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SANTA CRUZ

RESISTING AND/OR EXPANDING THROUGH HYBRIDITY: AN EXAMINATION OF HOW TEACHERS NEGOTIATE EQUITABLE FIELD-BASED EDUCATION IN THEORY AND PRACTICE

A dissertation submitted in partial satisfaction of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

EDUCATION

by

Alexandra I Race

March 2023

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Abstract

Resisting and/or Expanding through Hybridity: An Examination of How Teachers
Negotiate Equitable Field-based Education in Theory and Practice

Alexandra Race

Equity in science education is a central goal for many educators, researchers,
policymakers, learning institutions, community organizations, and more. Scholars are
increasingly looking to critical, intersectional, transdisciplinary, and dialectical
theories to better understand the tensions that promote or limit equitable science
education (Stetsenko, 2016; Sharma, 2020; Higgins et al., 2017; Takeuchi et al.,
2020; Strong et al., 2016). This dissertation explores one specific intersection of
science education inequity: access to equitable field-based education (EFBE).
Utilizing critical ethnography (Freire, 1970; Barton, 2001; Trueba,1999) and cultural-
historical activity theory (CHAT) (Vygotsky, 1986; Engestrom, 1987; Cole, 1988;
Leon'tev, 1978; Sannino, 2015), a patchworked theoretical framework I call critical
ethnographic CHAT (CE-CHAT) (Higgins et al., 2017), this research aimed to
understand how teachers, who were former participants of a professional
development program for pre-service teachers that aimed to prepare them to teach
EFBE in their future classrooms, took up the program goal of EFBE in their first
year(s) teaching, in both theory and practice, exploring the overlapping systems
constraining or expanding the process of hybridization. The findings from this study
provide insight into the multiplicities of enactment (Buxton et al., 2015) and nuanced
pathways that teachers took when trying to hybridize and enact EFBE in their
classrooms and the tensions they faced. From these pathways, a story of resistance

and expansion emerged, as all the teachers I spoke with, regardless of where they were on their pathway to EFBE, strongly believed in the goal of EFBE and saw it as something they could accomplish overtime.

Dedications and Acknowledgements

"Through others, we become ourselves." -Lev Vygotsky

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Chapter 1: Introduction

Equity in science education is a central goal for many educators, researchers, policymakers, learning institutions, community organizations, and others. However, inequities, be they systemic or context-specific, continue to exist, disproportionately impacting minoritized communities (Jones & Burrell, 2022). Much research has been done to understand how these inequities persist and are perpetuated. Scholars are increasingly looking to critical, intersectional, transdisciplinary, and dialectical theories to better understand the tensions that promote or limit equitable science education (Stetsenko, 2016; Sharma, 2020; Higgins et al., 2017; Takeuchi et al., 2020; Strong et al., 2016). One area of this research focuses on teacher education (TE) and professional development (PD). While TE and PD may only play a limited piece in teacher becoming, understanding how novice educators are prepared for, come to understand, and implement equitable science practices in their classrooms can provide much-needed insight into teachers' pathways to equitable science education practice (Fortney & Atwood, 2019; Szostkowski & Upadhyay, 2019).

This research explores one specific intersection of science education inequity: access to equitable field-based/nature-based pedagogy. As the field remains a space of historic whiteness and exclusion (O'Brien et al., 2020; Morales et al., 2020; Finney, 2014), and education is shaped by neoliberal policy and practices (Apple, 2001; Bazzul, 2012), other scholars and I argue, it is increasingly important to critically reflect on and conduct targeted research to expand FBE into a more equitable and inclusive space. Additionally, as both spaces are similarly commodified

(nature/the field and education) for capitalistic gains and the maintenance of hegemonic epistemologies (Wachsmuth, 2012; Carlone et al., 2016), research that explores this double deficit is needed to understand pathways toward liberatory practices in each space, individually and together (Freire, 1970). 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).

Many define field-based education as extending teaching outside the classroom and into real-world settings (Lonergan & Andersen, 1988). I, however, drawing from Cole (2007), use 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). This view invites a multiplicity of interpretations of the field, with attention to the unique understanding everyone brings. The rise of the use of outdoor spaces in formal education has grown during the COVID-19 pandemic to increase the safety of students and to expedite the return of in-person instruction. The benefits of teaching outdoors have been increasingly studied, showing to support engagement, benefit mental health, and support socioemotional connections (Rickinson et al., 2004). However, traditional outdoor/field experiences have often been found to be inaccessible by teachers and students due to costs/available resources, lack of preparation, epistemological orientations guiding experiences, and perceived value in a neoliberal context (Barrable & Larkin, 2020; Carlone et al.,

2016; Zavaleta et al., 2020; Bang & Marin, 2015). Additionally, a culture of teaching outside of the classroom is not the norm at most K-12 schools. Most students are lucky to have one outdoor science camp experience in elementary school and potentially a smattering of field trips in the rest of their education, always relegated to extra (Glackin, 2018). This is compounded for minoritized students, most likely to benefit from these experiences, as they typically have less history with outdoor/nature-based experiences (Finney, 2014).

Recognizing that field-based education and equity have arisen from different theoretical and epistemological foundations, this research aims to trace pathways to hybridity between the two. Following Bhabha (1994), hybridity is defined 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). Hybridity is situated in the intersections and overlap in between spaces of FBE and equity, keeping in the forefront social, cultural, and historical differences in origins, as potential areas of overlap. Attention to the positioning of FBE and equity within the hybridization process can provide insight into how individuals align epistemologically and where the areas of intersection might create expansive zones.

Using this framework, one can 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). One can come to trace the process to hybridity, but to do this, one must understand more clearly where equity and field-based/experiential theory and practice arise, that is, their ideologies and epistemology, mediational means, and expected outcomes, recognizing that these may differ for everyone. Markers of this process include new resources, pedagogical approaches, language, collaborative definitions, questioning, and more.

This research explores the expansive pathways to hybridization of equity and field-based education in teachers who were former participants of a professional development program for pre-service teachers that aimed to prepare them to teach equitable FBE in their future classrooms. This professional development program was implemented through their teacher education program and represents a collaboration across departments at a major west-coast university (Ecology and Evolutionary Biology and Education (MA/C Program)), the natural reserve system, and the local educational offices. Utilizing critical ethnography (Freire, 1970; Barton, 2001; Trueba,1999) and cultural-historical activity theory (CHAT) (Vygotsky, 1986; Engestrom, 1987; Cole, 1988; Sannino, 2015), a theoretical framework I call critical ethnographic CHAT (CE-CHAT), I aimed to understand how the participants took up the program goal of equitable FBE in their first year(s) teaching, in both theory and practice, exploring the overlapping systems constraining or expanding the process of hybridization. Guiding this research are the following questions:

1. How did teachers take up the negotiated object/goal of equitable field-based education?

   a. Do they translate this into practice, and if yes, how so?

2. How was the hybridization process shaped?

   a. Examine neoliberal tendencies, power inequities, and epistemological hegemony.

   b. How did teachers respond to these forces?

Equitable Science Education: A Space of Contradiction

As Fortney et al. (2019) insightfully recognize, "equity is a term that everyone in science education—teachers, researchers, policymakers, principals, school administrators, curriculum developers, test makers, funding agencies, and science activists—seems to understand intuitively but all understand differently" (pg.260). The consequence of this is that work toward educational equity in the sciences often emerges in ways that contradicts itself, and maintains the educational systems in which inequity persists (Carlone, Haun-Frank & Webb, 2011; Burgess & Patterson Williams, 2022). This is particularly evident in the disconnect between reform-based science education and social justice approaches to science education. The National Research Council (2012), that produced the Next General Science Standards (NGSS), defines equitable science education as:

> Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices: with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students' interests and

experiences is particularly important for broadening participation in science. (pg. 28)

In response to this vague definition, Calabrese Barton & Tan (2020) criticize how these reform efforts have failed to contribute to equitable science education:

> Like the previous attempt at reform (Project 2016 Science for All Americans,1989), the equity focus is primarily symbolic, with an expectation that students who do not benefit from the cultural norms of STEM will assimilate to the dominant culture. Equity talk, when construed as a one-size-fits-all, assimilationist lens (Calabrese Barton, 1998; Dawson,2014; Lee, 1999), ignores the disconnects and inequities wrought by imposing a Western science canon as universal, without considering the power-mediated cultural dimensions of STEM or of science teaching and learning (e.g., Bang & Medin, 2010). (pg.2)

While NGSS was collaboratively created by educational scholars, educators and others, the pathways to equity outlined lack critical and systemic analysis. These contradictory spaces of equitable science education put science educators and science teacher educators in a challenging position as they work to meet state mandated standards and introduce critical research-based science equity/social justice practices.

Increasingly, attention to equity and social justice have been seen as overlapping pathways towards equitable science education. However, again, competing understandings have led to a wide range of what equitable, social-justice oriented science education might look like. For many, this is a focus on inclusive practices that attend to culturally relevant science and community-based resources (Ladson-Billing, 1995). Others however, challenge this focus on inclusivity, instead pushing for a focus on rightful presence (Calabrese Barton and Tan, 2020). They explain, "Rightful presence, as a justice-oriented political project, focuses on the processes of reauthoring rights towards making present the lives of those made

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missing by the systemic injustices inherent in schooling and the disciplines (Calabrese Barton & Tan, 2019)" (pg.2). Navigating these ever shifting understandings is a time consuming process left largely to educational scholars. While these critical approaches to equitable science education work to dismantle systemic inequities, work needs to be done to translate these theories into practice to better clarify and support equitable science education in and out of the classroom.

While contradictions and variety of understandings of equitable science education exist, I agree with Rodriguez and Morrison (2019), "that it is essential for researchers, teacher educators and policy makers to more explicitly define (and adhere to) their ideological and conceptual positionalities in regard to diversity, equity and social justice throughout their work" (pg. 266). To work towards contributing to a more transparent and less contradictory space, I define my own positionality toward equitable science education. In the context of this work, I focus on one particular area of equitable science education, equitable field-based education. While the idea of "equitable field-based education" was explicitly framed as a concept that was being collaboratively defined and expanded during the professional development program, when I refer to equitable field-based education, I include the following criteria: Student-centered (Ladson-Billing, 1995); Based in a Common Experience; Supporting Environmental/Science Identity Development; Social justice/historical perspectives (Bang & Marin, 2015); Epistemic Heterogeneity (Rosebery et al. 2010; Pugh et al, 2019; Carlone et al., 2021); Accessibility (Zavaleta et al., 2021; O'Brien et al., 2020); Resources based in need (Dawson, 2014a);

Expansive view of the field (Cole, 2007); Non-binary definition of nature (Kimmerer, 2013; Little Bear, 2000; Grande, 2008); Racial and Environmental Justice Focus; and Reflexive Practice (Martin, Tran & Ash, 2019). These practices, in my opinion, work towards creating field-based learning experiences that "create(s) learning environments that connect in deep ways to the life experiences of all students" (Nasir et al., 2006, p. 499), while also working towards dismantling the exclusionary practices, both material and epistemological, in science education.

Pre-Service Teacher Professional Development: Utilizing the "Field"

Informal, "out of classroom" settings have been increasingly used as sites for pre-service teacher professional development. Spaces like afterschool programs (Katz et al, 2011), science museums (Gupta & Adams, 2012), and natural spaces (Trauth-Nare, 2015) have been found to impact pre-service teachers' professional identity, ability to translate theory into practice, and self-efficacy in teaching environmental science content, respectively. Professional development that promotes reflective practices in these spaces has also been found to increase agency, sensitivity to learners and context, and dialogic practice (Martin, Tran & Ash, 2019; Fien & Rawling, 1996). In spaces where field-based education might be better utilized, like environmental education (EE), teacher education and pre-service professional development remains underdeveloped (Heimlich et al., 2004; Yates et al., 2019; Li & Kransky, 2019). A recent report exploring EE professional development needs suggested these needs: implementation in K-12 settings, community engagement, equitable inquiry-driven approaches, networks of resources, and pedagogical tools to

address the growing climate crisis (Fleming, 2009). While there has been an expansion of in-service EE professional development and the impact these have had on teacher practice (Li & Kransky, 2019; Sondergeld et al., 2014), there have been few programs centering around environmental equity. Research that centers on pre-service professional development programs centering on equity and environmental education is much needed to inform/transform such programs.

While analytically I take an 'expansive view' of the field, historically field-based education defines the field to "cover any arena or zone within a subject where supervised learning can take place via first-hand experience, outside the constraints of the four-walls classroom setting" (Lonergan & Andresen, 1988). Field-based learning that occurs in the physical, environmental, or biological sciences typically occurs in natural settings like reserves or beaches, though the "field" can also mean the schoolyard, a city block, or student's homes. How we define the field and field-based education are increasingly important as a tool towards equity and access, and are additionally relevant as the challenges of COVID-19 have made typical field experiences even more challenging to organize.

Field-based learning has been found to be an impactful approach for many students. In higher education settings, field-based learning has been found to increase retention and self-efficacy in Ecology and Evolutionary Biology majors, especially in minoritized students (Beltran et al., 2020). During COVID-19, online field courses provided an important source of respite and connection to local places (Race et al., 2021). Field-based learning also provides opportunities to learn and practice relevant

techniques, have first-hand experiences with course content, and can enhance higher-order learning and increase interest in the environment (Lonergan & Andresen, 1988). In K-12 settings, the utilization of field-based education is limited due to a variety of physical, psychological and resource barriers. These include fear and concern about health and safety; teachers' lack of confidence in teaching outdoors; school curriculum requirements; shortages of time, resources, and support; and student resistance (Dillon et al., 2006). Important for overcoming these barriers are administrative support (needed to overcome the structural barriers); professional support; and curricular support. It is important to note that the word barrier has been noted by some to support deficit discourses around creating equitable science programs and offerings (Dawson, 2014b). This work and use of the word barriers tries to avoid that and instead, "explain why and how social exclusion arises," and works to offer support to those, "attempting to understand and develop socially inclusive science" (Dawson, 2014b, pg.2). The program being studied aims to provide teachers with the resources and confidence to address these barriers while incorporating a much-needed focus on equitable field-based education.

Limits to Equity: Teacher Education, FBE and Neoliberalism

The call for a commitment to equity and social justice in education has been steadfast for many years (Ladson Billings, 2006; Neito, 2000). While there are many pathways towards equitable education, one area that has been called into focus is teacher education (Cochran-Smith et al., 2016; Thompson, Darwich & Bartlett, 2020). Understanding how teacher education programs prepare future teachers to

teach for equity and social justice can provide insight into how teachers take these practices into their classrooms. Some argue that a central need in this preparation are tools to grapple with the neoliberal agenda that may limit teachers' ability to teach for social justice (Bartell et al., 2019; Reagan et al.. 2016). Neoliberalism focuses on the goals of economic and global competitiveness, shifting the role of education from a social function to an economic one (Apple, 2001; Bazzul, 2012). As described by Bartell et al. (2019), in this neoliberal context:

> curricular reforms were implemented which reduced learning to bits of information and skill to be taught and tested, efforts were made to reduce educational costs through moves such as increasing class sizes, and teachers' work was intensified at the same time teachers were isolated from decision-making processes and from each other (Ross & Gibson, 2006). (pg.302)

Neoliberal reforms place teachers into a position of limited agency, where schools prioritize measured success and standardized views of teacher quality over innovative pedagogy (Sharma, 2017). As described by Tolbert et al. (2021), many teachers may face a "praxis crisis" when trying to implement social justice based approaches in their classrooms, the desire to use their approaches they learned in their teacher education program met with resistance and challenges.

How teachers are prepared to address the growing neoliberal agenda in education grows increasingly challenging as areas of education become imbricated in a growing hegemonic neoliberal ideology. This ideology, as Bencze and Carter (2011) describe, promotes "such virtues as individual responsibility, competition, excellence, efficiency, standardization, privatization, and commodification" (pg. 650). We see such virtues translated in spaces, like the science classroom or field

sciences, which means, as Bazzul (2012) states, "emphasizing individual achievement over the common good and consumption while underemphasizing, depoliticizing, and naturalizing the role of corporations, market logic, and private interests in science" (pg. 1005). This thinking can lead to proleptic schemas, or overly future oriented thinking. Bunn and Bennett (2020) explain how neoliberalism can create education systems, "preoccupied with the future, with study increasingly viewed as being important for and in the future, rather than valuable in the present" (pg. 698). Thus, individualism, competitiveness, commodification, privatization, proleptic schemas and standardization are hallmarks of neoliberalism and are important markers for tracing neoliberal tendencies in teacher education, professional development and schools, as teacher collective power is deliberately diminished, students are increasingly tested, and schools become businesses (Tolbert, Spurgin & Ash, 2021).

Some have imagined field sciences as a space of moderate pushback on neoliberal ideologies, Carlone et al (2016) citing that field sciences can promote "wonder (Gilbert, 2013), learning for learning's sake, aesthetics (Wickman, 2006), collective agency, interdependence of living things, conservation, and altruism" (pg. 199). Despite this, neoliberal logics in K-12 settings can lead to diminished field-based opportunities due to cost or lack of prepared educators (Dillon et al., 2006) and a perceived lack of value in terms of preparing for valuable job opportunities (i.e. biomedical sciences vs. natural sciences) (Fleischner et al., 2017). This in turn, leads to fewer opportunities for students who come from lower socioeconomic schools, decreasing the diversity of students exposed to field-based pedagogy.

Field-based education, historically and currently, has largely been created by and offered to middle-class, western European-Americans (Newsome, 2020; Taylor, 1992; Toomey, 2018). Additionally, people of color are often subject to practices in FBE that can lead 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). As Ash and Race (2021) note, "such othering practices are often rendered invisible by forces like neoliberalism, systemic racism and dualism supporting dominance (i.e. nature/culture), and thus, are accepted as normative behavior" (pg. 3). Research and practices that work to name and shift these othering behaviors are central to developing equitable field-based education.

Epistemologies Contributing to FBE

How individuals come to understand their place in the world, both physically and culturally, is often greatly influenced by systems of education. How explicitly or implicitly concepts of nature, place and beyond are explored, where they are explored, and how can contribute to the privileging of certain epistemological understandings. In science education, western science epistemologies are seen as normative, and as Pugh et al. (2019) explain:

> often when scholars have engaged in understanding students' and teachers'... epistemic orientations that are distinct from western science they have done so with the goal of the   goal of replacing, changing, or facilitating their participation in dominant paradigms instead of working to develop learning environments that engage epistemic heterogeneity (Rosebery et al. 2010).(pg. 3).

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This to me highlights a need for researchers to understand and champion the diverse epistemologies that students bring to science and other educational spaces. Field-based education requires a deep understanding of the historical emergence of the dominant narratives and understandings of nature, the environment and the field and the explicit and implicit consequences of these epistemologies. Engaging in equitable approaches and epistemic heterogeneity, where heterogeneity means spaces for different ways of knowing and relating to science, requires an exploration of non-dominant epistemologies as to name and privilege these in practice and research. It calls for, as I, and others have argued in varying ways (Bang & Marin, 2015; Carlone et al., 2021), an epistemological justice, drawing from and acknowledging all the epistemologies, language and practices that have been silenced.

Dominant (western) conceptions of nature greatly shape traditional approaches to field-based education. Western ideas of nature stem from the European Enlightenment and the Cartesian binary (Callicott, 1992), which as Moore (2015) describes "extend[s] Descartes' famous mind–body dualism to the notion that Nature and Society are epistemically, even ontologically, independent entities" (pg. 9). This nature/culture, nature/society dualism has contributed to an understanding of nature as separate from humans, and "wilderness" and "nature" are seen as spaces untouched by human development. While scholars point out that this separation is one that is merely a human creation, as Cronon (1996) states, "wilderness hides its unnaturalness behind a mask that is all the more beguiling because it seems so natural" (pg.7), this ideology is pervasive in our language, understandings of environmentalism, and how

we interact with nature. This idea, that man is separate from nature, as succinctly described by Wachsmuth (2012), "has played [a role] in (1) legitimizing both the human domination of nature in the name of progress, and (2) naturalizing socially produced injustices such as inequality, racism, sexism, war, and imperialism" (pg. 508). Even moves toward environmentalism, sustainability and "greening" have been taken up and largely driven by capitalist goals like profit, gentrification, and expanded markets (Smith,1996; Checker, 2007; Greenberg, 2015). As Angelo (2021) points out, these pursuits, especially within the context of the "greening" of urban spaces, are similarly justified by these dualisms, with the ubiquitous idea that "green-a(i)s-good."

In response to this, other epistemologies of nature have arisen in field-based education. For example, educators are being increasingly introduced to Indigenous epistemologies as a counter to western science epistemological dominance (Medin & Bang, 2014; Bang & Marin, 2015). The binaries of nature/culture, nature/society, nature/human that dominate Western epistemologies do not have the same hold in Indigenous knowledge (Kimmerer, 2013; Little Bear, 2000; Grande, 2008). As Medin & Bang (2014) summarize, "the European American model sees humans as separated from nature and the Native American model sees humans as a part of and living in relationships with the rest of nature" (pg.12). When dichotomies/binaries that are used to dominate and create power over people, land, animals, etc., do not exist, the moral obligation returns. When the distinction between human and nonhuman and the associated agentic dominance given to humans is removed, it shifts understanding of

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who has knowledge and influence. Understanding what these pedagogical approaches utilizing epistemic heterogeneity might look like in field-based education is essential to creating expansive spaces of epistemic justice.

Hybridization

Hybridity theory has been used broadly in education research to conceptualize how power, epistemologies, languages, and cultures may come together to create spaces of negotiation and scaffolds of learning while moving away from dichotomies driving further disjunction. Educational scholars using hybridity theory draw largely from Bhabha (1994), Moje et al. (2004), and Gutierrez et al. (1997) to theorize how hybridization might be explored and described. Bhabha (1994) first described the concept of third space: a space that can emerge between competing forms of knowledge, discourse, etc. Drawing from postcolonial theory, this concept tries to represent the many paths and tensions that individuals must travel in borderlands, where their way of being is not supported or represented. Hybridizing the ideas/discourse/culture of the previously disjunct spaces, third spaces attempt to put together "traces of certain meanings or discourse" giving "rise to something different, a new area of negotiation of meaning and representation" (p. 211). Moje et al. (2004) describe third/ hybrid space in education research in three ways (as summarized by Cuenca et al. (2011), pg. 1069): "(1) build bridges between marginalized discourses; (2) allow members to navigate across different discourse communities; and (3) create conversational spaces that bring competing discourses into dialogue with each other." In this perspective, ''everyday resources are integrated with disciplinary learning to

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construct new texts and new literacy practices that merge the different aspects of knowledge and ways of knowing offered in a variety of spaces'' (Moje et al., 2004, p. 44). Gutierrez et al. (1997) utilize activity and sociocultural theory (Vygotsky, 1986; Engestrom, 1987) to conceptualize third spaces as expansive zones of proximal development to help "understand the complexity of learning environments and their transformative potential" (pg. 287). In this view, hybridity is proposed as "both as a useful lens, a theoretical tool for understanding the inherent diversity and heterogeneity of activity systems and learning events, as well as a principle for organizing learning. Utilizing multiple, diverse, and, even, conflicting mediational tools promotes the emergence of third spaces, or zones of development, and, thus, expands learning (Engeström, 1987)" (pg. 288).

