

Monster soft toy for Queenie. 4a: Anna's sketch up design of the monster toy; 4b: monster toy she created, cc: Anna and her baby sister Queenie, for whom she made the monster soft toy; 4d: Hybrid soft-toy bag made for a visitor



Unpacking claim #1

Across both vignettes, we see that the meanings that resided in materiality were nuanced. While the public library in its physicality and geographic location loomed as a barrier to Fall and Samuel and their peers living in the same neighborhood negotiating the same related challenges to library access, Fall and Samuel’s making of a mobile little Free STEM library materially and literally filled the gap, and addressed this injustice playing out in their lives. The tools, both material and human present at Fall and Samuel’s community making space led them to ask for specific materials and enlist help from peers and adult mentors to build a little free STEM library for the youth in their neighborhood who attend the community club where they walk to after school or from home. Fall and Samuel literally made what was missing in their community – a library stocked with donated books and maker kits, also made by them, for themselves and their peers. For the youth, their lives - including their sociopolitical locations in society, were “presenced” (Tzou et al., 2019) - in symbolic and disruptive ways through the materiality of making.

Similarly, the newcomer youth at Willow STEM club identified what was missing from the donation center. While clothing were plentiful, small purses and toys were not available. By identifying small purses and toys as things they need, newcomer youth are authoring their rightful presence not just at the center, but also in the STEM-rich making program. Rather than accepting how the city, acting as hosts, were extending hospitality through specific materiality hosts deemed necessary to recently resettled refugee families, youth, through their making of small weekend purses and soft toys, inscribed what rightful presence for newcomer families ought to entail – fun, play, joy, and not merely survival.

The youths’ understandings of their community needs are historicized. Samuel and Fall’s making activity supported them in naming naming and illustrating how

they live in what they described as a “library desert” -- historicized inequities related to resource access disproportionately affecting Black and Brown youth growing up in lower-income circumstances. Their work opened up new questions and ideas for what they may consider as they built their library systems (e.g., how access could be more open for youth, what kinds of books youth may want, etc.). Like the youth making toys at Willow, they aimed to make visible these historicized inequities while making for a world that replaced such inequities with power, agency, and joy.

Claim #2: Youth Leveraged Made Artifacts to Seed for New Social Futures and Rightful Presence by Claiming Space Through Materiality

With their made artifacts, youth advocated for new modes of participation both for themselves as youth-makers and for peers who were not members of the community making club due to age limits or other factors beyond their control (e.g., inability to be at the community club when Make club take place, due to lack of transportation or other conflicts). The following threads were pursued to further probe research question #2:

1. In what ways did community members respond to youths’ made artifacts?
2. How did youths’ made artifacts act to author a rightful presence for themselves and for others in community?
3. What is the relationship between materiality and the potential for expansive rightful presence in community?

Vignette 3: Organizing and Hosting a Coding Day for Young Peers at the Community Club

Youth at Make Club had spent one academic year engaging in learning how to code. In the winter semester, youth learned how to code using the platform Scratch. Using the tutorials available on the platform, Make clubbers learned how to select from available options of the sprite and background, to editing existing options, to importing their own options of sprite and background, as setting up the storyline of their Scratch projects. Youth then learned the various block-based visual programming domains including types of movements, nested actions, sounds, events and more fine-grained control. Throughout the semester, youth “scratched” movies of showing aspects of what they enjoy doing at the community club. Examples of these movies showcased youth and their friends hanging out, playing basketball, having conversations in peer groups, and dancing at different parts of the club. The club administrators were impressed with the scratch movies and showcased them on the large announcement flat-screen in the club’s lobby. This led to younger peers who also attend the community club, but who are not in Make club, to see the scratch movies.

This led to the younger club members asking to join Make club so they could “do what they are doing, I want to make a movie like that too.” Apart from asking club administrators if they could join Make Club, the younger children also asked Make Club youth this question. Make Club youth had conversations during Make

Club sessions about their younger friends and wondered if there were some opportunities for them to teach their younger friends how to “make a scratch.” This conversation would continually be invoked through Make club sessions that academic year, as the youth continued to develop their skills on Scratch by creating games on the platform. After Scratch, the youth explored Ozobots, a different type of block-based coding that uses a 3D tangible bot and drawn codes on paper with different color combinations. Codes included both directionality and speed, with many combinations that could be combined to create games and challenges.

While learning how to code with Ozobots, the conversation about teaching younger club members were invoked again, with Lanita opining:

“Ozobots would be more fun for the younger children because they can draw with markers –it is more fun and easier than typing on a laptop. Also, the Ozobots are cute and you can touch them and see them move fast or turn around or do a tornado. I think that’s fun for little kids... that coding is like you can make the robot dance.”

The Make Club youth decided to host a “Coding Festival” for younger friends at the community club at the end of their coding unit (Figures 5-6). Preparation included which Scratch projects to showcase. For example, the youth considered that scratch movies were interesting but non-interactive for the audience, while scratch games were more directly interactive. Out of all the many ozobot projects, how would they choose which ones to showcase in a scaffolded way --“from easy to more complicated, show the easiest codes to draw first” – so that it made most sense for their young friends and be as fun as possible. Four of the Make club youth designed and painted a big banner. They sought permission from the club administrators to use the big meeting room in the club building to host the festival. Youth decided amongst themselves who would facilitate the scratch games and who would facilitate the ozobot coding. That afternoon of the festival, more than 40 young club members (ages 5 to 10) engaged with Make Club youth at the coding festival and explored block coding with Scratch and Ozobots.

As a result of the coding festival and the younger children’s overt enthusiasm, club administrators made the decision to have smaller scale “pop up making” sessions twice a semester where Make Club youth could share what they were doing at Make club with the younger children. This commitment is not trivial, as existing programming schedules, along with club staffing, would need to be rearranged.

Figure 5.

Coding Festival. 5a: Big wall signage for the Coding Festival painted by 3 Make Clubbers; 5b: Young peers playing the Scratch games made by Make Clubbers before trying their hand at “scratching a game.”

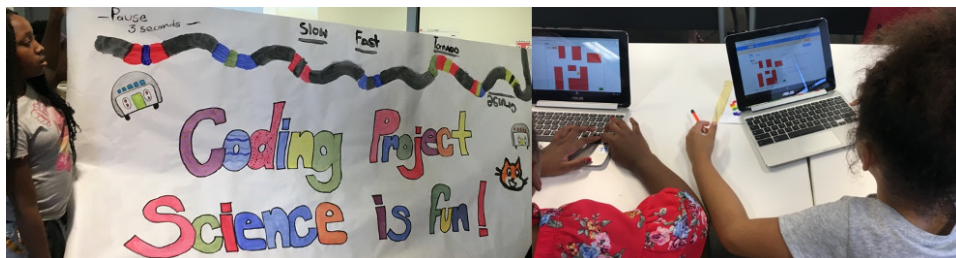


Figure 6.

Coding Festival. 6a: Make club youth Meg facilitating young friends trying out ozobot coding; 6b: Make club youth Meg, Jayla and Star circulating the room to help young friends with ozobot coding.



Vignette 4: Name Plates—Making Present Lived Lives and Fraught Histories in Science and Society

One of the main activities of the YAC was to provide input on the development of activities for the new Maker Center the museum was creating. At this particular session, Olga, an adult mentor worked with the youth to pilot a “power tools” activity: Building marble mazes. Olga shared a few different examples she had built. Youth were provided with a wide range of tools (hammers, electric drills, saws), and materials (varying sizes of wood, screws, nails, popsicle sticks, arts and crafts). Everyone was encouraged to play around with and explore what such activity could “look” and “feel” like.

Everyone but Samuel made a marble maze. Instead, he used the available materials to build a six-foot-long wooden sign for his local afterschool club. When asked why, he said that a sign would be more useful. He could also hang it at the club where everyone could see it. He elaborated:

I was having fun with all of the tools, and like try to make one. But I was thinking

about what else I could do? Like, with all of the tools, and I saw this big piece of wood. We don't have our own sign. I could make us a sign. . . I think when people see my sign they think 'that's cool. I want to do that too.' It kinda shows who we are and what we do.

Inspired by Samuel's actions, adult YAC members created a plan to provide all youth the chance to make their own "nameplates." This activity made visible a set of discourses and practices around youth as rightful members and co-designers, as Ivy described in the quote at the beginning of this paper.