In my work, I draw from all three scholars to conceptualize hybridization. However, I take Bruna's (2009) analysis and critique of these scholars to heart, her argument emphasizing that hybridity is always happening and it is not something that must be 'achieved,' per se. Thus, while I recognize that hybridity is inherent in the system, the process of hybridization here is centered on two disjunct areas of scholarship/practice "field sciences" and "equity," a very narrow lens that may miss the many other hybrid spaces the teachers may have created in the professional development program. Similar to others exploring hybridization in teacher education (Cuenca et al., 2011; Zeichner, 2010), I aim to understand how teachers came to see these concepts in a hybrid way, exploring the practices, language and tools that emerged. I agree with Bhabha (1994) that "Learning to work with contradictory

strains of languages lived, and languages learned, has the potential for a remarkable critical and creative impulse" (p. 210).

Theoretical Framework

Guiding this research, is a theoretical framework that patchworks critical ethnography (Freire, 1971; Barton, 2001; Trueba,1999) and cultural-historical activity theory (CHAT) (Vygotsky, 1986; Engestrom, 1987; Cole, 1988; Sannino, 2015), that I call Critical Ethnographic CHAT (CE-CHAT). This framework supports research that is equity-driven, centers praxis, destabilizes neoliberalism and dominant ideologies, engages in multi-sited sensibilities, and uses an intersectional analysis, exploring the overlapping influences of power, identity, and more, to dialectically explore how science education can be re-positioned for expansive, community-focused learning. Critical ethnography and CHAT are theoretically aligned in their foundations, drawing from Marx, Vygotsky, structuralism, and materialism, making the marriage a comfortable fit (Langemeyer & Roth, 2006). In this section, I briefly outline the theoretical aspects I draw from in CHAT and Critical Ethnography, and then describe CE-CHAT and how it guides this research. I also describe hybridity theory.

Cultural-Historical Activity Theory

Cultural-Historical Activity Theory (CHAT) is a framework that emerged from sociocultural theories of learning. Socioculturalism was the theoretical product of Russian psychologists Vygotsky, Leont'ev, and Luria (Sannino & Engestrom,

2018), who recognized that learning is collective activity entrenched in cultural and social products and understandings of the world. CHAT draws from the rich body of theories on development, learning, and language developed largely by Vygotsky (1986) and centers activity as the main driver of human systems, which has led to different interpretations of the theory (Werstch, 1998). Significantly expanded in modern educational research by Engestrom (1987) and others (Cole, 1988; Sannino, 2015), CHAT has gone through four generations, the theory growing to embrace the complexities of the systems that it has been used to analyze (i.e. schools, hospitals, businesses, etc.).

I draw from third-generation CHAT, which emerged to "develop conceptual tools to understand dialogue, multiple perspectives, and networks of interacting activity systems" (Engestrom, 2001, p. 135). Engestrom (2001) outlines five principles to summarize and describe CHAT in this current iteration.

First, the unit of analysis is the collective, interacting activity systems working towards a common object. While individuals and other factors impact and drive the system, and can be sub-units of analysis, these interactions are best understood through the lens of the complete activity system(s). The second principle is multivoicedness. Multivoicedness is a recognition that activity systems contain many diverse people and perspectives. As Engestrom states "the activity system itself carries multiple layers and strands of history engraved in its artifacts, rules and conventions" (pg. 136). The tension that exists between these widely impacts the activity system(s) and demands action. The third principle is historicity. Activity

systems have a history that must be known to understand the impact it has had on the current meanings shaping the activity. The fourth principle is the role of contradictions as drivers of change in the system. As Engestrom (2001) highlights, these are not the same as problems or conflicts. Contradictions emerge from the historical accumulation of tension within and between activity systems. Finally, the fifth principle is the possibility of expansive transformation driven by contradictions. An expansive transformation can occur when the object and goals of the system are changed and broadened, the activity system growing and shifting to accommodate these new ideas.

These five principles combined contribute to the theory of expansive learning, which "puts the primacy on communities as learners, on transformation and creation of culture, on horizontal movement and hybridization, and on the formation of theoretical concepts" (Engestrom & Sannino, 2009, pg. 2). This theory of learning, which draws from Lave and Wegner's (1991) theory of situated learning, moves beyond the unidirectional conceptualizations of learning to truly embrace expansion as a metaphor. In an expansive learning cycle, the object of learning does not yet exist, instead, it is created through the collective negotiation of an object, the need for such negotiation emerging from contradictions within the activity system.

Expansive learning and transformation require attention to the agency required to recognize and make a change to a system. Engestrom (2011) named this transformative agency and highlights how it is used to develop "new concepts that may be used in other settings as frames for the design of locally appropriate new

solutions" (p. 606). Sannino (2015) argued that transformative agency is a product of double stimulation in the expansive learning cycle. Double stimulation was first used by Vygotsky (1997) as a way to assess higher order learning and to better understand the role agency plays in object oriented activity (Engestrom & Sannino, 2009). In an intervention using double stimulation, one gives an individual or group a challenging task, the first stimulus. This is then followed by the introduction of an external artifact, the second stimulus, that can be used as a new mediating artifact to help solve or reframe the task at hand. It is important to mention here that a second stimulus is different than a typical mediating artifact in that it is: (1) "actively constructed by the participants", (2) "requires that an ambiguous and often quite skeletal or sketchy artifact is step-by-step filled with increasingly rich meaning", (3) "has to take the shape of a relatively stable material representation that can serve as an 'anchoring device'" and (4) "is constructed for the purpose of dealing with the challenge of the contradiction manifested by the first stimulus" (Engestrom, 2011, p. 621). This lens gives us insight into how everyday situations can give rise to agency, exploring how people come to "break away from what is given" (Engestrom et al., 2020, pg 4). In my research, this gives insight into the emergence of transformative agency in the hybridization process, like how teachers might address challenges they face while attempting to theoretically and practically approach equitable field-based education in their classrooms. Indeed, even the concept of "equitable field-based education" could be seen as a second stimulus as it is actively constructed by participants and increasingly filled with rich meaning to address the challenge of lack

of diversity in conservation and ecological sciences (as defined by professional development program goals).

Transformative agency through double stimulation is one of many aspects that provides insight into the dialectical nature of CHAT, which is fundamental. As Engestrom et al. (2020) state, "dialectical thinking enables us to go beyond categorising types of agency to actually revealing the processes of its emergence and development, and the ethical quandaries and responsibilities attendant with becoming entangled with those processes" (pg.5). As described by Dafermos (2018), "Dialectical thinking examines an object in the process of its change and transformation. It focuses on the analysis of a thing in its mutual, internal connections with other things" (pg. 246). CHAT has the potential to view human development in non-reductionist ways through dialectics, though some argue this is often lost in current research employing CHAT (Langemeyer & Roth, 2006), researchers straying from CHAT's roots in Hegel and Marx, which provide theoretical foundations for Vygotsky's use of dialectics. Attention to the dialectics in research urges us to further examine the complex nature of social development, and critically examine the genesis of systems and their actors. This brings to light the role of the researcher, the focus of analysis, and what is potentially lost or misrepresented when CHAT is weakly theorized. In my research, dialectical thinking is central to conceptualizing the hybridization process, as hybridization is inherently dialectical. Dialectics remind us that systems are always in a state of change, and provide a lens into the process of development, like hybridization of the object of "equitable field-based education."

In conclusion, CHAT is a valuable research approach that brings into focus over-lapping systems, emerging contradictions, the role of mediational means, and cycles of learning and transformation, all within a broader cultural and historical contexts influencing meaning and outcome. The four main principles I center and draw from CHAT are (1) the expansive learning cycle (Engestrom, 1999); (2) the concepts of historicity and multivoicedness;(3) transformative agency through double stimulation (Sannino, 2015); and (4) dialectics (Vygostsky, 1997) . For me, when these four principles are utilized in a CHAT driven design and analysis, research and teaching better attends to the role of power, differing historical and cultural contexts and how that might influence emerging contradictions and negotiated objects.

Critical Ethnography

Critical ethnography emerged from the reassessment of the dominant paradigms and epistemologies in the social sciences and humanities, beginning largely in the 1960s. As researchers became troubled with the positivistic approaches' inability to capture the complexity of social reality, and traditional ethnographic approaches were seen as too ahistorical and apolitical, a resurgence of interest in feminism, Marxism, and phenomenology arose (Anderson, 1989). In the field of educational research, specifically, critical ethnography gained popularity in the early 1980s, drawing influence from neo-Marxism, feminist theory, and Freireian research (Lather, 1986; Palmer and Caldas, 2015). It represented a merger between critical theory and ethnography, which was both timely and necessary, as it moved critical

theory towards practice and ethnography into the political realm (Barton, 2001;

Anderson, 1989; Palmer and Caldas, 2007).

As a methodology, it still shares similarities with ethnography. These include

long-term immersion in the field, participant observation, extensive interviews,

artifact collection, and "thick description" of the culture or community they aim to

describe (Palmer and Caldas, 2007; Geertz, 1973). Multi-sited analysis is also used.

Rahm (2012) describes, "a multi-sited ethnography.. is best understood as a sort of

ethnography that "reconfigures and complexifies the spatial plane on which

ethnography has conceptually operated" (Marcus, 1998, p. 63)" (pg.126). In short, a

recognition that one site is not enough and only gives a partial view. This may be

especially important when the concept of the 'field' is invoked. Additionally, it shares

a reliance on qualitative data analysis techniques, such as coding and grounded theory

(May, 1997). However as described by Thomas (1993), "traditional ethnography asks

what it is, critical ethnography asks what it could be" (pg.4). Critical ethnography

moves beyond cultural descriptions and analysis by the researcher, instead looks to

challenge the status quo or norms through the voices of the subjects (Thomas, 1993).

Critical ethnography has evolved and been shaped by various critical

traditions to build a more critical and transformative methodology. This

diversification often means there is no one right way to do critical ethnography, but

there are common domains, described by Barton (2001):

> As a result, critical ethnography has broadened, drawing its strength not only
> from its openly ideological agenda but also from its embrace of human
> agency, which it locates within the shifting, contextual, and multilayered
> terrain of power and oppression. (pg.906)

In other words, this methodology centers the human experience as a way to name (and dismantle) hegemonic practices. Indeed, a central tenet of critical ethnography is "that social life is constructed in contexts of power" (Noblit, 2004). Thus, one of the goals of critical ethnography is that it attempts to analyze social and power dynamics that are not immediately nameable.

Critical ethnography has been criticized by some, given it is seen as "openly ideological research" (Lather, 1986), though this argument has gained less traction with the recognition by many that no educational research is neutral, though to varying degrees, especially in science education research (Blair, 2004). As stated by Anderson (1989), "the apparent contradiction of such value-based research with traditional definitions of validity has left critical ethnography open to criticism from both within and outside of the ethnographic tradition" (pg. 253). Despite the methodological rigors that critical ethnographers often take, the agenda of critical ethnography does not line up with traditional ethnographic call for "objectivity," though the concept of "objectivity" in research itself has been questioned. Lather (1986) addressed the challenge of being in what she calls being "between a rock and a soft place" by suggesting traditional approaches to validity (e.g. triangulation, member checks and theoretical grounding), as well what she called catalytic validity or "the degree to which the research process reorient, focuses, and energizes participants in what Freire (1973) terms 'conscientization' "(pg. 67). We see the impact of this call for catalytic validity in the work of Trueba, Barton and others.

One challenge of critical ethnography is the time that must be dedicated to the research. This concerned me because the space I research is often limited to weeks, rather than years. To lessen this concern, I found the concept of an "ethnographic stance" helpful (Moschkovich, 2019). Moschkovich (2019) reminds us "even if the research design is not full-blown ethnography, a study can use a mixed tool kit that includes some ethnographic methods such as participant observation or open-ended interviewing" (pg. 65). Additionally, one can still use the many theoretical assumptions of the methodology while perhaps not conducting a full ethnography. However, this does limit the research questions that may be asked. In the case of a "critical ethnographic stance," I would argue some central theoretical assumptions may not be obtainable in a shorter amount of time (i.e. liberation) but work to name oppression and create spaces for change can be started. This is a tradeoff that one can live within while being conscious of and naming the constraints.

To conclude, critical ethnography offers an approach to education research that challenges the neoliberal, hegemonic practices that maintain an exclusive culture in education. I personally draw from Barton (2001) (who draws from Trueba and Freire) to align my theoretical and methodological understanding of critical ethnography. These are:

> (1) "critical ethnography is situated within the belief that all education and research is intrinsically political and steeped in cultural beliefs and values"; (2) "Critical ethnography is based on a vision of praxis centrally about a ``political commitment to struggle for liberation and in defense of human rights''"; (3) "Research is framed through the agency and the corresponding responsibilities of the researcher and the researched"; and (4) "Critical ethnography is research that is an advocate for the oppressed in ways that

genuinely embrace the histories, cultures, and epistemologies of the oppressed" (pg. 906-907).

For me, these goals center equity, praxis and work to change spaces of science through fostering the agency of individuals.

Critical Ethnographic Cultural Historical Activity Theory: CE-CHAT

The theoretical framework of CE-CHAT that I use addresses concerns that CHAT and critical ethnography individually face. Critical ethnography brings critical theory and an intersectional lens that CHAT so often is lacking. Also, power is central to critical ethnographic research, which moves CHAT towards an analysis that can take on a more transformative activist stance (Stetsenko, 2016). Critical ethnography also helps CHAT avoid the common shortfalling of a reductionist view of a system with its increased attention to the reflexivity of the researcher (Barton, 2001). Conversely, CHAT can strengthen critical ethnography with tools to analyze organizations. Also, with its historic use in a variety of spaces, it opens up research towards the analysis of larger systems.

Agency is central to the potential transformation of spaces explored by CHAT and critical ethnography. CHAT brings attention to the emergence of transformative agency and critical ethnography invites the development of critical consciousness, both embodying the commitment to praxis that CE-CHAT promises. This attention to both concepts re-orients the focus from praxis to transformative praxis (See Figure 1). As Maseko (2018) explains:

> Praxis is part of critical consciousness through which one demonstrates the ability of reflexive thinking that leads to commensurate transformative action. Transformative praxis is a product of multidimensional critical consciousness,

> which is informed by the notion of education as a practice of freedom and praxis, which Freire explained as "reflection and action upon the world in order to transform it" (1970, p. 36). (pg. 84)

In educational research, transformative praxis challenges us to question the purpose of education and examine the ideological and material forces (neoliberalism, whiteness, systemic inequities) that enhance or limit praxis. It moves towards larger, institutional changes to structures that limit equity and maintain oppression, working to break out of the cycle of reproduction and reification. In this research, transformative praxis provides a lens into how teachers might take up the hybridization of equitable field-based education and translate it into their classrooms, with attention to how they strategically navigate the systemic tensions they face.
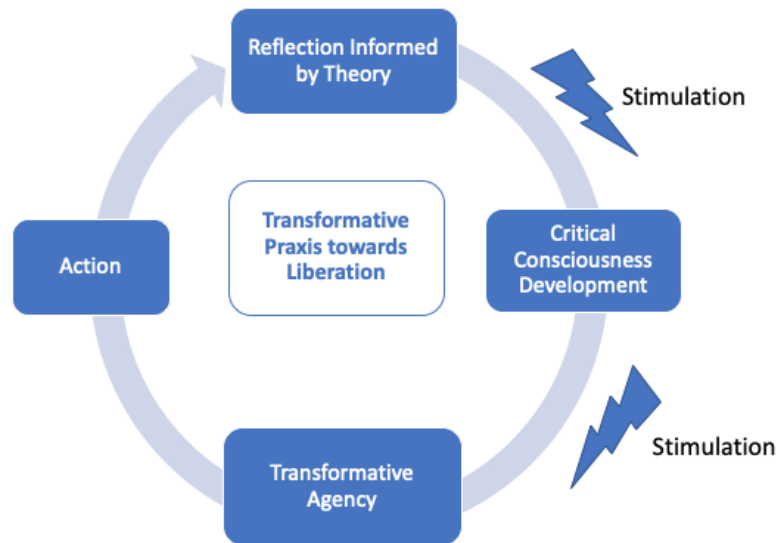
Figure 1. Model of the Hybridization of Transformative Agency and Critical Consciousness to Conceptualize the Development of Transformative Praxis

CE-CHAT prioritizes research that centers equity and moves toward practices that support it (praxis) by critically examining forces constraining or expanding it.

Both CHAT and critical ethnography see change as an important outcome of learning. Through the lens of CE-CHAT, the expansive learning cycle can support research that centers on the intersecting inequities systems bring to education. However, here attention to the multi-sited sensibility of research is vital. Multi-sited sensibility refers to "the methodological imperative of understanding learning as "movement" within and across activity systems—a sensibility central to equity-oriented and humanist research on learning among youth from non-dominant communities" (Vossoughi & Gutierrez, 2014, pg 604). Third-generation CHAT similar calls for a multi-sited lens, Roth & Lee (2007) emphasizing:

> What is needed is to recognize that the foundations of knowing are surely multisite ecologies integrating the individual, social, and whatever cultural tool kits are salient across the life span. Researchers who adopt third-generation activity theory hence make it a priority to ascertain the role of dialogue, multiple perspectives, and issues of power when dealing with interacting activity systems as networks. (pg. 200)

Through CE-CHAT, this sensibility centers the non-static, everyday process of learning, calling for greater attention to historicity and multivoicedness within activity systems, with better attention to the overlapping influences of multiple systems on the expansive learning cycle. Vossoughi & Gutierezz (2014) reaffirm, "indeed, this inquiry into the range of activity systems implicated in a given setting lies at the crux of our emergent articulation of a multi-sited sensibility for research on learning" (pg. 622). In this research, this calls for attention to the many systems/sites influencing the hybridization process, each bringing their own histories, rules, epistemologies, hierarchies that shape "equitable field-based education" as well as the teachers moves towards transformative praxis in their classrooms.

In CHAT and Critical Ethnography, the researcher and the participants both play a central role in shaping the trajectory of the space or activity being studied. This calls for explicit attention to what is being explored and why. Stentsenko (2021) calls for:

> direct acknowledgement (see Philip et al., 2018, p. 83) that we must "carefully examine and address the cultural and political contexts and consequences of our scholarship" so that we can deliberate questions of "*for what, for whom*, and *with whom*" that are necessarily intertwined with the *how* of research. This is a bold call for a new ethos of scholarship that makes "explicit our own understandings of power and our visions for equity and justice" (Philip et al., 2018, p. 83). (pg. 6)

Researchers that utilize CE-CHAT must take this into consideration and I believe it is key for moving education research towards the goals of expansive, community-driven learning. In this work, I use CE-CHAT to critically examine the systems that shaped how pre-service teachers from each year of the Program took up and hybridized the negotiated object of equitable field-based education and how this manifested itself in their classroom practice. I also use CE-CHAT to explore the power differentials, both epistemological and structural, across the multiple systems that came together to support the professional development program.

Chapter 2: Research Design and Methodology

Project Overview and Context

This study investigates the pathways teachers took toward the hybridization of equity and field-based education (EFBE) in theory and practice, capturing the local and systemic tensions they faced. These teachers were participants in the pilot years of a professional development intervention program ("The Program") for pre-service teachers (PST) that aimed to prepare them to teach EFBE in their future classrooms. The research questions that guided this study are:

1. How did teachers take up the negotiated object/goal of equitable field-based education?
    a. Do they translate this into practice, and if yes, how so?
2. How was the hybridization process shaped?
    a. Examine neoliberal tendencies, power, and epistemological hegemony.
    b. How did teachers respond to these forces?

Investigating these questions required an embedded case study design across multiple layers of analysis. At the collective level, I conducted a mixed methods case study of 16 teachers who participated in the Program from 2018-2021. These teachers were interviewed and surveyed, and member checks were conducted. At this level of analysis, five equitable field-based lessons (EFBL) were observed, three in-person and two via written reflection and interview. Previously collected data from teachers' time in the PD program was also used to inform how the hybridization process was shaped. The purpose of this case study was to gain a better understanding of how teachers came to take up and understand the goal of EFBE, what shaped the

hybridization process, what systemic tensions/barriers they faced when trying to implement EFBE and how they responded to these forces.

To better capture the nuanced and multiplicities of pathways to EFBE, a CE-CHAT-informed comparative case study (CCS) was conducted of four teachers (Buxton et al., 2015; Bartlett & Vavrus, 2017). The focal teachers were selected due to their unique and reflective practice and were paired with the teacher who either faced similar local contradictions or shared similar responses to tensions in their pathways to EFBE. Guided by CE-CHAT, these CCS contextualize teachers' journeys to EFBE with a focus on historicity, tracing teachers' journeys to teaching; multisitedness, tracing tensions and ideas across the activity systems influencing teachers; and attention to transformative praxis, exploring limits and supports to cycles of praxis. Previously collected data was used to supplement these CCS, informing my understanding of teachers' pathways to and through the Program. At this level, interviews with Program Leadership helped provide context for the Program and its evolving offerings/goals through the pilot years.

Context

The Equitable Field-Based Education (EFBE) Program, referred to as the "Program" in this study, is a pre-service teacher 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 interdisciplinary, collaborative group emerged in 2018 with a shared

commitment to advancing diversity and equity in ecology and conservation biology through equitable approaches to field-based education. Organizers recognized the limited field-based experiences that K-12 students were exposed to and hoped to change this through a "teach-the-teacher" model, where participants would share and spread the practice of EFBE in their future schools. The current overall program goal is to "empower diverse educators to in turn empower their students via equitable field-based learning opportunities, ultimately fostering diverse leadership, voices, and cultural traditions in environmental and climate risk mitigation science in California." Long-term, the system-wide goal is to disseminate the professional development model state-wide to other teacher education programs, increasing the number, scope and reach of teachers trained in equitable field-based pedagogy and some efforts have been made to do this.

Housed in the pre-service teachers Master Credential Program and supported with funds from the Natural Reserves, program components varied over the years because of the global pandemic and shifts in program expectations and leadership, creating what one might consider a natural experiment (see Appendix). For example, in the first year of the program, most of the planning and workshop development was done by leadership from the Biology Department. In the second and third years, a Program Coordinator was hired, a science educator and lecturer, shifting much of the planning into the Education Department, with less involvement from the Biology Department leadership. The consistent program components included: the integration of Program content into two of the student teachers' courses (Science Education:

Research and Practice and Science Methods), quarterly Saturday workshops, and implementation of program strategies in lesson plan development. Leadership and organization of these components have shifted over the years of the program, leading to a natural variance in the approaches and focus of the program. Currently, there is no formal network of past Program participants, though during years two and three of the program, one or two past participants were invited to one of the quarterly workshops to share their experience implementing equitable field-based learning opportunities in their current classrooms. Additionally, the resources offered varied through the years of the program. For example, one key resource produced during the second year of the Program was a document outlining the criteria necessary for "Equitable Field-Based Learning Opportunities" (EFLO). These criteria were collaboratively developed by the second cohort and were defined as: "EFLO curriculum *must* address the following core themes: student-centered, NGSS-aligned, common experience, environmental identity, and social justice/historical perspectives." This resource was not made available to the first cohort, and the third cohort was not given the space to collaboratively expand on these criteria. Resources also varied in terms of the workshop's focus and guest speakers.

Participants joined the Program via self-selection. Program leadership advertised the Program to pre-service teachers during one of their seminar classes, and asked them to apply if they felt motivated, felt they could manage the additional work and if they felt they would be a good fit for the group. The participants in the Program varied over the years as well. The first year of the Program was designed

specifically for secondary science credential PSTs. The subsequent years expanded

the offering to multiple subject (elementary) teachers as well, though no changes

were made to accommodate this expansion. Over the three years of the pilot, 24

teachers participated in the complete Program offerings (see Appendix).

Prior experience in the Program context

This dissertation contributes to a larger longitudinal case study of the

professional development intervention program (2018-2022). In 2018, at the start of

the professional development program, I was asked to act as a graduate researcher

and participant observer for the project. In collaboration with my advisor, Dr. Ash,

we developed the research design and data collection protocol. During the first three

years of the program, I conducted interviews with participants, observed most of the

workshops, and collected surveys, associated artifacts, and reflective journals. My

role as a participant observer established me as both an expert and learner with the

participants in this study, us working together to come to understand how the goals of

the PD program might be implemented, understood, and evolved. The data that I

collected helped inform the subsequent programmatic offerings and focus of the

Program, as I analyzed feedback and responses from participants and suggested

relevant changes to Program Leadership.

Some of the themes explored in this dissertation were initially investigated in

data from the first year of the program. This research led to the manuscript by Ash

and Race (2021), titled "Paths Toward Hybridity Between Equity and Field-Based

Environmental Education for Pre-Service Science Teachers." This paper identified

three main tensions that arose in the Program for pre-service teachers in the first year: "(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" (pg.1). These initial themes provided insight for this study and helped guide research question development and the theoretical framework.

Since the end of the pilot years of the Program, I have continued to study the Program, though I have taken additional leadership roles, especially in the 2022-23 year of the Program. I have played an active role in designing and evaluating the workshops, helping provide guidance and feedback to pre-service teachers throughout the Program, and even presenting on topics like Epistemic Heterogeneity. This multi-year involvement in the Program has provided me with an in-depth understanding of the Program's evolution, goals, and implementation. While I have contributed to shaping the Program, my insights were guided by participant voice and reflection, a piece I made clear to the teachers.

Research Design

Embedded Case Study

This study takes the form of an embedded case study. Embedded case studies "involve more than one unit, or object, of analysis and usually are not limited to qualitative analysis alone" (Scholz & Tietje, 2002, pg. 9). This builds on the case study framework, in which a case study is "an in-depth exploration of a bounded system (e.g., an activity, event, process, or individuals) based on extensive data collection" (Creswell, 2002, p. 485). Creswell recommends case study if the research

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questions to be explored "relates to developing an in-depth understanding of a 'case' or bounded system" (p. 496) and if the purpose is to understand "an event, activity, process, or one or more individuals" (p. 496). This embedded case study involved the in-depth study of the participants of the pilot years of a pre-service professional development intervention program, first broadly across the collective and then with a sub-unit of analysis of four focal teachers via comparative case study (which I will explain further in the Analysis Section).

CE-CHAT Activity Analysis

In CHAT, the unit of analysis is the system (Engestrom, 2001). In my research, this focuses on the individual teachers as the subjects within the activity systems of their current schools. As I investigate the pathways to hybridity between equity and field-based education, I look at the tensions that emerge within these systems, and with others, like the Program. To clarify the composition of the activity systems, I draw from Beatty and Felman (2012) who similarly used CHAT to investigate the translation of professional development objects/goals into the classroom.

The first activity system I consider is the teacher's current classrooms. Focusing on the teacher's perspective, the teacher is identified as the subject (Figure 2). The object is the students and their learning, with the desired outcome that they have equitable access to learning about the lesson content in a field-based setting. In this system the community is other teachers, school administrators and staff, and students and their families. The rules include classroom, department and school

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norms, regulations, and the model of schooling adopted by the school. The division of

labor includes the authority of the teacher in their classroom and the associated power

differentials, as well as the power teachers have (or not) to design and implement

lessons. Finally, the tools include any equitable field-based lesson plans they have

created, materials needed to accomplish these, tactics for teaching outside, time, and

language. As mentioned, these will all vary to some degree for each teacher.
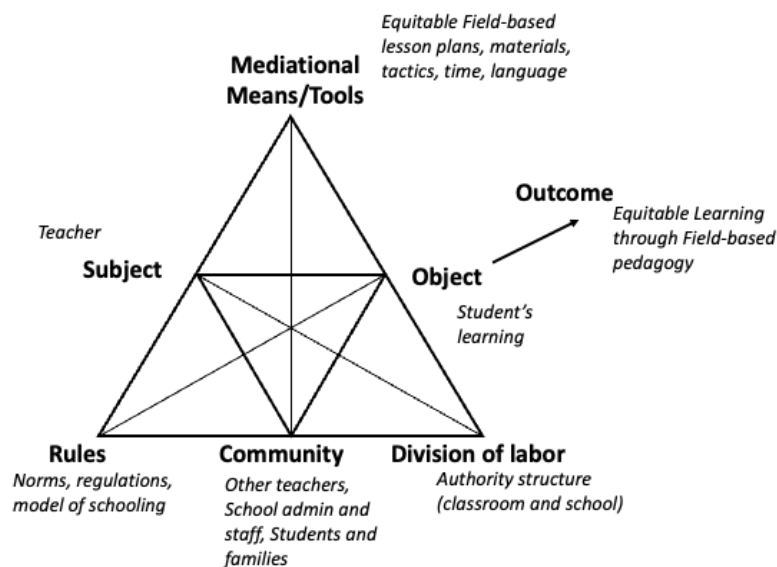
Figure 2. Teacher Classroom Activity System

The second activity system I consider is the professional development

program. It consists of the teachers, PD leadership, and other collaborators and

presenters, all engaged in the goal of collaboratively defining, creating, and

implementing equitable field-based lessons/education/pedagogy. As mentioned,

within the activity triangle, I focus on the viewpoint of the individual teachers as the

subject (Figure 3). The object/goal of this system is to support teachers' instructional

practice of equitable field-based education and the desired outcome is the successful implementation of this pedagogy in their future classrooms. Rules of the program included expectations of the program (i.e. attend workshops, create an equitable field-based lesson) and the norms of the teacher education program in which it was situated. The community included PD leadership and facilitators, and other teachers in the program. The division of labor describes the roles and responsibilities of the program leadership/facilitators and the teachers. The division of labor shifted over the course of the program, initially faculty in the biology department largely organizing the program, but with the hiring of an educator as program facilitator, the organization shifted to the education department. This shift was a product of tensions between nodes in the system, the division of labor impacting the program's object, which resulted in tension between the object and subject (the teachers), resulting in a transformation. Finally, the tools of the system, which broadly included materials, strategies, resources, and ideas, also shifted throughout the program, tension between the division of labor and tools leading to varying understandings of what was needed to teach equitable field-based education.
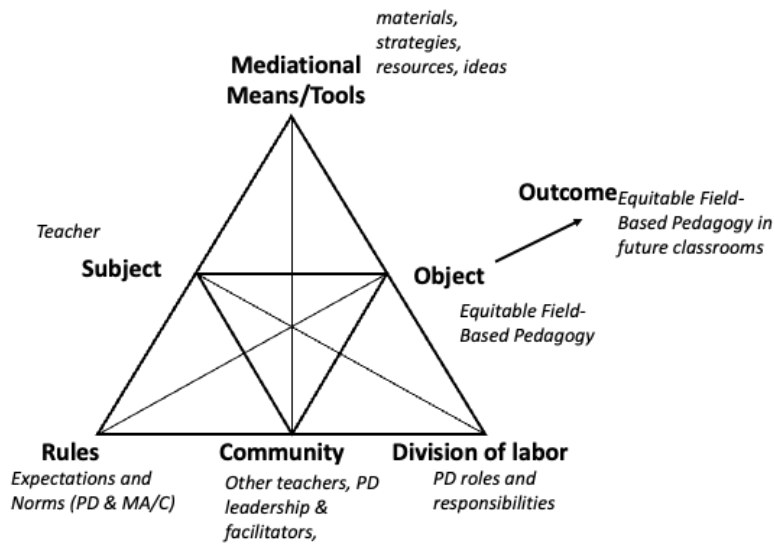
Figure 3. Professional Development Activity System

A CE-CHAT analysis centers on transformative praxis, examines neoliberal tendencies and dominant ideologies/epistemologies, engages in multi-sited sensibilities, and uses an intersectional analysis to explore the overlapping influences of power, identity, language, and race. In my work, this calls for attention to the many systems/sites influencing the hybridization process, each bringing their own histories, rules, epistemologies, hierarchies that shape "equitable field-based education" as well as the teachers' moves towards transformative praxis in their classrooms. Transformative praxis provides a lens into how teachers might take up the hybridization of equitable field-based education and translate it into their classrooms, attention being given to the lesson plans created and their delivery in the classroom.

Methods

Participants

Participants in this study were involved during the pilot years of the Program from 2018-2021. Participants were invited to participate via email and were offered a

stipend for their participation. The recruitment email explained that I was interested

in how participants of the Program have adopted, explored, and translated the

program goals into their classrooms (and if not, why?). Of the 24 total participants

who completed the Program during the pilot years (2018-2021), 16 participants are

involved in this study. These participants self-selected into the study. I had responses

from two additional participants (who completed the survey), but they were not

available to be interviewed. From the cohorts, four out of five participants are

represented from year one, seven out of twelve from year two, and five out of seven

participants from year three (Table 1). Mostly, participants were either secondary

science teachers or elementary school teachers and taught at a variety of areas in

California (one participant taught in Colorado) (Table 2).

Years Teaching	Gender	Ethnicity	Grade Level Teaching
1	Male: 2 Female: 3	White: 2 AAPI: 0 Black: 0 Latinx: 3	Elementary:1 Middle:1 High:3
2	Male: 0 Female: 7	White: 4 AAPI: 1 Black: 1 Latinx: 1	Elementary: 3 Middle:4 High: 0
3	Male: 1 Female: 2 Non-binary: 1	White: 3 AAPI: 0 Black: 0 Latinx: 1	Elementary: 0 Middle: 0 High: 4

Table 1. Study Participant Data

Name (pseudonym)	Subject and Grade Level Teaching	School Location
Dylan*	Algebra; 9th Grade	Urban; CA
Brett	Physics; 11th/12th Grade	Suburban; CO
Nancy	Biology/AP Biology; 9th & 11th/12th Grade	Rural/Suburban; CA
Brandon	Biology/AP Biology/AP Environmental Science; 9th & 11th/12th Grade	Suburban/Urban; CA
Priscilla*	Dual Language Kindergarten (Spanish)	Rural; CA
Felicity	5th Grade	Suburban; CA
Cassie*	5th Grade	Rural/Suburban; CA
Mindy	Math & Science; 6th Grade	Suburban/Urban; CA
Ingrid*	Science/ STEM Elective; 8th & 7th/8th Grade	Suburban/Rural; CA
Daphne	Science; 8th Grade	Suburban; CA
Emily**	Science; 7th Grade	Suburban/Rural; CA
Grace	Science/STEM Elective; 8th & 7th/8th Grade	Rural; CA
Cameron	Biology/ ELL Biology; 9th Grade	Suburban; CA
Linda**	Biology; 9th Grade	Suburban/Rural; CA
Larry	Biology/AP Environmental Science; 9th & 11th/12th Grade	Suburban; CA
Georgia	Dual Language 2nd Grade (Spanish)	Rural; CA

Table 2. Participant Teaching Context   *Classroom Observed **EFBL Reflection
                                                                      ***No Member Check

Data Collection

Data for this study comes from semi-structured interviews with teachers, member checks, survey data, equitable field-based lesson (EFBL) observations, artifacts, Program Leadership interviews, and previously collected data from participants' time in the program.

Semi-Structured Interviews: Teacher Participants

Sixteen semi-structured, reflective teacher participant interviews were conducted over Zoom in the Winter of 2022. They ranged from 55 to 90 minutes long and explored teachers' experiences teaching, their conceptions of quality teachers, equity, the field, and equitable field-based pedagogy. I also explored barriers to equitable field-based education both within the local and broader context of K-12 education (See Appendix). In preparation for each interview, I gathered all previously collected data I had for each participant. I used this data to inform direct reflection on components of the Program, including participants' lessons plans and research papers. The interview protocol also included a series of questions for participants who had not been able to implement an EFBL, asking them to describe a lesson they wanted to do instead.

Semi-Structured Interviews:Program Leadership

Six semi-structured interviews were conducted with Program Leadership, four with Education faculty and two with Natural Sciences faculty. Interviews ranged from 30 to 70 minutes in length and were conducted and recorded over Zoom in Winter 2022. The interview explored their roles in the Program, their thoughts on Program goals, the evolution of the Program and its impact on teachers (see Appendix). These

interviews were collected to provide contextual background on the Program in addition to the previously collected data.

Member Checks

Member checks were conducted in May-June 2022 with fifteen of the participants (one participant did not respond to my follow-up emails) and were conducted and recorded through Zoom. Most teachers had completed the 2021-2022 school year when I spoke with them. These interviews were between 10 to 20 minutes long, and consisted of participants reflecting on the individualized early analysis of their data. Participants were asked to review the document for accuracy and provided any additional information I should know. This additional information included any additional EFBL they had done, if there had been any change to their local contexts and what plans they had for the future. Member checks were not fully transcribed, instead only key reflections were transcribed and detailed notes were taken during the interview.

Survey

A survey was completed by twelve of the sixteen participants. All participants were invited to participate via email, but due to their busy schedules not all participants were able to complete the survey. The survey collected teachers' background information and demographic data, responses to a series of 35 Likert-scale questions (5 groups of 7 questions) and three open ended questions. The Likert scale questions were drawn from validated surveys to assess nature connectedness (Barrable & Lakin, 2020), confidence and frequency of teaching hands-on, inquiry

driven approaches, both inside and outside (Meichtry & Smith, 2007), and reflections

on the impact of the program on their teaching (see Appendix). The open ended

questions asked participants for their definition of EFBE, barriers they have faced to

teaching EFBE and the benefits of EFBE.

EFBL Observations

Observations of five EFBL were conducted, three in-person observations and

two via written reflection and interview (see Table 2). The in-person observations

were conducted in three classrooms, a 5th grade class, a 7/8th Grade STEM Elective

class, and 9th grade Algebra class in the Winter of 2021. Each observation was one

class period, or one activity, ranging from 180 minutes to 90 minutes. The 5th grade

observation was of a fieldtrip to the on-campus creek, hosted by a local non-profit

organization. The 7/8th grade observation was of an EFBL on water quality. The 9th

grade Algebra EFBL was about modeling parabolas using water balloons. The lessons

were not recorded due to lack of parental consent, but extensive field notes were

taken, and a post-lesson debrief was conducted with each teacher. Any relevant

artifacts, like the lesson plan or worksheets, were collected. For the EFBL I was not

able to observe due to scheduling, the two teachers, one in a 7th grade science class

and another in a 9th grade biology class, instead provided reflections on the lessons

and responded to a series of questions (See Appendix). The 7th grade EFBL had

students conduct observations of a small on campus natural space. The 9th grade

biology EFBL had students explore natural selection through observations at a local

pond. After the self-reflection document was completed, I conducted a short debrief interview with the teachers over Zoom.

Previously Collected Data

To provide context and information about the participants' experience in the program and past understandings, I drew from previously collected data. For example, as mentioned, I used this data to ask teachers to reflect on previous definitions of EFBE, and how they compared to current understandings. Data was collected by me from 2018-2021, during the three years of the pilot program. Data collected included pre/post interviews, quarterly reflective journals, ethnographic field notes of workshops, associated MA/C student coursework (including research papers, presentations, and lesson plans), and surveys. Participants were offered a large stipend for their participation the first year, allowing me to collect extensive data from all participants. In the second and third year, we were only able to offer a small $25 stipend, so I was only able to interview or collect reflective journals from select participants. However, I do have all the associated coursework, observation data and survey data from workshops for these years.

Data Analysis

I use the theoretical and methodological framework of CE-CHAT in combination with the qualitative method of thematic analysis (Braun & Clarke, 2012). My analysis focused on teacher interview data, with other data, including observations, surveys, program leadership interviews and previously collected data, used for supplementary data or as a triangulation tool. I took a three-stage approach to

my analysis: (1) Open coding to develop Individual Analysis Documents; (2) Development of axial codes; and (3) Member Checks and theme generation (Strauss and Corbin, 1998).

Open coding, which is the first level of coding with the aim to begin to identify themes, was centered around teachers' understanding, practice and local context as it related to EFBE. Interviews were transcribed using temi.com, an online voice to text software. The initial transcription generated by temi.com is not 100% accurate, so I listened to the interviews and corrected the transcription. During this process I generated analytic memos, attending to historicity, multisitedness, and forces shaping the hybridization and translation of EFBE. A product of this initial analysis was a short response to the research questions for each participant, an Individual Analysis Document (IAD). These IADs, about 1-page in length, aimed to categorize how teachers had taken up the goal of EFBE, outlining their practice and understanding of EFBE (Table 3). It also attended to the forces shaping their hybridization of EFBE, looking to the impact of neoliberal practices/ideologies, identity, previous experiences, epistemological frameworks, and power. As transformative praxis is a dynamic and potential outcome of the hybridization process, attention was given to the moves that teachers made in the professional development program and their current placements to shape/define and enact equitable field-based education, exploring how they moved across systems and what factors enhanced or limited praxis.

RQ1	Brett approaches the goal of EFBE with an ethics of care and connection. While he has been limited in his ability to do EBFL due to a lack of block scheduling, teaching physical sciences rather than biological sciences, being a new teacher, and a lack of collaborative colleagues, he is invested in the practice of teaching outside and is looking forward to increased opportunities to expand his practice with an upcoming shift in the schools' pedagogical approach. He sees a deep division between his students' digital lives and their connection to nature, feeling, "And that's my job. I'm supposed to just kind of like reintroduce the youth to nature." When considering EFBE, he similarly mentions the importance of developing curiosity for science and the natural world, which might shift students' perceptions of science stating, "I believe that that's so important getting out and doing field-based stuff. I think that what science is, you know, science, isn't this Pearson textbook, science is getting out and getting dirty and looking at bugs and turning upside rocks. And like, if, if nothing else is to develop curiosity like that's my main goal." He also mentions community connection, funds of knowledge, and using the field that you have as central to EFBE. The lesson he hopes to do taps into the local environment around the school, looking to the connection between the local oil refinery, water/soil measurements, and socioeconomic status.
RQ2	Shaping the hybridization process seems to be his previous experiences in the natural sciences, a strong sense of quality teaching, and the digital divide. His past experience in the natural sciences and outdoor education are clear in the framing he takes of what science is. His strong commitment to being a professional educator, which he mentioned was shaped during his teacher education program, is clear in the way he views equitable education and lesson plan development. He plays a large role in leadership in his school community to help support his ideas of quality teaching. However, it also may limit his ability to connect and collaborate with others, his feelings of dissatisfaction with his colleagues were clear, "I'm just kinda like, screw it. I'm just gonna do it on my own. That's the boat I'm in, and that's where I wanna be, frankly, because I mean, I can do it. No one knows my students better than me." While clear he is deeply connected to his students, his dislike of the current cultural obsession with phones, social media, and shallowness seems to create a disconnect between what he views as the "right way" to connect to nature.

Table 3. Example of Individual Analysis Document for Member Check

The second stage of axial coding calls for, as described by Saka et al. (2009), "identification of commonalities and differences in each category" (pg. 1004). Here I began to link categories and subcategories across the data to understand the potential

contradictions between categories which inform the process of transformative praxis as related to EFBE. To examine the dialectical relationship and emerging tensions, data that showcased "relationship codes" (i.e. subject-mediating artifacts, subject-object, etc.) were identified (Trust, 2017). Additionally, a multi-sited sensibility guided the creation of axial codes (Vossoughi & Gutierrez, 2014). I explored the categories of tools, object, community, etc. across systems, dwelling in the areas of disjunction, such as mismatches between teachers' goals and their schools' goals, to potentially find pathways and overlaps in moves towards hybridization in theory and practice.

I also looked "to the social and political forces that create boundaries and borders with real, material consequences for [teachers], and seek to study how these boundaries are experienced as well as reproduced, ruptured, reimagined, and reshaped" (Vossoughi & Gutierrez, 2014, pg. 625). This called for attention to power, neoliberal tendencies, and other barriers, both subtle and not so subtle, that teachers faced in their attempts to hybridize equity and field-based education. While neoliberal policy and ideals are thoroughly entrenched in systems of education and thus are often rendered invisible, I look to certain areas to see how neoliberal tendencies emerge in science education. These areas are:

- Curriculum/Assessment and Standards (Weinstein, 2017)
- Individualism vs Collaboration (Bencze & Carter, 2011; Apple, 2006)
- Views of success (i.e. performance on standardized tests, career in science, other?) (Carter, 2005)
- What counts as quality teaching (Sharma, 2017)

- Model of Education/Schooling (Torres- Olave & Gonzalez, 2021)
- Science as neutral or sociopolitical? (Barton, 2001; Bazzul, 2012)

How these neoliberal tendencies come into contradiction or in alignment with the teachers' hybridization of equitable field-based education provides a lens into the potential resistance/subversion of these tendencies. As I didn't expect all these tendencies to be rejected, I looked to the spaces of "neoliberalism AND," the expansive spaces for resistance and reimaging. Analysis traced the macro, systems level interactions to the micro individual negotiations.