Over time, making nameplates was incorporated in the Center's outreach programs (Figures 7-8). One of the outreach activities involved the local refugee center, where Center educators worked with the local refugee youth to construct their own nameplates and write stories of home. The Center then hosted a temporary exhibit with the nameplates made by local refugee youth, and their accompanying stories. Through their nameplates, the youths were able to share, not only their names, but complex dimensions of their lives as captured by the ways they organized, decorated, and described their nameplate. For example, one nameplate, created by one youth from Kenya, included his name, a crafted map of his country, and his country's flag. He wrote:

I use yellow and blue because they are my favorite colors. I use fabric to make my country's flag and pipe cleaners to make my country's map using colors exactly as they look on the flag. I want people to know more about Kenya and where I am from. I want people to get the feeling of how beautiful Kenya is from the map. The flag is a perfect expression of how beautiful Kenya is and its fantastic, lovely people. The land of agriculture. Lovely Kenya.

One of the youth YAC members, upon seeing the nameplate exhibit produced by the refugee youths, stated,

I was just like, WOW! These are so amazing. It just really helps me to think more about what refugees are feeling right now. I love the nameplates. It is really hard to believe that we actually started it [with our nameplates]. It really shows, like, how important it is.

Figure 7.

Samuel making his name plate at YAC, with help from adult mentor



Figure 8.

Name plates as artifacts reclaiming whose presence and presentation matter

8a: Example of a nameplates in YAC initiative (in 2016);

8b: Exhibition of Refugee nameplates (in 2019); 8c: Kenyan youth's name plate



Unpacking Claim #2

Youths' created artifacts in themselves acted to seed youths' own rightful presence in their respective making programs. At Make club, while the focus was largely on coding, youth were involved in decision making, once they had an initial understanding of what coding is and entailed, on how they wanted to engage with Scratch and Ozobots. Adult mentors practiced "just in time" (Authors, 2018) facilitation when youth were stuck on particular tasks, and consistently left decision-making to the youth, such as the storyline of scratch movies, characters to be depicted, backgrounds used, speech, sounds and movement. At YAC, one youths' actions -Samuel- to use existing ideas and materials to make a name plate instead of the prescribed artifact (marble maze) was materially authored Samuel's rightful presence at YAC –his name inscribed in wood literally claiming space at YAC club, signaling his presence.

Youths' made artifacts also acted as catalysts for seeding the rightful presence, through materiality, of people in the community. With Samuel's nameplate, not only did YAC members, inspired by Samuel, create their own personalized nameplates that remain displayed on the makerspace wall, but the nameplate activity became central to many of the Center's outreach programs. This mattered because it shifted not only the materiality of the Center as youth-authored artifacts with their names became a part of the space, but also the spatial imaginary (Watkins, 2015) of how people talked about, expressed, and valued youths' expertise, and how they were recognized as STEM people. The nameplate activity made visible a set of discourses and practices around youth as rightful members and co-designers of the Center's makerspace.

The co-development of the nameplates led to a cascading set of discourses and practices which helped to transform how youth and visitors experienced the Center. Youth went from being invisible and transient recipients to being rightful members whose ideas/creations matter and co-designers of the Center's makerspace and activities. Educators adapted and expanded the nameplate activity. They created

the space for youths' presence to be explicitly visible. Youths' work and stories describing the work were made accessible to visitors. This centering of youth-authored material artifacts also bore witness to youths' systematic erasure and transformed spatial imaginaries adults held about how spaces could be re-created, for whom, and why. As the nameplate activity moved across space and time, it signified youth agency and presence in STEM. The purposeful decision, on the part of Olga, to render the activity as central to the makerspace, reflected her desire for youth to be seen in ways of their choosing, even when they were not physically present.

Olga, herself an immigrant, reflected on the outreach as an expansion from YAC noting that the outreach program with refugee youth should position them as insiders of the Center and our community – not the outsiders they are often positioned to be by national policies and political rhetoric. Rather, she hoped, the Center could be a space for visitors to learn from the refugee youth, through the knowledge, stories, and desires shared in their nameplates.

At Make Club, the youth organized and ran a coding festival for more than 40 younger children at the community club. During the 90 minute session, club administrators and staff streamed in and out of the festival space, witnessing how the Make club youth were able to teach their younger friends how to start block-programming. Some of the administrators joined in as well, with one staff member, Deana, exclaiming, “This is the first time I’ve coded! So, this is coding. it’s not as intimidating as I thought. I wish I had done this as a kid.”