To best understand the multi-sited, dialectical process of hybridization, at this stage, in addition to the above-mentioned approaches, I traced through the interviews the emergence and definition of key codes- equity, the field, and equitable field-based education- across the program and into the teachers' classrooms. It is important to note that these definitions are not static, nor do they necessarily equally contribute to the hybridization process. However, the areas of overlap, like equity and "the field," provide important insights into how teachers move towards hybridization, each an important process of negotiation in understanding what equitable FBE means to the teachers. Previously collected data was used to inform initial understandings of these concepts and were further explored in the interviews. Using this data, I traced the hybridization longitudinally, across the sites shaping definitions, understandings, and reflection, with attention to the historicity each member brings to their epistemological orientations.

Finally, member checks were conducted using the IADs. After member check data was verified and any additional data collected during the member checks were

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included, a final coding pass was completed in DeDoose to generate themes exploring

the conceptualization of EFBE, common tensions, and hybridization pathways.

Classroom observation data was used as a triangulation source to support the

emerging themes. At this stage, survey data was analyzed using SPSS. Likert-scale

questions were averaged, and data was explored across different factor variables, like

cohort year, ethnicity and subject taught. Due to an incomplete sample, the survey

data was used largely as a triangulation tool.

Comparative Case Study

To best present the nuanced pathways to hybridization of equity and field-

based education and the associated forces and contradictions/tensions shaping the

process, I did a comparative case study. While the data was collected and analyzed

using CE-CHAT, a comparative case study was selected as a vehicle to explore

findings due to its ability to capture similarities and differences in activity systems. I

draw from Bartlett & Vavrus (2017) definition of a comparative case study, with a

key ideas including: "focusing on the processes through which events unfold;

reconceptualizing culture and context; a critical approach to power relations; and a

revised understanding of the value of comparison" (pg. 900). The addition of this

approach arose after I shifted to a chapter-based model. It required me to think

critically about how I would showcase my findings in a way that captured the

common hybridization themes and contradictions/tensions but didn't reduce these to a

one-dimensional list. At this point in my analysis, I had identified forces and

contradictions/tensions shaping the hybridization process and categorized levels of

transformative praxis around EFBE, so to select case study participants, I centered my

selection on participants who faced similar local contradictions or shared similar

responses to tensions in their pathways to EFBE. Once selected, I attended to

historicity (exploring their journeys to becoming educators and their time in the

Program), forces shaping hybridization, contradictions/tensions in the activity

systems, and how these emerged in their practice. I selected one lesson per teacher to

highlight how various understandings of EFBE were translated into practice and what

local and broad forces shaped this. I centered the analysis around one common

contradiction/tension per case study to showcase how the multiplicities of enactment

emerge.

Researcher Positionality

As positionality and reflection are key to my theoretical framework, I wanted

to briefly discuss my positionality. I am a white woman from a lower/middle-class

background who attended public schools from elementary to graduate school. As a

previous biology/ecology major and someone who took field courses, I strongly

believe in the importance of field-based pedagogy as a result of my own personal

experiences and outcomes. However, I am mindful of the many inequities that face

field-based education (whiteness, racial inequities, economic barriers, social

exclusion), and have worked to understand how these may be improved in my other

work. In my Ph.D. program, I have become critical of systems of education and work

to understand why the inequities that have been studied for decades have continued to

persist, specifically in science education. I have personally changed epistemologies

over the course of my educational career and recognize that these are not static and are greatly influenced by the ideas and people I have come to interact with and meet.

My role as a participant observer and researcher in the previously collected data for the longitudinal case study placed me in a unique position to conduct this research. First, my rapport with participants was well-established going into the data collection for this study. Additionally, as the previous work aimed to define EFBE collectively and understand its potential implementation, I was seen as a co-collaborator in working towards the goal of EFBE. While I position myself largely as an observer in this study to maintain objectivity and to center the teachers as experts in their own local contexts, my positionality as an expert within the Program space must be considered when interpreting the methodological and analytic decisions made in this work.

Limitations

The participants in this study joined via self-selection. This could lead to self-selection bias, skewing the findings as perhaps only the Program participants who felt they had taken up the goal of EFBE would respond or want to participate. My role as a participant observer in the Program helped alleviate some of this concern, as participants had come to see me as someone who was also working towards understanding EFBE. Thus, for participants who felt they did not have anything to share, or had not been able to accomplish EFBE, our previous relationship helped alleviate concerns of being seen as 'failing' Program goals, as I made clear in recruitment emails that all experiences are valid in this research

Chapter 3: What is Equitable Field-based Education?

The program aimed to facilitate deep discussion and negotiation of how one might define and implement equitable field-based education (EFBE) in K-12 settings, hoping to promote an expansive learning cycle for teachers that supported the integration of EFBE in meaningful and unique ways. To understand how teachers took up this goal and recognizing the diverse epistemological and theoretical backgrounds informing equity and 'the field,' I found it helpful to first look at each concept individually to trace the hybridization of equitable field-based education as a framework for teachers. Similar to Buxton et al. (2015), I aimed to understand what shaped the "multiplicities of enactment" that emerged for these teachers, recognizing that the definitions put forward by teachers would lead to diverse outcomes in practice/enactment rather than a one size fits all model. To understand how the varying definitions of equity and the field came together or hybridized, I describe the teacher's definitions of equity and the field, sharing key themes that emerged for each topic. I then describe teachers' definitions of equitable field-based education, exploring the common themes across the definitions to understand shared experiences and forces shaping the hybridization process.

What is equity?

People come to educational spaces with different understandings of equity, which can lead to a variety of challenges while attempting to implement equitable instruction at a variety of levels, including K-12, teacher education and professional development (Ash & Race, 2021). Understanding how teachers define and enact equity in their practice is a central piece to understanding what forces shaped these

definitions. While research has shown the impact of teacher education programs on shaping teachers' conceptions of equitable education (Cochran-Smith et al, 2016; Grudnoff et al., 2021), I aimed to understand what other forces, like neoliberalism and epistemological orientations, shaped definitions of equity. Three main themes of how teachers defined and/or described equity emerged: (1) Pedagogy and Content; (2) Learning Supported Adaptively; and (3) Holistic Social Justice Approaches (Table 4). These themes capture not only definitions of equity, but how in practice these understandings are enacted (or not).

Pedagogy and Content

When considering pedagogy and content, teachers described equitable approaches to involve anti-racist pedagogy, interrogation of systems reifying inequity, centering social and environmental justice content, using culturally relevant pedagogy (CRP), and tapping into students' funds of knowledge. Of the sixteen participants I interviewed, three centered on anti-racist pedagogy, six mentioned interrogating systems of oppression, ten considered social/environmental justice, six named culturally relevant pedagogy (CRP), and five mentioned funds of knowledge. These ideas represented best practices for the teachers; as Dylan highlighted, "I think the first thing is you need to make sure you have set the foundation of an equitable anti-racist classroom in order to be doing this work." However, for about 75% of the teachers that considered pedagogy and content, these ideas had not been translated into practice and represented more of a goal they were working towards once certain barriers, like the COVID-19 pandemic, had been minimized.

Learning Supported Adaptively

For most teachers, considerations on how to adaptively support learning was a key component of equity, especially when it came to their day-to-day teaching practices. These included scaffolding through numerous approaches (i.e., group work, resources like examples or graphic organizers, data-driven support), language supports (i.e., sentence frames, visuals), accessible content for all students (multimodal assignments and assessments) and supporting skill development. Of the sixteen teachers interviewed, fifteen mentioned scaffolding, eight considered language supports, eleven aimed to ensure accessible content, and fourteen supported skill development. The teachers that most considered language supports were those that worked at the schools with the highest ELL populations. Only 4% of the codes related to language support were applied to data from teachers that worked at a school with < 25% of ELL students, whereas 61% of the applied codes were from data from teachers working at schools with 50% or more ELL. Cameron, who taught 9th grade ELL science courses, focused his considerations on equity in those classes, stating, "that's probably where I'm trying to do the most equitable practices." Here we see how local context shapes equity practice, and teachers' efforts are directed where they feel they are most needed.

Holistic Social Justice Approaches

Increasingly, supporting students beyond content learning is becoming more central to teaching practices (Winn, 2018). For teachers, such holistic practices were considered to include restorative justice, creating safe spaces, and providing socio-

emotional support. Of the sixteen teachers interviewed, five practiced restorative

justice, seven mentioned the importance of a safe space, and eight used

socioemotional support. These holistic approaches were often in response to the

COVID-19 pandemic, with more schools placing importance on socio-emotional

support for students to respond to the trauma students experienced. For example,

Cassie explains how the stress of the pandemic shaped her teaching:

> I, first of all, found that paying attention to a student's emotional needs is really important. People always say that's really important, but I think sort of the last year and a half has really shown us how important it is because it's clear to me that when we have a positive case in our classroom…or when we get tested every week, it's stressful and disruptive for them. There's a noticeable shift in their energy and their anxieties. It just kind of brought to the forefront of my mind how the students can't really be entirely present to learn something else in that moment if they find that there's a positive case when that happened, I just kind of had to scale back and address those needs first.

We see how the ongoing stress of the pandemic impacted students, a positive COVID

case shifting their ability to focus. Other teachers similarly mentioned reduced

content instruction time due to an increased focus on holistic support. The return from

distance learning also saw increased violence at schools; teachers where this

happened utilized restorative justice to work towards creating a safe space. A safe

space represented a place where students could feel comfortable learning regardless

of ethnicity, gender, sexuality, or socioeconomic status.

Equity Themes	Categories	Quotes from Teachers
Pedagogy and Content	Anti-racist	"I think that this lesson works because my black and brown students see me as an anti-racist educator."
	Interrogation of Systems	"Having that intentional moment of saying, 'who gets to use this space and why?' is a big foundational thing for me with equity. And looking at the power structures there."
	Social and Environmental Justice	"Looking at these different power plants and these different refineries..There's some governmental organization that knows how much it's all putting out and knows what they're doing and so just making kids aware of what's around them."
	CRP	"Taking a look at a phenomena that might mean more to a student who's not necessarily usually valued at school, like their kind of story isn't represented as much and having that be the center focus of the story for that unit, I think that would be a way to introduce equity."
	Funds of Knowledge	"How can I draw on students' knowledge to create a field at home?"
Learning Supported Adaptively	Scaffolding	"I'm going to set up some lessons where I can give some more background knowledge and scaffold for them..in case some of them don't have any prior experience or knowledge at all."
	Language Supports	"Another thing that I do is that I try to show as many pictures as I can, less words. It's hard to scale back because I need to give every bit of information like now, now, now, and I have to realize that I can't really do that because not everyone is at that pace where I can show you a slide and it's full of words."
	Accessible Content	"I really try to take a UDL approach, where I'm trying to give students multiple ways to engage with the material and multiple ways to show me their learning."
	Skill Development	"Building those 21st century skills with the students and allowing them to see that real life and real data analysis can be a lot of things and what you learn and what you gain from it is different in each sense and step."

Holistic Social Justice Approaches	Restorative Justice	"If the student's head is down or if the student's hood is on and they have a decent reason, I am understanding of that. I'm not going to yell at them to take their hood off or take some detention for it if they just got a haircut and they're not feeling well."
	Safe Communal Spaces	"They're explicitly told that everyone's welcome in this space. So what are we going to do to make sure that they feel welcome and kind of forcing students to reflect and see the other side, I think is super important in terms of equity."
	Socioemotional Learning	"I'm trying to do more SEL practice in secondary education because that's important and fortunately enough my high school knows that that's important and they're trying to figure a way to do it."

Table 4. Equity Themes and Examples

In summary, as we see from Table 2, equity understandings and the associated practices ranged from general to more liberatory/critically oriented (Freire, 1971). This scale of practice showcases how teachers are at different levels of understanding when it comes to equitable instruction, and how context shaped focus and approach. This initial analysis provides pathways to examine other forces shaping these understanding/practices, which I will further explore in comparative case studies later in this dissertation. It also provides insight into how equitable instruction is positioned in teachers' classrooms before considering equitable field-based instruction, an important key to seeing the multiplicities of enactment of EFBE.

What is the field?

In outdoor, experiential, and science education, the field is generally conceptualized as a natural space (Lonergan & Andresen, 1988). However, due to the structural constraints that many K-12 educators face, participants were encouraged to

think expansively about what the field could be. In response, teacher's concepts of the field quite naturally came to be shaped by their context and past experiences. Three major themes emerged from these understandings, (1) Natural Spaces accessed in varying ways; (2) Community as the Field; and; (3) "Field of ___" (i.e., science, ecology, math, genetics) (Table 5).

Natural Spaces accessed in varying ways

For many teachers, the understanding of the field as a natural space was adapted to their local context. Some still considered the field to be a traditional natural space, naming local parks, Natural Reserves, or field trips to nearby lagoons or creeks. For others, the ability to leave campus was not possible due to COVID-19, so they had to think more locally, the school yard or backyard becoming a place of natural exploration. The amount of natural space (i.e. trees, plants, water, hills, etc.) on their campus framed teachers' conceptions of this option. How teachers imagined students accessing the field also tied into their local teaching context. For many, the field was accessed outside of the classroom, as teachers saw the benefits of getting outside. As Ingrid stated, "When students can get out in nature and experience it for themselves, that can stick with them.. more than a lot of other stuff that you can do in the classroom." However, when getting outside was not possible, teachers created workarounds through virtual experiences or bringing the field inside. As Priscilla explained, "It's more than getting out there..it's not that exclusively because of course you can also learn about things inside the classroom through research…It's all around. It's not just the outside. It's the outside from the inside and the outside." The field as

everywhere is an expansive understanding that resisted the dominant narrative of the field and offered teachers agency as they considered what and where the field could be.

Community

For teachers who lacked access to natural spaces, taught non-science subjects, or were beginning to reconceptualize the field through an equity lens, the field came to mean community. Teachers interpreted community in different ways, but generally, it meant either a community-driven, local, or place-based issue facing students. Dylan, who taught 9th-grade algebra, explained how she came to understand the field as community:

> For me, it was like, how do we broaden this term of what the field is so that we can really support our students in having access to this no matter where the students live.. I really stuck to this definition of field based learning that it was a specific focus of study, depending on the community that you belong to. So looking at things as a community based task, whether it be on the actual ground that your community exists within, or whether it be a social dynamic that..exists within your community, that felt the most powerful kind of takeaway for me.

In this case, the community came to take the form of data about police funding in the city where she worked. Other ideas presented by teachers included looking at local pollution data and collecting plastic water bottles at the school. While these ideas all looked different, they all explored the community as 'field' in an expansive way.

"Fields" of Science

Finally, for some teachers, the field was viewed more expansively to include the skills and practices one might encounter in any field of STEM, be that ecology, genetics, math, etc. While the 'field' in ecology or geology might be considered a

natural space, with practices like journaling, observation, and measurement being centered, teachers utilizing this view took this approach to see the associated 'field' within any subject they might be covering. As teachers recognized getting outside of the classroom might not always be an option, but they still wanted to implement EFBE, they moved towards this expansive view that ranged from hands-on activities to games. Here Grace explains how she thought of this "field of science" view, "The field was just knowing how to set up your experiment for any type of field, like knowing how to handle it in general." This 'real world' of science view moved to provide students with experiences that dismantled the binary between classroom science and 'doing science.' By better connecting to practices, this understanding of the field provides students with a connection to the science community and what it might be like to be a person in that field.

Field Themes	Categories	Quotes from Teachers
Natural Spaces	Traditional	"That would be really cool if we could have them create questions or focus on a topic and observe it in the wild. That would be ideal."
	On Campus	"The [school]courtyard has a lot of plants. And so I was like, okay, scientific illustration, this is what we're doing."
	Accessed in the classroom	"We look at NOAA data. We talk about what's around them and what they have seen or what they can more

		easily see."
Community	Local Issues	"The field is us researching something happening in our community… That's where I..want to be."
	Justice Focused (Racial/Environmental)	"And I started from this place of like how I celebrate black joy. What I ended up going with did not hold that line of, like, this is a celebration of black joy, but rather how do I arm my black students and my students of color with the abilities to have critical conversations."
Practices for the "Field" of Science	Connections	"The field is considering real world application. How can I use this and how is this beneficial to me and my life?"
	Skill Based	"If there's ever any time that I can get them to get a sample of something I let them go outside and use scientific instruments."

Table 5. Field Themes and Examples

In summary, the field came to mean physical locations, representations, practices, and ideas. As we are reminded by Cole (2007), an expansive view of the field is "rich with dynamic cultural, social, economic, political, historical contexts and perspectives that frame and construct the ecological processes within them" (p. 39). The Program evolved to support this understanding given the unique barriers teachers encounter in K-12 settings, but as we see, similar to equity, context, historicity and epistemologies shape understanding and praxis.

What is Equitable Field-Based Education?

Set up as an unknown, the concept of equitable field-based education became a space for teachers to expansively think about how equity and the field sciences might come together as a new pedagogical approach. My analysis suggests that this process sparked the beginning of an iterative cycle of transformative praxis through double stimulation, the concept equitable field-based education a first stimulus, and the potential practice of EFBE a second stimulus. As teachers hybridized these two disparate epistemological spaces (equity and field sciences), third spaces allowed for teachers to merge their past, current, and future ideas of what equitable field-based education might be. Four main components emerged as central to teachers' understanding of EFBE; (1) Accessible by All; (2) Student Centered Scientific Practices; (3) Justice Oriented Content; and (4) Facilitating Students' Connection to Nature (Table 6).

Accessible by All

Accessibility is a key piece to teachers' understanding of EFBE. Accessibility here takes many considerations: physical, monetary, cognitive, epistemological accessibility. For physical accessibility, teachers were concerned with students' ability to access any outdoor space comfortably and safely. For Cassie, who had a student with autism, she thought specifically about how to support her student on a short hike to a local creek. She explained her plan, "I'm thinking about the supports that I will put in order to make sure that he can go down the little hike safely and the things that I'll put into place for him to be able to experience being there comfortably, like

probably sitting on a towel." Other teachers considered gear or clothing that students might need, aiming to have experiences that students would be able to do in their regular school clothes. This was a key piece of monetary accessibility, as having to buy any gear, which can be a key component to feeling supported and comfortable in a field experience, can be an undue burden on many families. This also includes making any field-trips low cost (or providing scholarships).

Cognitive accessibility was also important to teachers. They wanted students to feel like they were mentally prepared and supported. This included preparation before a lesson, so students had the skills, knowledge, and understanding of what to expect. Ingrid explained how this was a key piece of making a lesson equitable, "I think making sure that students are given adequate background knowledge beforehand and supports with like, collecting data. I don't think it's equitable to just hand students a data sheet and send them off." Preparation is a key piece of this. Nancy explained how she prepared her students for an EFBL, "Orienting them to using their five senses, to asking questions when they're in a space, and making sure that they understood dangers...We looked through images that I took from the field reserve to see expected plants, and expected bits of data." By preparing students for the experience, she minimized the cognitive stressors that one might have when experiencing something new for the first time. Other teachers additionally felt it was important that lessons be accessible to students regardless of previous nature-based experiences. Many teachers worked with students they perceived to have had limited natural experiences, so they felt it was important that experiences be accessible to all,

as Emily described, "access so that everyone can participate, and [have] a voice. So it's not just about past experiences." This also included making space for epistemological differences in understanding how we relate to and describe nature. As Emily reflected, "My view of natural spaces is a very Western view, as a white woman from a privileged background. Which is how a lot of my students experience natural spaces but I imagine not all of them." However, as I will discuss later, many teachers felt they lacked the resources to create classrooms that supported varying epistemologies.

Student Centered Scientific Practices

When it came to thinking about what an EFBE lesson should contain, a key component included student-driven scientific practices. Teachers wanted students to engage in authentic scientific practices, using methods, tools, and skills that a scientist would use. Brett reflected on the value of such practices:

> Even if academically it's not the most rigorous thing or it doesn't really link up scientifically, where it's like, it's not really variation, but they measured stuff, came up with some hypotheses, they answered some questions and they talked with each other in the field. I think that is important.

Student driven research and data collection in field-based settings allows students to gain self-efficacy and confidence in their scientific practices (Race et al., 2020). Access to such practices in field-based settings have shown to minimize experience barriers for minoritized students, and support retention in the sciences (Beltran et al., 2020). If practices were not research driven, teachers emphasized the importance of activities being hands-on and experiential. As Felicity reflected, "I think allowing students to have a hands-on experience and become scientists is extremely valuable.

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They feel empowered." Teachers felt that hands-on activities allowed students to practice important scientific skills, and in field- based settings, teachers considered practices like observation, sketching, using tools like measuring tapes or quadrats, and asking questions. Grace felt this was a central piece to EFBE, as she explains "Make sure that they have access and practice using all of these different tools. For example, they don't think [what they are doing is] science, and I have to be like, how else can we know if we don't actually have that qualitative data from observation?" As she emphasized, "my biggest thing is making sure that they're doing science versus just hearing about it." Breaking down stigmas of what counts as science and what science looks like through actual practice is central to many teachers' understanding of EFBE. Teachers' hoped that these activities would support science identity and students' feeling like they can (and do) do science.

Justice Oriented Content

When teachers thought about driving phenomena or content focus, they believed EFBE should be justice oriented. While they recognized that lessons needed to meet the standards (i.e. NGSS), topics should cover issues relevant to the students' lived experiences and community, while developing critical thinking.This pushes on the traditional field-experience that teachers may have imagined, forcing them to think about what an equitable field-based lesson vs. a 'traditional' field-based lesson might look like. Larry reflected on this:

> We read [about] someone's class where students went around and surveyed people about a new skylight in school and did this whole research project on it, proposing what [they] should do with that. I'm like, dang, that would be awesome to get there. So I guess that's the part where I'm like equitable field-

based learning to me more than just going outside.

This view pushes teachers to re-imagine what a traditional science curriculum might look like, and how students are centered in the content of lessons. Grace reflected on how a just field-based lesson would look:

> A field-based experience experiment doesn't necessarily have a connection to your own identity and it doesn't necessarily have a connection to why you would want to actually do this science. So then it kind of still feels like this is for school versus this is for me and what I want to do.