Discussion

We drew on material culture and the intersections of materiality with rightful presence in this manuscript to consider this point: Materials in making are neither benign nor static --they are active with histories that imbue each object with unique meanings and potentialities to position makers and would-be makers in specific ways. As vectors of meanings, materiality can instantiate for makers at the moments of encounter, fraught positionalities embedded in specific systems of injustice. Connected to the rightful presence framework, materiality is powerful in precipitating new social interactions by dint of shaping the physical environment.

When considering materiality in making, the focus tends to be on how outfitted a makerspace is, in terms of the range of making-related tools and gadgets. Compelling arguments have been put forth by maker educator researchers to broaden what counts as making and who a maker is (Peppler et al., 2016) by challenging what makers do and what they use materially to do so. Researchers (Honey & Kanter, 2013; Gollihue, 2019) have argued against the fetishization of high-tech gadgets that has come to characterize the maker movement (3D printers, laser cutters) while asserting that low-tech making is just as valuable (e.g., scrap building).

If materiality in making act as vectors of meanings with the potential to shape new social-futures for a widening range of community stakeholders, then it is not just the range of materials and tools that one should be concerned with but also what kinds of meanings, and for whom, particular materials act as vectors for. The direction in which power is exerted through materiality and its magnitude can be

bent by relationality. This has implications for what kinds of materials are present in making spaces, and who, relationally to youth makers, is shaping youth-material interactions. Since objects as vectors can evoke past experiences, a positive first encounter likely increases in importance. For example, the newcomer youth had been working with adult making mentors for more than a year before the toy and purse making sessions took place. Their established relationship was foundational for creating space for the difficult dialogue on what youth felt they needed but yet unavailable from the city's donations. This established relationship afforded open communication of preferred material to work with, and what artifacts youth wanted to make. This established relationship was only made possible by the many hours adult facilitators spent with the youth at the Willow community where they became keenly acquainted with the norms that govern that space, including what kinds of donations were in constant supply and what were lacking, and how these everyday needs, as impacted by state laws and rules of the host country, can intersect with the newcomer youth making program at Willow.

Likewise, with the little Free STEM library built by Fall and Samuel at Green Club, their 4-year long relationship with adult mentors was foundational for shaping the co-inquiry process. Adult facilitators engaged Fall and Samuel collaboratively as they probed the complex issue of library (in)access: what it means to live in a library desert, how access to libraries is complicated by an impoverished public transportation system, how these realities intersect with youth labeled as struggling readers in school, how these issues can inform what they do at Green Club.

The modes of action with which the culture of the maker movement need take to shift away from only reflecting the dominant culture, requires careful consideration on how making programs serving minoritized youth-of-color are outfitted, and who gets to decide what materials to use. As Miller (2005) explained, “the study of material culture often becomes an effective way to understand power, not as some abstraction, but as the mode by which certain forms and people become realized, often at the expense of others” (p.19).

Materiality mediated by relationality can also catalyze new social futures. The little Free STEM library vignette illustrates powerfully, how. Galvanized and sustained primarily by the relationality between the youth and their making program adult mentors in community, Fall and Samuel materially created and materially provided missing resources and services for their peers. The little Free STEM library at the community club is now, itself, a vector of powerful meanings, broadcasting possibilities for other youth-makers in the community. The little Free STEM library materially and symbolically messaged clearly to youth in community who could make and who changed their world. The ways in which new social futures were catalyzed across the vignettes were also varied. The little Free STEM library became a sustainable, consistent resource at the community club. The coding festival brought about a change in activities offered at the club for younger children that would offer them opportunities to make with Make Clubbers. YAC members impacted how other community members in their city, including refugee youth, might engage in making in ways that elevate their voice and agency in community.

Considering material culture and the power inherent in materiality removes blinders and perturb boundaries between youths' worlds in their everyday lives,

affording a more critically panoramic view of how social histories of physical materials can play an orienting role in making. A lack of such interrogation impoverishes the field's considerations of how exactly, making-related learning experiences could work towards justice-oriented roles such as democratizing STEM education, fostering creativity or supporting meaningful interdisciplinary learning, all goals espoused by maker educators and advocates of the maker movement.

Ethics and Consent

This study was conducted following the ethical review guidelines of the Institutional Review Boards at The University of North Carolina at Greensboro and Michigan State University.

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