These teachers believed that student agency and identity are key to EFBE, as it recenters how students see their role in the classroom and the lesson. To these teachers, EFBE is reciprocal in that teachers and students both shape and determine the approach, content and outcomes. EFBE also includes representation, so students (especially students of color and women) can see themselves in the field. Daphne explained, "Different representations. It's different when an African American student sees an African American professional in the field." This connects to the other understandings of EFBE, as it increases accessibility through inclusivity and centers students' diverse racial and cultural identities.

Facilitating Students' Connection to Nature

Many teachers perceived a severe 'nature deficit' in their students' lives (Louv, 2008). They saw EFBE as an antidote, a way to facilitate a connection to nature for their students. The idea of facilitated exposure was prevalent in many teachers' understanding of EFBE, as Mindy explained, "I think..more exposure to the outdoors and more comfortable in the field, what you want is for kids to feel a connection to nature versus being scared by it." This connected to larger long term

goals, like supporting interest in science and conservation, a more traditional view of FBE. This additionally connected to issues of access, as teachers saw EFBE as a way to provide students who had never had access to nature the experience. Nancy described how this impacted her students who took the Field-Based Elective she created at the charter middle school she worked at, "These were students who had never been out of the city. So seeing beyond the city and seeing nature, they were losing their minds. They loved it. They talked about it the whole two years that I was there. It really connected with them." While not the focus of this research, EFBE can be incredibly impactful for students, potentially supporting environmental/science identity, science self-efficacy and a sense of belonging in natural spaces.

Equitable Field-Based Education Definition Examples
Allowing students tangible experiences with nature: bringing nature to life in front of students and breaking down the barrier of what it means to be "in nature." Allowing populations of students opportunities to do "real science" in a way they may not have connected to their learning before - relationships build interest and interest drives learning.
It means that students have the ability to experience and learn from nature no matter their beginnings or background.
An equitable field-based education means that all students are getting practice in contributing to the field of science and addressing an issue that matters to them.
Giving all students an opportunity to have a positive experience in nature, discussing local environmental issues and brainstorming ways to combat them

Table 6. Select EFBE Definitions

Summary

In summary, in these hybridized understandings of equity and the field we see the multiplicities of enactment that emerged across teachers' understanding of EFBE.

These definitions represent a continuum of equity considerations and understandings of the field, made clearer by isolating definitions of equity and the field individually. We see ideas of equity emerging in content considerations, and understandings of the field in facilitating nature connection. Accessibility contains considerations across multiple levels of equity and the field, as does student-centered practices. Some may argue that not all these definitions represent equitable pedagogy, for example, some teachers take the blanket "for all" statement (equality), and others recognize that targeted resources and ideas should be centered (equity). While this is not surprising given early mismatches in equity definitions in the program (Ash & Race, 2021), tracing these differences in the hybridization process gives us insight into how teachers responded to the variety of intersecting forces and systems shaping their understanding and practice of EFBE. As we have begun to see, local activity systems (context) greatly shape considerations and practice of EFBE. In the following chapters I will explore in greater detail what shaped the hybridization process, if and how teachers were able to implement EFBE in practice and what tensions/contradictions teachers encountered in their journey to transformative praxis centered in EFBE.

Chapter 4: Building a Culture of EFBE: Emerging Tensions

As discussed in the previous chapter, teachers' definitions and understandings of equity and the field gave insight into how teachers had come to understand what EFBE might mean theoretically and conceptually. However, as they moved towards practice in their local contexts, they faced challenges as they tried to translate their understanding into practice. To understand what forces the teachers encountered in their local activity systems, I look to the emerging tensions. As CHAT reminds us, tension/contradiction is both a barrier and a driver of change in a system (Engestrom, 2001). Tensions can emerge at multiple levels of the activity system. In this research I look specifically at what are called secondary contradictions, tensions that emerge between components in the activity system. As Engestrom (2001) explains:

> When an activity system adopts a new element from the outside (for example, a new technology or a new object), it often leads to an aggravated secondary contradiction where some old element (for example, the rules or the division of labor) collides with the new one. Such contradictions generate disturbances and conflicts, but also innovative attempts to change the activity. (pg.137)

In this case, teachers have in some way started to introduce the concept of EFBE into their classroom activity system. By looking at the emerging tensions, one can gather insight into what forces may have shaped teachers' EFBE practice and hybridization as they worked to build a culture of EFBE at their new schools.

In this chapter, I take a macro, meso, and micro-level approach to organizing the emerging tensions. Drawing from Raffo et al. (2009), the macro-level looks to wider social and policy structures, the meso-level looks to local school contexts, and the micro-level looks to the individual relationships, etc. I discuss the following

categories, macro, meso, micro, respectively, to highlight the emerging tensions: (1)

Neoliberal Education Policy; (2) Structural Constraints; (3) Navigating Dominant

Epistemologies and Ideologies (Figure 4). I begin with a discussion of the largest

barrier faced by teachers when trying to implement EFBE, the COVID-19 pandemic,

as it shaped all systems of education during the time this research was conducted.
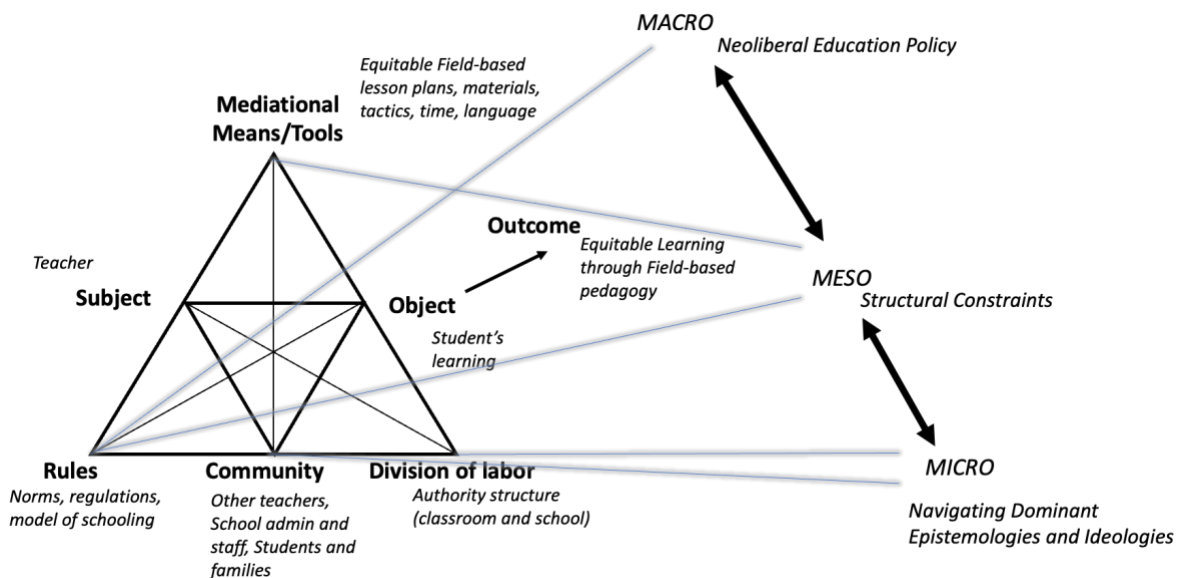
Figure 4. Examining the Classroom Activity System through a Macro, Meso, and Micro-level

COVID-19 Pandemic

It would be remiss to not begin this section without a discussion of the

COVID-19 pandemic. The pandemic created unparalleled challenges for these novice

teachers on top of the already difficult task of learning how to become a teacher.

When it came to trying to implement EBFE, all teachers mentioned the pandemic as a

systemic barrier. Distance learning and the uncertainties of in-person or hybrid

learning created an undue strain on teachers' time and mental health as they navigated

their first years of teaching. As one third-year teacher said, "Every year, so far for me, has been a first year." The shifting academic context, adapting to new curriculum, and navigating the academic and socioemotional impact the pandemic had on students left teachers with little time to do anything extra. They were required to take on many hats, draining them further; as Brett explained, "It's just the damn hardest job out there. Now with COVID, it's just so classic, I'm asked to be so many things. I'm a counselor, I'm a therapist. I'm a post-secondary options coach, I'm a teacher, I'm a janitor, and now I'm kind of a cop. I'm like a mask cop now. There are so many roles." The pandemic also prohibited field trips and, depending on the school, even going outside. These conditions additionally did not support teachers' ability to collaborate and share what they learned about EFBE; as Mindy explained, "We haven't really talked about it…I feel like anytime I do meet with my colleagues, COVID and learning gaps are our focus. Not saying that field-based learning can't also help fill in those learning gaps. It just ends up [focused on] immediate needs." However, as the COVID restrictions have continued to be removed, teachers eagerly looked forward; as Cassie explained, "I've got a lot on the docket as the COVID stuff calms down. I'm really looking forward to that being less prevalent in our school spaces and making more space for other stuff. I don't feel like there is a lack of potential ideas, there's endless things that could be done." This attitude, as I discuss later, was prevalent in all the teachers I spoke to.

Neoliberal Education Policy

Education policy widely shapes systems of education by deciding how funding is distributed to how teachers are certified. These policies have been increasingly infused with neoliberal ideologies, as school-choice, high stakes accountability and competition have become norms in our education systems (Angus, 2015; Apple, 2006). In the science classroom, these neoliberal ideologies emerge in ways that often create barriers for teachers who wish to implement equitable, justice oriented pedagogies (Strong et al., 2016). One specific example is how meritocracy, a belief that success and wealth attainment resides in individual merit, has shaped science standards. As others have criticized (Strong et al., 2016; Au, 2009; Tobin, 2011), meritocratic standards fail to address inequitable access to resources, yet continue to assume a notion of objectivity in measuring student outcomes. Even the largely celebrated Next Generation Science Standards (NGSS) fail to address differences in student science backgrounds and exposure (Strong et al., 2016). For teachers utilizing these standards, they are additionally met with the burden of preparing their students for high stakes accountability testing. In this section, I highlight the impact of the tensions between neoliberal standards and the goal of EFBE, in both middle and high school settings (Advanced Placement (AP)).

Standards

While learning and navigating standards is a challenge all novice teachers face, for a few teachers, specific grade levels and course types came into tension with the goal of EFBE. For example, in 8th-grade science in California, students are

required to take a standardized test. Preparing students for this test became a major focus of instruction. Grace, a first year teacher, explains how much this was a burden on her teaching:

> I didn't realize how much standards were going to burden me. I'm so stressed about making sure that the kids do well on that eighth grade exam. All I'm thinking about is assessment. I'm like, this is what happens, this is what tests do, this is what they warn me about. Here I am though, I need them to pass that test. Because you feel stupid when you don't and they're not stupid. So, that has been my biggest concern..is this actually going to teach them how to pass this test? Or is this actually going to be able to prepare them for the questions that are going to be on these tests?

Despite much research showing the damaging effects of standardized tests, neoliberal models of assessing success persist and have lasting consequences on modes of instruction (Tobin, 2011). For teachers like Grace, who were prepared to approach teaching in an equitable, social justice oriented way, standardized tests came into tension with their teaching philosophy and goals. This contradiction between teaching to the test and teaching the way she was prepared places her in a challenging situation. She wants students to feel they are successful at science, and despite knowing that standardized test scores are not a complete representation of student learning, she is forced to operate under this neoliberal version of success. Daphne, a 7th grade teacher, similarly felt the pressure of standards, saying it was challenging to "to fit everything they need for the state test in eighth grade and figuring out how to provide a meaningful experience while still covering all of the standards." Creating meaningful experiences for students, like ones potentially supported in EFBE, comes into tension with the need to focus on the state test. This finding adds to the growing call for teacher education programs to better prepare preservice teachers how to

navigate the growing neoliberal enclosure of education (Bartell et al., 2019; Reagan et al., 2016).

Another area that similarly experienced tensions due to testing requirements were AP courses. While AP teachers, especially those that taught AP Environmental Sciences (APES), were able to implement some outdoor lessons, they felt the AP course format limited them from being able to incorporate more equitable field-based lessons versus those that were strictly field-based. Larry, a first-year teacher who taught APES and 9th grade biology, reflected on this:

> I just would rather not teach AP because it's so opposite of any of the 5E, inquiry based learning at all. There's a part of me that wants to do that, figure out inquiry learning, and 25% of the course should be labs is what the course exam description says. But then the reality is drilling students on this information is the way to get them to pass the test. And if the goal at the end of this course is to have them pass the test, why not do that? So yeah, it's a struggle teaching that because this isn't really how I want to teach.. It's kind of like, it's just more sterile or something like that. I don't feel like I can be as creative at things and don't feel like there's a need for that because it is just like I'm teaching to a test.

This quote provides a unique insight into the praxis crisis teachers face when trying to implement innovative pedagogies like EFBE (Tolbert et al., 2021). As Larry grapples with whether to put the time and effort into adapting the AP curriculum into a format that matches what he thinks the course should be taught, the reality of the course's goals, passing a test, stops him. He feels stifled by the course's expectations, feeling any creative efforts to pedagogy, like EFBE, would not be appreciated or valued by those in his classroom's activity system. AP courses offer an interesting reflection of how meritocracy and neoliberal policy have shaped what is meant to be "high level" instruction and content in high schools. While this model is similar to college-level

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science lecture courses, the educational inequities that emerge due to this format, like tracking, are a contributor to attrition in the sciences (Atwater, 2000). This model, of course, comes into tension with how teachers like Larry want to teach but are limited by the expectations of the AP course exam. Brandon, a third-year teacher who taught AP Biology and APES, similarly found the AP format limited their ability to do EFBE, stating, "the ability of doing this [EFBE] is definitely a lot easier outside of the AP world and I don't think the AP world is the most effective space for this." This begs the question, what is the most effective space for EFBE? How do teachers overcome the praxis crisis of the undue burden of neoliberal educational policy?

Structural Constraints

Schools come with certain structural constraints that all teachers must navigate. Classroom layout, class period length, number of preps, school budget and available resources are just a few things that shape how teachers work. As teachers moved towards the goal of EFBE, it was expected that they would face tensions with these structural constraints, as many school activity systems had not encountered the concept or practice of EFBE before. The structural constraints addressed in this section are: (1) Schedules; (2) Resources: Curricular and Spatial; and (3)Time. These tensions arise from the Rules (1) and Mediational means (2,3) nodes of the activity system, respectively (Figure 4). Rules here are school rules and regulations. These range from being locally determined by the school and district to more state-level regulations. Because of this, teachers faced varying levels of tension from school to school. Mediational means are the tools or artifacts, both material and conceptual,

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that mediate the subject's (teachers) activity towards the goal (EFBE) (Cole &

Engestrom, 1993). Here these include, but are not limited to, equitable field-based

lesson plans, materials or ideas needed to accomplish these, tactics for teaching

outside, time, and language. In previous research exploring the first year of the

Program, access to appropriate mediational means during the Program was an area of

tension for participants (Ash & Race, 2021). Not surprisingly, these tensions persisted

as teachers looked for tools to support their ability to teach EFBE in their classrooms.

Schedules

Class scheduling proved to be a very important factor shaping teachers' ability

to take their students outside for equitable field-based lessons. One major barrier was

if the school they worked at had block scheduling or not. One teacher, Brett,

explained how 50-minute class periods impacted his ability to do EFBE:

> I can't, I don't have time. Once I get the kids settled and out the door, there's
> probably, realistically, at most 25 minutes outside. By the time we walk, even
> if we go to the sunken gully where there's some water on our campus, it's
> done. If you try to break apart and schedule a 50-minute class, what you end
> up with is either you're doing too much in too little time, or you end up with
> an abbreviated staccato…Then the kids have seven classes. My kids that are
> in seventh period, I'm the last, I'm number seven. They don't care. They may
> love you, but they're done. Man, it must be exhausting.

From this quote, we can sense the frustration Brett feels around the scheduling at his

school. He feels unable to do EFBE, even with access to a local green space, as the

class schedule does not provide enough time to engage students outside in a

meaningful way. His frustration with the schedule also emerges with his empathy

with his students, as he highlights the exhausting day students must face in a

constantly changing stream of class periods. He has fought to change to block

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scheduling at his school, joining committees and taking on roles of power, all working to express his opinion that, "50-minute classes are straight up damaging." Other teachers, like Daphne, similarly faced issues with short class periods coming into tension with their goal of EFBE. She explained, "I wish I could take them outside and have more experiences that were more hands-on. It's been tricky because..I see them every day, but one day you see them for 35 minutes and then 45 minutes for the rest of the days." While she implies that seeing students every day is beneficial, the types of pedagogical approaches and lessons feasible in that amount of time are drastically reduced.

Another issue some teachers faced with scheduling was when lunch and break were scheduled. At some schools, lunch periods overlap with other periods of instruction. Ingrid explained how this hindered her ability to take her students outside:

> I've tried to get my kids outside the classroom on our campus. But our school has this really weird schedule where some students have breaks and lunch when other students don't. So a lot of the time when I'm teaching, if I bring my students out, there are other students not in class and that has been not super successful in keeping them focused.

Ingrid taught 8th grade science and a STEM elective class. I observed her STEM elective class as they started a lesson unit on local watersheds and water quality. This unit ended with a field trip to a local river to collect and test water samples, a trip organized and offered by a local natural history museum. I asked her if she thought it would be possible to do a similar lesson with her 8th-grade science class, to which she responded no, as it would be extremely logistically challenging to coordinate that

large of a group of students. While she could take her STEM elective class on a field trip, this tension with the schedule made it challenging for her to offer EFBE to her general 8th-grade science classes on campus. This additionally highlights another structural barrier teachers face, class size and the number of students; the more students they must reach, the more scheduling logistics they have to navigate, especially if students have to miss other classes.

Resources: Curricular and Spatial

While teachers did create an EFBE lesson or thematic unit during their time in the Program, they often did not align with the teachers' current positions. Thus, if they wanted to teach EFBE, they were required to either create a new lesson, adapt other resources, or reach out for support from outside sources. As Ingrid answered, "So besides what I developed in the program, I would have to come up with something kind of all on my own as my school definitely doesn't have anything already for that." When asked what would support their ability to implement EFBE, seven of the teachers mentioned curricular resources as being the biggest thing they needed. As Mindy stated, "more examples. I think that the most helpful things in the Program were the guest speakers coming and talking about what specifically they were doing and how they worked it in." Though it was a goal to support teachers to think creatively about how to imagine EFBE in their local context, the Program could do more to potentially relieve this tension. While EFBE is a relatively novel concept, there are teachers and organizations that work to support things like environmental justice, equity in outdoor learning, and beyond. Nancy, who taught in Southern

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California for two years, felt the impact of moving away from the organizations and

resources she had been introduced to her in Bay Area training. She suggested:

> Having one of those meetings with student teachers, mentors and folks that
> are part of the Program, and kind of planning out, well, when you move to
> Portland or when you move to Austin, Texas, or when you move down south,
> how can we support you? I think it's more of a collaborative conversation in
> the moment and with the individual.

 Many teachers know before the end of the Program where they will be teaching the

following school year. Spending time to support and connect teachers to existing

networks would potentially help reduce the tension of lack of curricular resources.

Additionally, teachers that were able to implement EFBL often were supported by

non-profit or other educational organizations as they helped ease the tension of time

and curricular resources. Creating a document with available partners would

minimize the barrier of having to find available community resources.

Tensions emerged for teachers who were teaching a subject that was not

traditionally represented in the field sciences, like chemistry or physics. Due to the

emphasis on the biological sciences in the program, it was hard for them to imagine

how they could implement EFBE in their classrooms. While an expansive view of the

field was encouraged, and some teachers took this to heart through either a

community or "field of science" approach, most teachers felt that EFBE could only be

done during certain units of their curriculum, as Brandon said, "I would say I haven't

had much opportunity to practice it [EFBE] because of distance learning and not

getting the chance to teach ecology and evolution in person yet." This contradiction

of what subjects were content aligned with EFBE speaks not only to a need for

curricular resources for teachers teaching non-biological sciences courses, but an increased interdisciplinary focus and/or expansion of the field in the mediational means provided by the program.

As teachers worked to incorporate EFBE into their curriculum, the school campus often became their field. The teachers I spoke to worked at schools with a range of access to areas that they would consider a valuable field space for teaching. Some teachers had access to nature rich campuses, with creeks, trees, plants and nearby hiking trails. Other teachers however, had campuses that either had only blacktops or fields that were inaccessible. Mindy, for example, described her field, "I would've loved to be able to bring them outside.. to take them somewhere where they can observe plants..but the field has so many gopher holes that it's not safe for the students to walk on it or they'll just sink into it. So while we have this green space, we're not able to use it." Emily, similarly, felt the impact of lack of spatial resources for EFBE, explaining, "I don't think that would be as valuable of an experience because there's just picnic tables and blacktop, so I don't think it would capture their interest as much." These concerns about safety and engagement made it challenging for these teachers to enact EFBE. However, as teachers became more familiar with their local context, they began to reevaluate their understanding of EFBE. For Emily, her growing understanding of the limitations of her context began to shape her view of the field, asking during her interview, "I just had this thought, would bringing the field inside count as a field based lesson? So say if I brought in some stuff I collected ? .. I'm just trying to think like, okay, if I were to do this, how could I practically do

it, given my constraints, and that seems very feasible." Here we can see in real time how the hybridization of EFBE is shaped by the emerging tensions in Emily's local activity system. As teachers try to implement EFBE in their classrooms, they must reevaluate components of their understanding that are coming into tension with their goal of teaching EFBE. For teachers like Emily, this means reevaluating what exactly the field means to her in the context of her classroom.

Time

Intertwined with the need for curricular resources was the need for time for lesson plan creation. For novice (and all) teachers, time is a very valuable resource. They are often pulled in many different directions, all while trying to learn what it means to be a quality teacher in their local context. So, the time needed to create equitable field-based lessons was something they often did not have, as Mindy explained, "I feel like just the biggest one [barrier] is timing, having enough time for myself to like to sit down and really create that ideal lesson." Cassie felt similarly, "If I could have anything to help support teaching more equitable field-based lessons, it's just the time to do so. I mean maybe you hear that quite a lot that planning time, there's never enough of it." This structural tension is endemic in our systems of education. Teachers are expected to often take time out of their own schedules to prepare and their salary does not reflect this time and effort. When it comes to implementing innovative pedagogical practices, especially those that are novel to their local school context, teachers face the double bind of time, time to create lessons

and the time to convince their school community that this is something valuable to do.

Navigating Dominant Epistemologies and Ideologies

The program was designed as a 'teach the teacher' model with the hopes that teachers who participated in the program would go to their future schools and share their experiences and the goal of EFBE with their co-workers and the local community. As teachers settled into their local contexts, several tensions emerged from the relationships they tried to build around supporting a culture of EFBE. Much of this was centered if there was a collaborative community of educators. If teachers wished to introduce EFBE into their classrooms, they often needed the buy-in of their grade-level teaching partners and school administrators. If there were contradictions in the dominant ideologies and epistemologies that existed in these spaces and teachers' teaching philosophies and practices (i.e. the goal of EFBE), teachers faced challenges in building relationships around EFBE. In this section, I highlight three areas of tension that emerged: (1) Collaboration: Navigating Ideologies; (2) Disrupting Dominant Epistemologies; and (3) Charter School Neoliberal Logics.

Collaboration: Navigating Ideologies

Teachers faced varying levels of collaboration at their schools. I was specifically interested in the collaborative culture that existed between teachers and their grade level partner teacher(s), and within their department (i.e. science department). I looked to this to gather insight into the potential spaces for EFBE collaboration and transformative praxis. At the grade level partner level, teachers

either had negative, neutral, or positive experiences. For those with negative

collaborative spaces, it was difficult to discuss or share their ideas around instruction

and lesson ideas. Daphne's partner teacher had an overly negative attitude that

impacted her ability to share about EFBE. She explains:

> If I sense that they're open [to discussing EFBE], I'll bring it up. But
> sometimes it's either, you know, all they do is complain, or they're set in their
> ways. If I find that they're leaning toward one or the other, I'm like, I don't
> want to waste my time trying to convince you that this is one other thing you
> should do.

Time here comes into tension with power and collaborative culture. Daphne, mindful

of her time, doesn't wish to waste it if she feels her suggestions will not be well

received. Additionally, as she is still trying to figure out her own practice, she feels a

lack of power in her position as a new teacher, as she further explained, "In terms of

other colleagues, I haven't, because I mean, I'm a new teacher, I'm not going to be

like, this is what we should be doing." With a lack of collaboration, Daphne was

limited in her ability to move the goal of EFBE beyond her own classroom.

For other teachers, who had a positive culture of collaboration with their

partner teachers, often differences in understanding of the value of EFBE limited

discussion, as Priscilla explained, "Only with my partner teacher last year. This year,

we haven't. But our discussion was brief, again, it's a different mentality. But there

are things that are changing in the community. I'm hoping that that opens the door to

better possibilities of being able to do something like that." If other teachers are not

used to the idea of teaching outside, the concept of EFBE might seem unfeasible or

unnecessary. I found that at most schools, the concept of EFBE and an associated

norm or culture of practice was not present. In my coding, I ranked EFBE culture for each teacher's context out of ten, and the average was about four. This in tension with collaboration made it difficult to predict how presence of a collaborative culture or not would shape EFBE practice. However, when both were present, like for Nancy, it made EFBE much more possible, as she explained, "So we're all nature nerds…So just seeing that same level of energy and interest in the work here at this site is a positive." Nancy, working at a nature rich campus with a high culture of collaboration was able to incorporate EFB approaches into a quarter of her teaching time. While not a norm, as Priscilla mentions and theory reminds us, tensions lead to change. As teachers gain power and agency in their local contexts, one assumes a growing culture of EFBE could/should emerge.

At the department level, tension between old and new teachers around curricular change became clear. Many novice teachers mentioned collaborative relationships with new teachers, whereas the older teachers were seen as less open to change and collaboration. Larry reflected on pedagogical approach and student impact:

> I do see a big intersection between the way that things are being learned, how that content is being presented and the treatment of the students. Like a slideshow doesn't value their [students'] words as much and then they feel like their words are valued less.. That's been difficult, but honestly, it's one of those things where I think unless you have a very young staff, it's probably similar everywhere.

Science standards pre-NGSS were very much content oriented (hence a slideshow), as compared to the cross cutting, inquiry driven practice based NGSS (Reiser, 2014). Veteran teachers have been forced to adopt the reforms and curriculums from decades

of well-intentioned policymakers and administrators. So, when another curriculum, like NGSS, comes along, there is well-explained resistance to change, which would require reworking well-tested lessons, unit plans, and assessments. Novice teachers, on the other hand, have had no other example but NGSS, and thus these two populations come into contradiction. If teachers could be better paid, supported, and provided ample time to learn and grow as educators, perhaps this divide would diminish. But as this is not often the reality, novice teachers seem to find more space for collaboration with those in a similar position to them rather than veteran teachers who choose to use their valuable resource of time elsewhere.

Disrupting Dominant Epistemologies

While teachers considered how to make EFBE accessible to all students, epistemological orientation towards science and nature arose as a space to consider. This was not surprising, given that in social justice teacher education programs, like the one studied, teachers are often introduced to the idea of epistemic heterogeneity in the science classroom (Rosebery et al., 2010) and that there are different ways of relating to science and nature (Bang & Marin, 2015). For example, Cameron, a Latino first year teacher, was inspired by Megan Bang and Robin Wall Kimmerer, who explore Indigenous ways of engaging with science that moved away from the normative neoliberal, Western practices. He described how this impacted his thinking:

> I didn't really think about like making that type of connection, like cultural identity mixed with science education. That was definitely the first inspiration, the first idea that I was like, this is how I want my potential classroom to be. I want it where my kids can relate to back to themselves and their cultural

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identity. And I think a lot of that has to deal with me as a Latino where I wasn't really taught my cultural upbringing up until college, where I had to learn it just in courses. So that definitely opened my eyes that this is like a new way, or not necessarily like a new way, but maybe like a way that's very different from Western ideals of how a high school classroom should be run.

From this quote, we see how Cameron hoped to incorporate ideas he learned in the Program and in his teacher education program. Social justice TE inspires teachers to reconsider the dominant epistemologies that shape science instruction, incorporating more culturally relevant pedagogy and examples. In a traditional science education class, Latinx and other minorized identities are generally not given space for connecting to their heritage and epistemologies (Bang & Marin, 2015). Cameron's reflection that his educational experience didn't focus on his cultural identity until college reflects how certain identities are privileged in educational settings and others are not (Pugh et al., 2019). As Cameron learned that this normative practice can be changed, and he can celebrate both science and cultural identity in his classroom, he created an understanding of equity in science education that permeated into his hybridization of EFBE. Teachers have a level of power in their own classrooms to change exclusionary practices, and to create space for diverse ways of thinking and doing science. However, as science teachers are largely prepared in the western science paradigm, they are often provided with few resources on how to reimagine what science might look like outside this view. Cameron exemplifies a transformative shift that can happen when teachers are provided with resources on how to move away from the traditional high school classroom model.

Charter School Neoliberal Logics

        Some teachers who worked in the charter system felt tension with the way neoliberal ideologies had surfaced in these contexts. Nancy, who worked at a charter school that served majority Latinx students, felt under-supported, overworked, and frustrated with her ability to work collaboratively. First, when trying to work with teachers at her school and their partner school, she experienced misogyny. She described the experience:

> I tended to be the one to send the email and ask for meetings and check-ins on where we are in terms of curriculum progress. It also felt like a bit of a boys club when I did go to their school and have those conversations with them. It almost seemed like they didn't want to listen to me because I was the youngest and the most female in the room. It often felt like a statement that I would make would get ignored and then the other credentialed teacher would hear it, say it, and they'd all say, oh yeah, we should include that in our notes, or we should do that next.

In charter schools, there is often a large population of uncredentialed teachers. This lack of preparation, in addition to contributing to larger educational inequities, fails to disrupt dominant ideologies like individualism and patriarchal thinking, creating negative power dynamics. The administration at her school additionally failed to support their current students, blinded by gentrification and neoliberal logics. She explained, " I overheard my VP once saying, "When our future students come to this school." They were preparing for gentrification and for that landscape to change, which upset me even further." While she ultimately left the school, she managed to implement an EFBE elective course at her school, serving her current students, rather than the future students [read as white] her administration focused on serving.

Brandon, who taught at a charter school, often felt like EFBE would not be well received by their school, as ecology wasn't valued as much as other STEM subjects. They explain:

> Even my own school is a system that is meant to uplift and encourage students to do great things, but it is a barrier.. I think it turns into, like, education is this messy system of hierarchy and getting approvals from the district or the superintendent or the principal or the school community. And if it's not STEM, is that the best choice? And I'm excluding ecology in STEM here. Outdoor science is definitely not valued as much in the STEM world.

As Carlone et al. (2016) remind us, field science can be seen as a moderate pushback against neoliberal logics. In Brandon's context, they were worried that they would not receive support or would be admonished when asking to do EBFE, as the school only prioritized certain fields of STEM (i.e. medicine). When they decided to leave their current school, they finally felt like they had the freedom to do what they wanted, as they stated, "I think knowing that I am going to be leaving this charter. I'm going to fully implement something that I want to implement. What are the consequences? Like, am I going to get fired? I already quit." In contexts with a prevalence of neoliberal logics, teachers feared lack of support, or even worse, losing their jobs. Trying to enact EFBE when feeling like one must choose between employment or pushing back against neoliberal logics places teachers into a praxis crisis that requires strategic navigation, as Brandon described.

Summary

In this chapter I have showcased common tensions that emerged as teachers tried to implement EFBE in their classrooms (Table 7). By tracing these tensions and teachers' responses, we gain insight into how teachers move towards creating a

culture of EFBE in their classrooms and local contexts. As tension/contradictions act as drivers of change in a system (Engestrom, 2001), tracing tensions allows us to better understand the process of hybridization that emerges in teachers' activity systems and how various forces shape their work towards EFBE. The tensions discussed are not necessarily surprising, as schools are ongoing sites of contradiction towards work to equitable teaching and learning. However, the more critically we examine these tensions and the continuing work to navigate them to work towards EFBE and other social justice oriented pedagogies, we can make changes to support teachers before and after they enter their classrooms.

Emerging Tensions	Themes	Quotes from Teachers
Neoliberal Policy	Standards	"There are so many life science standards that to cram them all into one course in one year and to then expect to go deep into any of them, I think is a farce."
	High Stakes Assessment	"Sixth graders don't take a state test in California, they test in eighth grade, so it's pretty chill and low stakes. Nobody really pressures me to get through all of the curricula."
	Advanced Placement Courses	"AP Bio, they're really really jealous of all the outdoor activities that [gen bio] is doing."
	Schedules	"We still have 50-minute classes, and 50-minute classes, in my opinion, are our straight-up damaging."

Structural Constraints	Resources: Curricular and Spatial	"Some ideas or examples of what others are doing in different communities."
	Time	"My school doesn't give us enough time to prepare for our classes...I felt like if I wanted to give high-quality instruction, I needed to put more time into my work that was outside of the hours that were being asked."
Navigating Dominant Epistemologies and Ideologies	Collaboration: Navigating Ideologies	"We do have science department meetings, but there's no real structure or direction..I know many conversations that they do have are about what's going to happen next year or in the future."
	Disrupting Dominant Epistemologies	"That definitely opened my eyes that this is like a new way or not necessarily a new way, but maybe a way that's very different from like Western ideals of how a high school classroom should be run."
	Charter School Neoliberal Logics	"I found at the charter, if I was asking for advice, or offering a comment on a lesson plan, I would get comments, like why are you giving me feedback? So it just felt really resistant to collaboration."

Table 7. Summary of Emerging Tensions and Examples

Chapter 5: Comparative Case Studies

Introduction

From the previous two chapters, we begin to see a picture of how teachers hybridize and conceptualize EFBE in theory and practice and the multi-layered contradictions they faced as they worked toward EFBE. In this chapter, I showcase how teachers' moves towards transformative praxis centered in EFBE were shaped by their local activity systems, exploring how local and systemic contradictions shaped teachers' practice of EFBE, aiming to understand how teachers faced the various challenges and forces, such as community push-back or limited resources, shaping their practice. This chapter presents two comparative case studies, each exploring two teachers who either faced similar local contradictions or shared similar responses to tensions in their pathways to EFBE. I aim to showcase how teachers' hybridization of EFBE was shaped, what types of EFBE lessons were created, and how teachers responded to various forces and tensions in their local context. Guided by CE-CHAT, I will contextualize these case studies through a focus on historicity, multisitedness and attention to transformative praxis.

I initially organized these comparative case studies to represent teachers at similar EFBE practice levels. Early in my analysis, I had categorized teachers' use of EFBE in practice as low, medium, and high. Teachers categorized as low had either been unable to do anything at all or only done one lesson that they categorized as "EFBE-like." Teachers categorized as medium had been able to do between one or two lessons and had clearly begun to center EFBE in their teaching philosophy.

Teachers categorized as high had done three or more lessons, and EFBE was central to their teaching philosophy. However, I realized that this framing moved towards a "fidelity of implementation" model rather than a "multiplicities of enactment" model when assessing PD outcomes. In a "fidelity to implementation" model, as Buxton et al.(2015) define, assumes:

> a) there is clear a priori agreement about better and worse ways for teachers to implement a project's practices; b) ratings of better and worse implementation should vary only minimally with changing classroom contexts and teachers' views of the needs and strengths of their students; c) the researcher/observer is in the best position to judge the quality of implementation; and d)teacher professional learning follows a predictable path from participation in professional development to desired changes in teachers' classroom practice. (pg. 491)

This model does little to account for the local context and contradictions teachers face. It assumes one understanding of how PD goals (i.e.EFBE) would be enacted, and doesn't account for individual teacher understanding. Additionally, it places the researcher in a position of judging practice rather than critically examining context and systemic forces. Thus, I moved away from this categorization, reaffirming my theoretical commitment to a "multiplicities of enactment" model that assumes teachers will travel a variety of pathways towards EFBE. These will be shaped by their ideas, contexts (local and systemic), past and future activity systems, moving them towards multiple cycles of transformative practice as they find how EFBE integrates into their practice. As a researcher, I aim to understand how teachers traveled these pathways to EFBE, what contradictions did they face and how did they respond, looking to local and systemic forces. The following comparative case studies will provide a more nuanced view at four teachers' pathways to EFBE, looking at the

similarities and differences in their journeys to gather broader understandings of the hybridization and enactment of EFBE.

Comparative Case Study #1: Navigating Community Resistance

In this comparative case study, I describe two teachers who, while teaching in very different contexts, encountered similar tensions in Community. Their responses, however, were very different, and this CCS highlights how the strategic pathways teachers take toward EFBE can depend on their personal history and preparation and how neoliberal logics and/or anti-science rhetoric emerges in their local context. I begin by tracing their pathway to teaching, outlining the experiences and motivations that may have shaped their understanding of EFBE in theory and practice. I then follow their time through the program and into their classrooms, exploring how they hybridized equity and the field. I provide an example lesson for each teacher to showcase how their understanding of EFBE was translated into practice. Finally, I examine their local activity systems, outlining how these teachers responded to the forces and tensions shaping their practice of EFBE.

History, Time in Program, and Current Teaching Context

Dylan

Dylan is a third year teacher. She came to teaching with a strong passion for supporting the whole student, emphasizing the importance of approaching teaching through social justice and anti-racism. This included treating students with empathy and respect, and recognizing that students come to the classroom with different

experiences and learning styles. She was vocal about the challenges teachers face, criticizing the culture of burnout that surrounds teachers' work. She stated:

> I'm not going to save the world by myself, and I think that a lot of really rad social justice-oriented education programs, like the one that we went through, you kind of leave feeling like I'm a superhero, I'm going to go change the world, which like, hell yeah, that's great. Yet, where is the conversation of like, you will be broken down, you will get so exhausted and you will push yourselves to limit that you didn't know that you had, so please rest and please put your oxygen mask on before you assist others.

Her mindfulness of the contradictions between social justice teacher education programs and the realities of teaching seems to have helped her navigate the challenges faced by many novice teachers. Part of this connects to her belief that teachers must prioritize self-care and connection to the local community to be successful teachers, as she sees a pathway to quality teaching through relationship and community building. However, she recognized how hard this could be, overtly aware of the challenges educators had faced during the Pandemic, reflecting, "especially through these last three years, there's just been such a colossal loss of educators in the profession because we're being forced to be martyrs and choose our students over ourselves."

History

Dylan, a white woman, grew up in a small conservative town, close to nature. She described herself as a 'math brained' person, who was very interested in science and math. Her passion for science came from early exposure to nature stating, "This is science [natural spaces], this is what I want to be studying. What I want to be involved with the rest of my life is ways to preserve this and to make this accessible

to everyone." Dylan received her undergraduate degree at a small, private university in California where she majored in Interdisciplinary Educational Studies and Environmental Studies. Her undergraduate experience afforded her both field-based and teaching experiences. She described these as very impactful, shaping her early understanding of what field-based education might look like. She was able to have field experiences, both locally and internationally. She described a memorable experience while studying abroad in New Zealand:

> We had a natural healer from the Maori community go on a hike with us and explain the healing benefits of all of the plants that we walked by. I was just so overwhelmed with the knowledge base and all of these plants. I just felt like the entire time I was there, anytime I was hiking, I just had this beautiful interaction with such curiosity of what I was seeing because it was in some ways very similar, but in some ways just so foreign.

We see the deep connection she feels towards nature and the impact exposure to non-dominant nature epistemologies had on her experience. Similar to many of the teachers who participated in the Program, a strong nature-based identity shaped and guided her pathway toward teaching.

Time in Program

Dylan was in the first cohort of the program. The program had a great influence on her, she said that "having access to the program was really, really important for me. It really just set in motion all of what I believe that education can be." She was paired with a cooperating teacher who was an expert in EFB approaches. She saw this partnership as transformative, affording her much agency and confidence in her pathway to teaching. Another aspect of the program that was impactful to her was a paper she wrote exploring a topic about EFBE. She said, "I

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wrote this paper that was essentially my own description of what field-based learning was and how I define field-based learning. Something that I found through that process was that there was such a vast umbrella as to what we can coin as field-based learning." This understanding pushed what was offered by the Program in the first year. This expansive view of the field, one that did not limit a definition to one specific place or idea, allowed her to approach EFBE in interdisciplinary settings, like math, that limited other teachers. For example, many other teachers saw EFBE as limited to biology or ecology content, finding it challenging to think about how EFBE might look in other topics or subjects.

In the first year of the program, the leadership and coordination of workshops were done largely by the biology faculty. Workshops featured a field-based research experience, examples from local outdoor educational non-profits, a strong connection to natural reserves, and a focus on lesson plan development and implementation. No criteria were provided as to what EFBE might specifically look like, and little discussion of equity was included in the workshops. Looking at early program documents, like an excerpt from this one from September 2018, we see no mention of equity, "If we address these barriers and enable diverse students to develop environmental awareness and *engage in field-based inquiry-driven learning from a young age,* we can foster diverse leadership, voices, and cultural traditions in ecology and conservation science in California." While barriers are discussed, and pathways to increase equal access to field-based education are focused on, there is little mentioned about the way the field-based pedagogy might be adapted to increase

equity, diversity used as a code word for equality. This mismatch in the understanding of equity and equality pushed the program to pursue and deepen a commitment to equity in the next years of the program (Ash & Race, 2021).

Dylan and her cohort mates played a meaningful and agentic role in this transformation. She was critical of the lack of discussions specifically around how one might enact K-12 EFBE, finding the dialogue was largely based on natural science faculty members' experiences teaching field-based courses in higher education. While the program in its first year was not perfect in its support of EFBE in K-12 settings, the integration of teacher feedback supported a cycle of transformative agency for teachers (Engeström, Sannino & Virkkunen, 2014; Severance et al., 2016). Teachers felt comfortable actively challenging and calling out practices they felt did not meet their understanding of educational equity. For Dylan, her role in the program strongly shaped even her career trajectory. She mentions that her job selection was influenced by the Program goals, stating:

> And it just kind of like smacked me between the eyes sitting there thinking of all of these ideas of how to do field-based education in urban areas that I want to take the skills that I have of creating lessons and, and of creating curriculum and take them to a place where it needs it the most.

She has also come back several years to support other teachers in the program, shaping her deep commitment to EFBE. During these visits, she was able to share her expansive view of the field, helping other teachers imagine how the field can mean community and what EFBE might look like in a math classroom.

Current Teaching Context

Dylan teaches at a charter high school in an urban area that serves predominantly African American and Latinx students. She teaches 9th-grade algebra, a subject outside of her original credential. She said this was a big challenge for her, and in her first year of teaching, she relied heavily on a previous teacher's curriculum. However, as she grew confident in her teaching, she was able to develop a curriculum that better met her teaching philosophy. She is well supported in her practice, she described her school as very collaborative, and her school community sees collaboration as essential to school, teacher, and student growth. She works closely with another algebra teacher and has an aide in her classes to support students with IEPs. While expected to meet district standards, she has had the freedom to explore teaching through a lens that meets her commitment to social justice and anti-racism. She believes that while content standards are important, teachers are also models for other skills, as she explains, "So in what ways am I, outside of content, modeling anti-racist behaviors? What ways am I modeling deep understanding and empathy? In what ways am I modeling holding boundaries, but also clearly expressing when someone has trespassed against a boundary of mine?" This philosophy exemplifies her agentic and holistic approach to teaching as it emerges in her local context. It showcases how she is challenging neoliberal standards of learning to center social justice and anti-racist ideologies and behaviors.

Grace

Grace is a 1st year teacher. She placed relationship building with her students and community as a central piece of her teaching philosophy. As a Latina, she grew

up seeing teachers as community leaders and individuals that should be respected. As a teacher, she saw herself, similarly, as a resource for the community. She felt as a teacher, she should give students the knowledge they needed to be change-makers in their communities. She reflected:

> I think that sometimes that part isn't realized either, that they actually have a lot more power and agency than they think. I think the classroom is a great place to do it because it's kind of like a bridge between a community..and places of power. So who made that knowledge that's being taught at school? So I think it's a good bridge between both of them in that we have as a teacher, we have the agency to look at that system and be able to recognize the power dynamics there and then also be able to discuss it with our students and give them that power by discussing it.

Giving students the opportunity to critically explore the systems of power that perpetuate educational inequity, especially in the communities where she grew up, was the hope she had for her teaching.

History

Grace grew up in the Central Valley of California. She said she was considered a top student, reflecting, "I got pretty much any of the opportunities that they could offer, but that was also not what everyone else got." She went to community college and transferred to a major public university in Southern California, where she studied Anthropology. She knew she wanted to pursue teaching but wasn't sure what subject she would want to teach. After graduating, she had the opportunity to work in student affairs, and assisted a group that worked to provide research experiences and educational outreach to high school students on environmental science topics. During this time, she had the opportunity to develop curriculum and lead outreach, which reinvigorated her passion for teaching. She

stated, "I realized that of everything that I was doing, what was making me the happiest was definitely when I was teaching in the class. I really was enjoying the lesson making and trying to think of ideas of how to engage more students into this material." She decided that despite her lack of background knowledge in the sciences, she would pursue a science credential as she felt it would be the most valuable subject for her to put her expertise.

Time in Program

Grace was a member of the third year of the Program. She was motivated to join the program because, as she stated, "I knew that one of the opportunities I wanted to give was hands-on stuff. Like not only looking at a textbook, which is what my memories of doing science were." The third year of the program was completely virtual. With no in-person field-based component, the workshops, held over Zoom, instead incorporated guest speakers that focused on environmental/health justice issues, Indigenous experiences, and multilevel approaches to the field (local vs. broad). This lack of a physical field led to an expansive view of the field, which encouraged teachers to think beyond the idea that the field is a specific natural space. For Grace, this ambiguity was challenging:

> The thing I struggled with the most was, what is the field? I know that's something that we've talked about, and I think I struggled with it because not only were we online and then didn't really get to do it in person, but I think to some degree, it started making me think, well, like what's the difference between field-based learning and project-based learning?

While many others came to the Program with a predetermined idea of what field-based learning was, Grace's lack of previous experiences created a tension that left

her feeling uncertain at the end of the program about how EFBE would look in practice. She further explained, "It would have been great to have the opportunity to have had the field-based experience with everyone… because for myself, I personally don't feel like I have that many field-based experiences from a more traditional definition of it." Grace's experience demonstrates it is important to recognize the variety of backgrounds, exposure, and practices teachers have experienced around key concepts to best support them.

Current Teaching Context

Grace is an 8th-grade science teacher. She works at a public middle school in the Central Valley. She chose to work in Central Valley as teaching in a community like where she grew up was central to her call to teaching and philosophy:

> I came in with a pretty strong philosophy, which was like bring all the stuff that I loved about living in a small town and the education I got there, which was just this sense of community, support for one another and just knowing your neighbor really well.. and then all the stuff that I wish I had, which I learned later in life when I moved to a bigger town, which was exposure to more hands-on science.

Much research has shown that teachers often return to within 15 miles of their hometowns to teach (Boyd et al., 2005). In areas that suffer teacher shortages, this return is especially impactful. Her motivation to support hands-on science education is supported by her district and co-teacher. However, given that she works in an old school, her classroom isn't equipped to do labs, as she described, "It's not amazing because my classroom is definitely not made for having labs, but it's better than the other 7th grade classrooms, which has carpeted floors, at least mine aren't carpeted so it's easier to be messy.. you just make it work." Her school also lacked a curriculum

and the textbooks available were 20 years old. She said that most of her time was spent focusing on her job, explaining, "It's more about once I get going and what I plan, I just can't ever stop. Like I'm always trying to make it better, improving and it feels like the work never ends." She further explained, "For me, I'm just like, well, I have nothing else. This is my life this year. I have accepted it." Standards also placed a burden on her teaching. Much research shows the damaging effects of standardized tests, but neoliberal models of assessing success persist and have lasting consequences on modes of instruction (Anderson et al., 2019). For Grace, who was prepared to approach teaching in an equitable, social justice oriented way, standardized tests came into tension with her teaching philosophy and goals. This was made even more clear to her while teaching a STEM elective course, which had no standards; she reflected, "I've noticed that a lot of the stuff, the big ideas that I have, start more in the STEM elective because I don't have to worry about standards."

Summary

In this section, I aimed to understand the multisited and historic systems influencing the hybridization of EFBE. Dylan and Grace came to teaching for different reasons, Dylan through her passion for science and nature, and Grace wanting to provide educational experiences that she lacked to her community. Although they were different in many ways, they similarly saw students as agentic actors in their educational journey, recognizing that students are part of a community that they have the power to influence and change. They felt teachers play a large role in supporting students to be agentic, thinking people students, Dylan recognizing the

non-content skills she might model for her students, and Grace focusing on providing inquiry driven experiential learning to her students, things they both felt they might not get in other educational spaces. Both were uniquely reflective educators, both providing insight into their pathways, past and current, to teaching. During their time in the Program, they each experienced very different versions of offerings: in-person vs. online, lack of equity focus/traditional view of the field vs. equity focused/expansive view of the field (See Appendix). Less teacher feedback was actively incorporated in the third versus first year due to the nearing of the end of the pilot period, positioning Dylan in a place where she came out of the program feeling more agentic and confident in her pathway to EFBE, though this was also supported by past field-based experience and in-person offerings. While this is not to say that Grace didn't approach EFBE with agency in her practice, she just had a less concrete idea of what EFBE might look like.

Hybridizing and Enacting EFBE

Dylan

Dylan defines EFBE as, "having a wider understanding of what a "field" can be. Having a more expansive view of "the field" means that even in highly urban areas, teachers and students will be able to engage in a curriculum that feels personal and rooted in their community's identity." Looking at her history and current context, the hybridization of EFBE was shaped by her experience in the Program, her school context, and her past experiences. Data collected while she was in the Program made it clear that the Program goal deeply resonated with her existing holistic beliefs and

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allowed her to build on them for her future teaching. This goal was supported and influenced by the culture of social justice at her current school. Underlying all of this was a rich background in traditional field experiences and a nature-based identity. However, these past experiences did not limit her understanding of what the field could be; instead, her time in the program prompted her personal understanding of what the field could be when focused through community issues. As she hybridized EFBE within her local context of teaching mathematics, she was able to draw from these experiences to come to an understanding of EFBE that allowed her to define the field in a way that hybridized equity and a local, place-based understanding of the field. While she doesn't explicitly name equity in her definition, she sees community as a pathway to equitably approach field-based teaching in urban areas, which are often lacking access to natural spaces. Community also provides a connection to students' lived experiences and identities, a key component of social justice pedagogies, like culturally relevant (Ladson-Billing, 1995), culturally responsive (Gay, 2002) or funds of knowledge (Moll et al., 1992).

Lesson

 For the past two years, she has taught a lesson exploring police funding in her class. Iteratively designed, the lessons cover algebra standards while promoting critical thinking. She explains:

> I came up with this idea of having students use the skills that we had learned in math class thus far to critically analyze what it would mean to defund the [city] police department. It hit on all these content standards of like recursive tables… and being able to understand what an inequality actually represents, what a variables within an inequality represent. Then how do we also use that

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information and use those charts to come up with a different solution to what
we currently have existing?

Drawing from publicly available data, students were able to look at the overall budget

of the police department and that of other public institutions, like the school district or

parks and rec. Students explore questions like: Do they need this much money as an

institution? Why does this institution receive more or less than others? Is that the right

way to do it? In your ideal world, how would this money be allocated? She said this

lesson generated great conversations for her students, as she described, "And they, as

14-year-olds, are getting to have these conversations of, 'this is where I think money

should go because this is the future that I believe [city] should have. This is the future

that I believe I deserve.'" She further explains the importance of critical thinking in

math, saying, "It was just really powerful for them to have this project where they had

to critically analyze what it would mean for their own community to make these

changes. To me one of the most powerful things you can do with math is use it as it

means to arm students to be critical thinkers." The content is distributed online via a

program that allows teachers to adjust for various learners. Students, at the end of the

lesson, either wrote a letter to the mayor or created infographics of how they believed

the funding should be distributed. In this equitable field-based lesson (EFBL), the

field has been understood as a community-based task, where students were able to

engage in an issue facing their city. The lesson topic is central to making it equitable,

she states, "the real thing that makes this an equitable assignment is that it centers and

challenges the dominant narrative of what we talk about in math." In this EFBL, she

had the opportunity to work collaboratively with the other algebra teacher at her

school, being well supported in its development and implementation across all 9th-grade algebra classes.

I was able to observe a different lesson in Dylan's classroom, a lesson introducing the concept of parabolas. In her classroom, I was struck by how it reflected many of the principles she believed in, with posters, flags, and quotes supporting allyship, social justice, indigenous sovereignty, and anti-racism. Even the warm-up question before the lesson on parabolas had students explore DACA trends and to think critically about what the data represented. EFBE was clearly integral in her philosophy and practice of teaching. In the lesson I observed, students went outside to toss water balloons and measure their trajectory. Dylan considered it to be an EBFE because it incorporated time outside of the classroom, allowed all students to come to the concept with a common experience on what parabolas are, and connected to how one might apply this math in 'real life.' She uses a more traditional 'outside of the four walls of the classroom' view of the field in this lesson, though she said it was initially hard to figure out how to incorporate outdoor time in her classroom. She explained, "I think in my first year teaching, it felt really daunting the idea of taking students outside of the classroom to do work. I think that I hadn't yet come up with a strong enough correlation with an outside activity to something that hits on algebra standards."

Grace

Grace defines EFBE as "all students are getting practice in contributing to the field of science and addressing an issue that matters to them." The hybridization of

EFBE was shaped by her past experiences and ideas from both her TE program and the PD program. Recognizing the gaps in her science instruction growing up, she was motivated to minimize the gap in experience that many students face when it comes to doing science rather than just reading it out of a textbook. In addition to a focus on hands-on, inquiry-driven pedagogy, she took an expansive view of the field, prompted by the virtual setting of her time in the Program, the field coming to mean more the associated skills and practices needed in the sciences. Shaping her understanding of social justice and equity were readings done during college and the MA/C program. However, her hybridization of EFBE is in the process of being explored and expanded, especially around equity, as she states, "I know I'm not hitting equitable per se, in like its totality. Right now, it's like a baby EFBE version that I have in mind." Recognizing that EFBE is a continuum of practice, an ongoing process toward transformative praxis, allows her to continue to move towards EFBE in a small, stepwise approach. This was a mindset she learned in the TE program, explaining, "It's helped me pace. Instead of viewing it as like, I need to get it all done in one year, I think it was a good reminder of like, I'm going to get there and I know I can start to get to those different goals, but for now, like I need to only keep one because it's just not possible for my first year."

Lesson

Grace has worked hard to ensure that there are hands-on elements to most lessons she teaches. When asked to describe an EFBL, she described a lesson where students were learning about the scientific method. She said she gave students the

opportunity to design their own experiments and provided them with whatever

resources they might need around a central theme of Alka Seltzer tablets. She said the

fact that all students had access to the resources they needed was what made this

lesson equitable, making sure "that they didn't have to worry about getting it

themselves in order to conduct something." This was the first lab students did, so she

worked hard to establish norms of students sharing work and working collaboratively

to answer questions. She made sure students felt comfortable presenting, having them

present to partners rather than the whole class. She explained:

> That was their first way of learning about the scientific process and learning
> all the terms that they're expected to know, to practice using the tools that I
> want them to be comfortable using, and knowing the expectations. Then kind
> of introducing the community of science and what it looks like a little bit too.
> So it was trying to do all that.

This focus on relevant skills, tools and practices was clear in her understanding of

what the field meant in this lesson. Here the field came to mean, she described, "just

knowing how to set up your experiment for any type of field, like knowing how to

handle it in general. This is prep for any field. We did talk about that too, different

science requires different methods, different questions, and different ways to

approach it, so it doesn't always look the same all the time." She said one challenge

for this lesson was supporting students who were not used to student driven, inquiry-

based labs. She explained:

> It was very hard for them, for me to be saying, 'Well, what do you want to
> do?' And they're like, 'I don't know.' So that was challenging, but I think that
> it was the right time to do it in the beginning, to push them. To be like, what
> really matters is your opinion, not mine and kind of establishing that early on.

For these students, she provided additional scaffolding, helping them google ideas of experiments they could do using Alka Seltzer. By establishing early in the school year this culture of student-centered inquiry, she supported the development of students' self-efficacy in their science practices, which is linked to science identity and persistence in the sciences (Race et al., 2021).

Summary

In both Dylan and Grace's definitions of EFBE, we see a clear link to their practice, with Dylan highlighting an expansive view of the field and Grace naming student-centered inquiry in the field of science. This link to me indicates moves towards transformative praxis as they work towards translating their conceptual understandings of EFBE into practical application. We additionally see the unique hybridizations and understandings of EFBE as they have emerged for these two teachers, each shaped by their pathways to their current context. Dylan's lesson centers on social justice and equity in its content, connecting to her time in the Program and her current school's mission. She also had to think creatively about how EFBE might be translated into an Algebra curriculum in an urban area, finding inspiration in the Program's goals and offerings. Grace's hybridization of EFBE represents a connection to her background as an Anthropologist, the field representing a physical but also a conceptual place where one can examine, practice, and learn about 'real world' science. Her lesson represents this understanding and works to establish a classroom culture of scaffolded, hands-on, student-driven inquiry. While they had different experiences in traditional field-based education, Dylan

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experiencing field courses in undergrad and Grace having no prior experiences, they both similarly use an expansive view of the field, Dylan responding to her local context and Grace navigating ideas and resources presented in the distance learning version of the Program.

As a third year teacher, Dylan has had more time to refine and iteratively design her lesson to best represent her conception of EFBE. She developed her lesson in her second year of teaching and has had two years to teach and improve. She has begun to incorporate additional out-of-classroom lessons like the parabola lesson discussed. As teachers create new EFB lessons, they go through a process of reflection, asking things like: How is this an EFBL? How am I considering the field? Equity? For Dylan, her practice as a teacher has gotten to a place where she feels she has the time and resources to explore other representations of EFBE in her practice. Grace, however, in her first year of teaching, is still working towards a practice that fully represents her conceptions of EFBE, especially around equity. While she hopes in the future to better incorporate equity in content, she works to support equity in other ways, like classroom practices and resources. Work towards equitable science practices is also seen as they both work to create lessons that center student voice and agency. Dylan's lesson focuses on creating spaces for students to have discussions around social justice topics, and Grace supports student choice in labs and curriculum. These practices work to shift away from the traditional banking model of education to one of problem posing, which is a central piece in the development of critical consciousness (Freire, 1971). As these teachers work to support their students

in the process of critical consciousness development, they in turn support their own

critical consciousness development, supporting their cycle of transformative praxis

(Figure 1).

Navigating Pathways to EFBE: Tensions in Community

Dylan and Grace placed community central in their teaching philosophies and

understandings of EFBE. Interestingly, for both teachers, community came to be a

place that came into contradiction with the goal of EFBE. Here community refers to

both community in and out of the school. Understanding the pathways these teachers

took to navigate these tensions provides insight into the multiplicities of enactment

that emerge when trying to teach EFBE, and it helps shape our understanding of how

teachers respond to the forces that limit their moves toward transformative praxis.

For Dylan and Grace, contradictions arose around the content of the lessons.

Dylan, whose EFBL focused on the discussion of police funding, experienced push

back from a parent. She described the interaction:

> This year in particular, I had my first parent challenge my lesson. They said,
> "How dare you offer this up to students? How dare you!" And this is a parent
> of a white student. They were like, "You are forcing our students to have
> conversations that they shouldn't have to have as 14 year olds. They're too
> young to be forced to have these conversations."

This mirrors the growing group of parents and communities in the United States

against Critical Race Theory (CRT) and discussions of race and racism. Dylan, highly

supported by her school community in her practice of EFBE, was able to have an

open conversation with the parent as she reflected on the experience:

> I think parent pushback is really challenging but also really important..Like
> what an incredible opportunity it afforded to me to outline all of the ways in

which I am offering their child the development of critical thinking skills and how this assignment hits on all of these content standards.

Confident in her ability to have an open discussion without fear of retribution by the school, Dylan was able to navigate this tension with agency. However, she reflected that she worried that her ability to do something like this was context dependent, wondering, "Let's say I get hired at another school next year. Will I have pushback from the admin rolling out an assignment like this? What would that look like?..How does this exist within a school that is not rad?" Many teachers will often leave school due to a lack of support from the school administration (Nguyen, 2021). While many of the teachers I talked to felt their school administrators would be on board for EFBE, they felt there would be little active support, and if they wanted to do an EFBL or field trip, it would have to be 100% organized and planned before going to administration.

While the school community is an important part of supporting EFBE, pushback from the local community/parents can silence teachers from pursuing EQUITABLE field-based education. For Grace, her school community maintained an unspoken code of what was allowed or not allowed to be discussed. The conservative community within which Grace taught limited her emphasis on equitable topics, as she explained:

> We did a plastic and waste lesson. We mapped around on campus the places that we found the most amount of trash and what kind of trash. We looked at it, then we made graphs, posters, signage, and art with the trash to tell people to stop. And it's like, you can stop there. But if you start going into anything else, like where a landfill is placed, then it feels like it's encroaching on things that do not want to be talked about.

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Grace explained that this silencing was an accepted school norm, and other teachers had warned her about the language and topics she covered. This appeared especially around "controversial" topics like evolution, as she described, "I've definitely learned, for example, my last unit was on evolution, and I was told not to say evolution. It wasn't told by any of the administrators, but the teachers were like, 'It's best if you just avoid saying it, because once you start saying it, that's when your parents are gonna start calling you.'" A focus on social, racial, and environmental justice is a key piece of EFBE for many teachers. When they are silenced by a conservative community that is maintained by the school community, they can still practice EFBE, but are limited to the full extent they can teach the content they truly want to teach.

This was seen clearly in a lesson that Grace had hoped to teach that explored what she saw as an equitable topic, a lesson on why students had bad internet. However, it was not accepted by the other 8th grade science teacher, as she explained:

> I did try pushing it for my second unit... I was like, you know what, we're learning about waves, maybe our main phenomenon should be like, why did our internet suck? Because a lot of kids had really crappy internet during COVID and especially in this area... I think it was assumed that it meant they had to learn the nitty gritties of the internet and also explain all that. And it's true, that's not required for the standard, for them to know specifically for a particular technology how waves work. I pushed it for a bit and it was just kind of pushed back a lot that it was like a no. And so I was like, obviously we're not going to make any headway, because like, this is what I do want and this other teacher doesn't want it, so I can't keep pushing it. So that was a big one. From there I was like, this is a battle that it's going to take a lot of time to keep fighting, and I'm also not in the position to have been able to prove it to him this first year, like, "See, this is why it's great," because I still was trying to figure out my teaching.

Despite feeling like she was working in a school district that supported science education and collaborating with a teacher who agreed with her mission to

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incorporate hands-on science, this example showcases how intersecting

contradictions limited her practice, neoliberal standards, conservative community,

access to mediational means, and power inequity. As mentioned previously, Grace

felt particularly burdened by the 8th-grade assessment and standards, and thus her

grade-level partner's reason, "It's not in the standards," may have been seen as a valid

reason not to do the lesson. However, if you look at the conservative community she

lives in, the topic may have been seen as too social justice oriented and thus vetoed

by the other teacher. One could also interpret her grade-level teachers' veto of her

lesson as a power differential, and Grace's interpretation of not being able to prove it

was a valuable lesson indicative of this. However, one could also look to the

mediational means necessary to complete this lesson, as perhaps neither teacher felt

prepared or had the time to learn how to discuss the nuances of Wi-Fi, and it was

easier to choose a different topic. In this system in tension, one might wonder how

these contradictions might be resolved, and moves toward transformative praxis could

be made. Grace reflected on her EFBE practice, "And I think it has a lot to do with

that I don't have the time to think of this right now and when I have tried it takes a lot

of effort. I'm just going to let that happen slower. I'm taking that as a five-year goal

versus like a first-year teaching goal." Responding to these contradictions will take

time and may require her to be in a position of power and stability. She told me, "I'm

going to wait until I'm tenured because if I'm not at their school for a third year, then I

can't do anything." Resistance takes many forms when working through systemic

tension, Grace was strategic when navigating her pathway towards EFBE.

Summary

In summary, these two cases show how attention to historicity, power, and a multisited sensibility provides a nuanced view of two pathways toward EFBE. Tracing teachers' pathways to teaching, through the Program, and into their local context gave a clearer understanding of how teachers took up the goal of EFBE, how it emerged in practice, and how the hybridization process was shaped. Both Dylan and Grace interpreted the field in their own unique ways. Their different pathways led them to similar tensions while trying to enact EFBE. While the Program assumed that EFBE was something that should and could be spread and taught in K-12 settings, there was little discussion around how to navigate situations where the practice might be pushed back against. These two teachers navigated these tensions differently depending on their context. Dylan, being supported by her school, was able to address the pushback directly. Grace, on the other hand, worked in a school where 'controversial' science content was silenced and thus responded with calculated resistance. In a larger context of growing national anti-science sentiment (climate change deniers, anti-vaxxers, etc.), creating a pathway forward for EFBE that reflects teachers' hybridized understandings of equity and field-based education will take time and support.

Comparative Case Study #2: Tracing Equitable Practices in and around EFBE

In this comparative case study, I argue that teachers' hybridization of equity and the field did not always initially translate to the practice of EFBE. I show how two teachers' enactments of equity emerged in other areas of their practice as equity was still being negotiated in their work toward EFBE. I aim to show how the hybridization of EFBE occurs over time, with various stimuli, contexts, and mediational means leading to iterations of enactments, conceptually and materially. This CCS is organized by first tracing the focal teachers' pathways to teaching and their moves through the Program and into their teaching contexts. I then showcase one enactment of EFBE in their practice, aiming to trace how local contexts might have shaped their praxis of EFBE. Finally, looking at how the hybridization process of EFBE supported equity work in other areas of their practice.

History, Time in Program, and Current Teaching Context

Linda

Linda is a first year teacher. She is very passionate about promoting social justice in the science classroom. She believes in dismantling stereotypes in the sciences and working to support all students in feeling like they can do science. She centers sociocultural theories of learning in her classroom, seeing students as agentic, active participants in a community of learners. Key to this is seeing students wholly as people and approaching teaching through a practice of respect and representation. As she states, "making sure that every single student in the classroom feels valued and seen and really promoting social justice, especially in the science classroom."

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History

Linda is a white woman from a nature rich area in California. Growing up, she spent a lot of time outdoors. However, despite having close access to nature, her teachers rarely took students outside, reflecting, "looking back, there were so many opportunities to get out and do research outside, but we just didn't take advantage of it in my classes." She said that the few times that she did go outside was important, explaining, "those little moments where we did go outside in school were really impactful because I still remember them." She completed her undergraduate degree at the same university that the professional development program took place, double majoring in Film and Biology with an emphasis in Education. During her undergraduate degree, she took no field courses and had limited field-based educational experiences. She participated in the CalTeach program that supports undergraduate students in becoming teachers, completing five teaching internships. During this time, she was able to create biology lessons and practice teaching at the middle school and high school level. She was particularly inspired by a high school teacher that created a school community garden, describing, "It was wonderful to watch the students work together to support the garden. They even cooked a giant meal with food from the garden at the end of the year for everyone at the school." Her passion for media and science combines in her love for science podcasts and videos, like Science Friday and SciShow.

Time in Program

Linda came to the teacher education program right after completing her undergraduate degree. Her previous exposure to teaching in the CalTeach program

inspired her to begin to brainstorm ideas of how to promote educational equity in science education, exemplifying her strong passion for environmental justice and equity. She joined the PD Program hoping to gain tangible ideas of how to implement equitable science instruction. As mentioned, the third year of the program was completed online, with a large focus on conceptually defining equity and the field. Like many other teachers in the third cohort, Linda felt discussions of equity in practice were valuable to her future teaching. She reflected, "the biggest thing that's had an impact so far is the piece of [the Program] that's really focused on making the curriculum equitable and accessible for all students." This centrality was also reflected in program goals, language changing from "equity-infused" to "equitable." This showcases the cycles of transformation that the program activity system underwent to move towards representing equity in a way that was meaningful to the pre-service teachers.

Linda came to the program with little field-based educational experience. Like many teachers, the concept of equitable field-based education was new to her, and she felt it should be introduced to all teachers. She explained:

> I think that this program that we're doing is such a great idea and a great program to really introduce us to these ideas because *I wouldn't have known without this*. So I think this is really important. I also feel like teachers going through credential programs, science teachers, they should take a class on field based learning because I think that would at least introduce them to the ideas and then they could either decide to jump on board and use it on their own or maybe not. I think it's important to give teachers that extra education so they're even aware that this exists.

While some teachers come to teaching with experiences in field-based learning, there is often little translation of the pedagogical approach into the K-12 setting. Many

teachers I spoke to felt this idea was very novel, and they did not see it in practice in their teaching contexts. For Linda, the Program opened her eyes to the connection between field-based learning and science teaching. She further described the connection between science and the field, stating, "science is really a very field-based discipline: going out, doing things, collecting data and making observations. I think it's important to get students outside doing these things, really seeing how interactive science actually is instead of just learning about it." For other teachers, similarly, EFBE was seen as a way to do science rather than just reading about it in a textbook. The Program encouraged teachers to think creatively about teaching, seeing the classroom beyond the four walls and out into the field, however teachers might define it.

Current Teaching Context

Linda is a 9th-grade biology teacher at a suburban school in California. She is teaching at the school where she was a student teacher, working in a year-long temporary position, filling the role of her previous cooperating teacher who went on medical leave. She chose the position due to her comfort and familiarity with the school and wanting to feel supported during her first year of teaching. Transitioning back to in person instruction has been challenging. She felt like her teacher education program, done remotely, did not provide her with adequate classroom management skills or lab development ideas, a tension many other novice teachers who went through their teacher education in the COVID-19 pandemic have experienced (VanLone et al., 2022). Additionally, as she transitioned back to the in-person

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classroom, she felt she had to adjust her teaching philosophy, seeing students as people to support a culture of respect and to meet the realities of teaching. While she still firmly believes in it, she explained that this does not necessarily immediately create the classroom culture she was aiming for. She explained:

> I think it is so much harder in practice than I realized it would be because I think my thinking was like, oh, all I have to do is treat them like people and they'll naturally have respect for me in our class, but that's not what happens with everyone. Some of them are really nice and respectful, but I think some of them don't owe you that. You can treat them as people and you can try to give them this sense that they are meaningful to our classroom community, but some of them sometimes block it out or they don't reciprocate that respect sometimes. I still genuinely believe that they need to hear it from me and be talked to, not like peers, but you know, people on the same level.

Other teachers also spoke to this disjunction between their perceived expectations of how teaching would be and what it was like, especially in the varying formats the COVID-19 pandemic created. Literature supports this, highlighting how novice teachers are often underprepared for the realities of teaching (Goddard and Foster, 2001).

As her school did not provide her a curriculum, she was solely in charge of designing the curriculum for all 9th grade biology classes, drawing from other teachers' previous lessons. However, she felt these previous lessons are not NGSS aligned. She explained: "I really feel like the way that they used to teach the class isn't super NGSS aligned, or at least as much as I would like, especially from everything that I learned from the program. So that's been kind of a struggle of like, how much did I keep the same? How much should I change realistically? Like how much do I have time to change?" Despite NGSS becoming the norm, there are still

veteran teachers and older curriculums that have not fully adopted the standards

(Smith, 2020). Finding the balance between creating a curriculum that met her

standards (and the states) and not burning out was a delicate balance that many other

teachers had to navigate (Nawana Parker, 2020).

The school she teaches at is in a majority white, small community.

Unfortunately, the few students of color that are at the school have faced instances of

racist microaggressions. She described these students' experiences:

> The students have talked to me about some of their teachers saying things that
> weren't completely considerate. The [teachers] are not doing it on purpose, I
> think they just don't know or don't realize that it might be hurting people.
> They've heard it from other students too. The administration sometimes
> doesn't understand some of the issues that they're facing as well.

Supporting these students and making sure they feel like their concerns are heard and

met has been a major focus for her. She helped these students create a club that

allowed them to share and address these acts of racist microaggressions, acting as

faculty leader. In summary, Linda faced three major tensions in her first year

teaching, the impacts of COVID-19 on her teaching and preparation, lack of NGSS

support and racist microaggressions emerging in her school community.

Daphne

Daphne is a second-year teacher. Methodical and data-focused, she looks to

research to support her teaching practice. For example, she mentioned, "there were

several studies that came out, I think, within the last few years that looked at rigorous

project-based learning and how it could increase test scores significantly." She is a

firm believer in Universal Design for Learning (UDL), a research-based framework

used to support teaching that meets the needs of all students and utilizes it across her

teaching as a way to promote equitable learning opportunities (Rose, 2000). For her,

UDL includes:

> ensuring that students have multiple means of representation in the classroom, and access to the curriculum. So whether it's their ability to listen to content, through audio, Speech to Text abilities, making sure that information content is given to them, not only in text, but also images and videos, and they can also talk to their peers. But at the same time making sure that the rigor is there, so that you amplify the learning, not distill it.

She sees herself as a co-facilitator of learning, not a "sage on the stage." She focuses

on creating a safe learning environment for all her students, free from judgment, hate,

and racism, stating, "how are you supposed to learn if you don't feel safe?"

History

Daphne is a first-generation Filipina. She lived in a variety of cities in

California that she described as ranging from lower to middle class. In college, she

initially planned to be a medical doctor but changed her course, instead focusing on

public health. This exposure to the highly competitive, neoliberal-oriented approach

to science education that emerges in pre-med spaces shaped her views on success and

learning in the sciences, as we saw above in relation to project based learning

improving test scores. She described herself as a unique candidate in the teacher

education program, as she had changed careers in her mid-twenties to education.

Before joining the program, she taught for a few years to see if she liked teaching.

She explained:

> Before switching over to teaching, I wanted to see if it was something I wanted to do. So I taught at a private school, kindergarten, then third grade for

a year, where you didn't need a credential. After third grade, I realized I do like teaching, and then I asked myself, well, I have this degree in human biology. How could I get experience, figuring out if I want to teach high school biology without investing time and money yet? So I taught at a public charter school, where the majority of my classes were ninth-grade biology students.

She was highly reflective about her own role in contributing to educational inequity as an uncredentialed teacher working in underserved communities. She also felt that her experience at the charter school represented a negative example of classroom management, feeling they were overly punitive, requiring her to give detentions to students for things like dress code violations. This gave her an example of what she didn't want to do in her classroom. She was introduced to restorative justice practices through PD offered at her school, and it became an increasingly integral part of her practice.

Time in Program

Daphne joined the Program with excitement to learn more about experiential, inquiry-driven science education. During the second year of the program in which she participated, a few major changes were made. A program coordinator was hired who was a middle school science teacher with an Ed.D. and experience in EFBE. Program leadership slowly shifted towards the Education faculty in response to the first year cohort's concern over the lack of equity focus, something the collaborative of the Program felt was better supported by the Education department. Participants in the second cohort, thus, were asked, What is equitable field-based education? What criteria should we consider when creating equitable field-based learning opportunities? These questions were central to the second workshop where guest

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speakers were brought in to discuss a variety of perspectives previously missing, like that of local Indigenous experiences, community centered activities (i.e. gardens), and the county offices of education. This reflected a serious shift in the program as it moved to incorporate a clearer focus on equity. It was during this second workshop that the Equitable Field-based Learning Opportunity (EFLO) criteria were developed for the first time. These criteria are: "EFLO curriculum *must* address the following core themes: student-centered, NGSS-aligned, common experience, environmental identity, and social justice/historical perspectives." These criteria became central to lesson plan development and program offerings in subsequent years.

Daphne was very organized and detail-oriented in these workshops. She was an active participant in the discussion, often the only person in the cohort to engage the guest speakers. The onset of the COVID-19 pandemic led to the switch to distance learning in March 2020. While teachers continued to reflect and hybridize EFBE as they developed an EFB lesson, now more scaffolded with the incorporation of the newly created EFLO criteria, being able to practice teaching an EFBL was difficult. For Daphne, this disruption left her takeaways from the program jumbled, stating, "everything else is kind of fuzzy."

Current Teaching Context

Daphne teaches 7th-grade science in central California. She works with largely Latinx and Hmong students, who come from lower socioeconomic backgrounds. Her school has 45-minute periods and limited outdoor space. The transition back from distance learning has been challenging, with fights among students who struggled

with coming back to in-person learning. The biggest challenges she has faced include curricular instability and negative interactions with staff and other teachers. Her school is in the process of piloting two different curriculums. While she saw this as a positive given the previously outdated curriculum, it was challenging to plan with a shifting curriculum. As she explained, "And so it's another year where I'm like, okay, what can I make? I like that freedom and autonomy, but it would be nice to have two years in a row where I teach the same thing." Like Linda, curricular tensions created a large drain on her time.

As a positive and productive teacher, she had interactions with other teachers and staff that left her feeling drained. She explained how her previous partner teachers negatively impacted her mood, "[he] was just so negative and a huge drag on my excitement...that it wasn't very fun." Luckily, he left, but she said other interactions with some male staff felt misogynistic, something she wondered, "if I were a white male, how would this interaction have gone?" These negative interactions initially impacted her agency in the school, feeling like her voice would not be respected when it came to suggesting curricular ideas, like those related to EFBE (Gale & Gourd, 2019).

Summary

CE-CHAT reminds us that historicity and a multisited sensibility play an important analytical role as we work to understand the trajectories of participants as they move towards a common goal. Looking at similarities and differences in teachers' pathways can help us make sense of the multiplicities of enactment that

emerge as teachers work towards EFBE. Both teachers came to teaching through opportunities to practice, Daphne in private and charter schools, and Linda through undergraduate teaching internships. Despite both having previous in person teaching experiences, neither was prepared for the socioemotional toll that the COVID-19 Pandemic had on students and teachers and had to adjust accordingly. Additionally, they both worked in contexts where either they or their students experienced racial, or gender-based microaggressions. While not the same, the power plays at work had similar impacts on the teachers and students, leaving them feeling silenced and frustrated. Both came to the Program with limited exposure to field-based practices, though due to distance learning, Daphne had the opportunity to have a shared field experience with her cohort, and Linda did not. Their limited previous exposure to field-based educational experiences suggests that both may not be bound to a certain pedagogical approach when it comes to EFBE and might potentially need multiple iterations of hybridization to create space to understand what field-based means to them.

Hybridizing and Enacting EFBE

Linda

Linda defines EFBE as:

> Equitable, field-based education includes opportunities for students to ground themselves in the real world using their curriculum. Classroom instruction extends beyond the classroom walls and includes opportunities for students to learn more about their environment/feel integrated with their environment, see themselves and diverse groups of people represented in the field of study, and each individually believes that they have a right to participate in these lessons. Field-based education also gives students an opportunity to connect with the community outside of their classroom with guest speakers and opportunities to

use their classroom curriculum to better understand their community and feel a deep need to protect it.

From this definition, we see three main concepts emerging: instruction beyond the walls of the classroom, place-based connection, and representation and belonging. Linda's commitment to social justice in the sciences shines through in this expansive view of EFBE. While she came to the Program with ideas on how to implement environmental and social justice education, most likely supported during her time in her undergraduate education courses, the program facilitated one example of the hybridization of EFBE, ideas like community connection arising from workshop discussions. She takes a view of the field that combines both traditional and expansive understandings, placing value in both the nature-based and community connection. Given her limited experience in field-based education prior to the Program, this hybridized view of the field mirrors much of the discourse from the Program. Her discussions of representation and belonging reflect a recognition of the inequities that persist in the sciences related to how accessibility, racism, and misogyny contribute to a lack of sense of belonging in marginalized groups (O'Brien et al., 2020). The concept of decolonizing or "desettling" science inspired her (Bang et al., 2012). She further explained how she saw equity playing out in her classroom:

> Decolonizing science and being very upfront with students that science does have a biased and troubling past. Even today, the scientists seen are mostly white men. So just being upfront about that, trying to incorporate the many contributions of scientists from other cultures and genders into science education, and making sure that students feel represented in science. So many students get to the science classroom on the first day, and they don't think that they themselves, or people like them, do science. I think it's really important to make it clear that the things that we focus on are just one narrow perspective, so it's not all science.

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This recognition of the role that teachers play in dismantling ongoing stigmas and underrepresentation is something the Program and the teacher education program aimed to support. While only a piece in the systemic issues contributing to inequity in the sciences, Linda clearly understood the role that inequitable science instruction (both epistemologically, ideologically, and resource-driven) plays in either reifying or dismantling these persistent forces. She elucidates this above, highlighting the lasting impact that the dominance of western, white male-oriented science can play on students' perceived ability to do or be a scientist. As related to EFBE, we see connections in this understanding to the EFLO criteria components; student-centered practices described through representation and social justice/historical perspectives in her recognition that science often only presents one narrow perspective. The hybridization process was an expansive space for Linda, supporting the beginning of a reflective practice that examines the systemic, historical, and local forces creating inequitable science education.

Lesson

Linda has been able to take her students out of the classroom a few times, utilizing her school's nature rich campus. For example, while learning about cells, she took her class outside to collect a plant sample. She described the lesson, "they went outside and they learned a little bit about the different plant species that they have. Then they had the opportunity to really look at the cells that are inside of the plants." She described how equity was considered, "In terms of equity, I did organize the lab so all students in the group had to do something with the microscope. Trying to

incorporate that everyone contributes to the lab and making sure that no one is sitting back and letting everyone else do the work." Equity was understood as equal opportunity in this example, allowing for group work, student choice, and scaffolding to support engagement. Here the field was both going outside in the local context and bringing the outside indoors. Linda did say, however, that "I do think that it's not at the full EBFE standard," as the content and focus of the lesson did not work to dismantle normative understandings of what science is and who does science. She said that EFBE ideas are always at the back of her mind; for example, when thinking about representation in her lessons, she explains:

> I have really been trying to think about representation and telling diverse stories in my class. Again, harder in practice than just thinking about these ideas, but I think having these things in the back of my mind when I'm designing lessons opens up the space to have those conversations with students when we're actually teaching them.

This suggests that EFBE and social justice approaches to science education are a guiding force in her process of becoming a teacher.

Daphne

Daphne defines EFBE as, "Common experiences rooted in exploratory learning; multiple perspectives ought to be considered when designing community solutions; to have tangible takeaways for students and teachers; to create the space to have a common definition for our impact and interactions with living things." This example of the hybridization of EFBE was shaped by a variety of factors, largely sociocultural educational practices rooted in UDL, past personal experiences and epistemologies, and the Program. Her education in human biology (pre-med) and her

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teaching experiences at charter and private school seem to play a role in her

neoliberal framing of science education and success (a career and good test scores).

When considering equity, her focus emerged more in her UDL practices rather than

lessons that focused on equitable content, like environmental justice. We see this as

she explains that an ideal EFBL would include experts who were aware of UDL to

support students' learning. She continues, "if we did have an expert on-site to describe

to the students what we're doing today and their experiences, I would ideally ask them

to not just talk to the students but have photos or videos with captions and different

representations." We see here that representation does contribute to her understanding

of EFBE, but more along the lines of physical versus epistemological representation.

Returning to her definition of EFBE, it largely focuses on the outcomes and

practices that EFBE should contain. Interestingly, this definition does not explicitly

name where (the field) this should take place. She explains how the concept of the

field is emerging for her in practice:

> I'm trying to think about how to create fields within the classroom space and
> on campus. So another thought I've had, I don't know if it'll all come into
> fruition, but one of the PE teachers has a green thumb and [we could] have the
> students plant things on their own and figure out photosynthesis. We learned
> about vertical farming and so I do have this grow wall in the classroom. So
> giving them access and exposure to things like that, I think it'd be nice if they
> could grow their own food, especially during COVID times and take it home
> and make something.

Here we see how the ongoing hybridization of EBFE expands concepts learned in the

Program (using the field you have and school gardens) into local contexts. We also

see early planning to collaborate across disciplines and expand the culture of EFBE.

As hybridization is shaped and expanded in local contexts, this example shows how hybridization is an iterative, often future oriented, process.

Lesson

Due to a variety of barriers, like limited green space, and short class periods, Daphne has not been able to take her students outside. However, she did do one lesson where she used a virtual representation of the field. She explained that the curriculum at her school had offered a lesson doing field notes, and it had reminded her of her time in the program, so she adapted the lesson for her class. She described the lesson, "instead of going outside and observing plants and animals, I gave them links to live cameras around the world, and they got to choose [what] they were observing in the wild. They note[d] the temperature and the time, sketch[ed] it out, and wrote their observations." She said she had hoped to go out and observe goats that were often in a nearby field, but since they weren't reliably there, she wasn't able to. When considering equity, she found scaffolding to be a key component. She explained:

> I think an equitable lesson would make it so that students understand the idea, understand why we're doing things, and how we're doing things in their way of interpreting it. I want to be able to check if they understand what we're doing and how to do it before I release them and that they have resources along the way; if they do get stuck or if they do need review, they can go to a graphic organizer and or go to this resources page.

Being able to support students as they navigated the lesson while also allowing space for them to interpret ideas in their own way created spaces of EFBE. The field here, a virtual space, was seen as an alternative to a natural environment. By taking an expansive view of the field, a sort of in-between, she was able to allow students to

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engage in the scientific skills she wished students to practice, like observation and drawing. This reflects her commitment to UDL, as reflected in the spaces made for scaffolding and students being able to express themselves in ways that best supported their learning.

Summary

As Linda and Daphne moved toward the hybridization of EFBE, both felt they hadn't quite translated their understandings to practice. This reminds us that while the hybridization of EFBE is an integral part of transformative praxis, it can often take multiple cycles to reach a level of practice that matches teachers' definitions of EFBE. It is a pathway, not an end goal. These understandings are additionally iteratively expanded on each cycle and can vary between context and subject. In the lesson examples provided, we can already see how they have adapted their understandings to their local contexts (i.e. abundant natural space vs. limited natural space). Additionally, as they moved towards transformative agency, both were conscious of their own journeys and actions they still wanted to take to integrate EFBE into their practice (Engestrom, 2011; Maseko, 2018). Epistemologically, Daphne largely approached EFBE with a Western view on science and practice, whereas Linda moved towards epistemic heterogeneity, or including multiple perspectives of knowledge, in the sciences, though felt she lacked resources on how to do this. In the section below, I will discuss further how hybridization led to the emergence of equity elsewhere for these teachers, examining how epistemological, neoliberal, and power differentials shaped this process.

Navigating Pathways to EFBE: Equity Emerging Elsewhere

While Daphne and Linda did not face active push back against EFBE, they were both in situations where if they wanted to implement EFBL, it would have to be something they created on their own. While ideas for field-based lessons are more common, examples of EFBL and other associated resources are not. Both mentioned a desire for more time to work towards these goals, both short- and long-term. Daphne hoped for more resources to facilitate EFBE in her context, stating:

> And examples. I would love examples… I want a video of someone already doing it, so that I'm not like reinventing systems already in place. Also, so there's not a huge barrier, like not a huge administrative barrier.. so you do have buy-in, you do have resources and then there's paperwork. So some sort of protocol in place, sign me up.

For Linda, she felt she lacked resources to provide epistemic heterogeneity, or spaces for different ways of knowing and relating to science, in her classroom. She explained, "I think the issue with it has been access to resources because I really want to aim to make my lessons more towards different epistemologies and different perspectives, but sometimes I worry that I don't know enough about it to actually teach about it. And I'm not sure where to find better resources." Science teachers are ill prepared in the western science paradigm, with little resources on how to reimagine what science might look like outside this view. In social justice teacher education programs, teachers are often introduced to the idea of epistemic heterogeneity in the science classroom (Rosebery et al., 2010) and that there are different ways of relating to science and nature (Bang & Marin, 2015). As teachers push against the norms of the traditional classroom, understanding the specific nature

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and possible antidotes to tensions they encounter can better prepare teacher education

and PD programs to support resistance to these forces.

While all teachers in the Program did develop lessons that were EFBE

focused, given the newness of the Program and the relatively new concept of EFBE,

there were limited additional curricular resources made available to teachers.

Additionally, the lesson plans they did make, which were created as class

coursework, were not often translatable to their local context as Linda explained:

> I wish that I did something different for that lesson. When I did that, I was in
> a group with a chemistry teacher, a physics/environmental science teacher and
> then one other bio teacher, so we kind of had to tweak it a little bit to
> incorporate everyone. I kind of wish that I had done something more biology
> focused.

While the program tried to minimize the extra work that the participants would have

to do by combining the goals of the Program with pre-existing assignments in their

teacher education courses, the constraints of having a mix of non-Program

participants in these groups forced teachers to create lessons that did not necessarily

match their future teaching context. While these skills of having to collaborate and

think creatively about how to integrate EFBE into a variety of subjects and work with

teachers who have not heard about EFBE are beneficial long term, for these novice

teachers, the need for immediate resources came into tension with the benefits. As I

have discussed, developing a culture of EFBE requires collaborative spaces and a

reframing of what content (i.e., ecology vs. chemistry) is accessible for EFBE. Given

this, perhaps the Program could reframe the lesson development assignment as also

supporting the skills needed to build a culture of EFBE rather than just emphasizing the creation of a lesson.

Despite the lack of time and resources, both teachers were able to create at least one lesson they felt was working towards EFBE. However, both felt the lessons they had created did not represent an example of a true equitable field-based lesson, as Daphne explained, "I wish I could've considered [equity] more. Found it tough with piloting two science curricula throughout the year and having to create content for the rest of the year." As they worked towards hybridizing equity and field-based education, integrating equitable practices into their EFBL was something that took more thought and effort than they felt they had time for. However, equity work was not missing from their teaching practice, emerging in other ways.

For Linda, her commitment to equity, anti-racism and social justice emerged in her response to students experiencing racism at her school. She explains:

> I brought them into the classroom after school one day because they were just so fed up about how the school and the administration was handling the issues. They started a club,   so now they meet in here every week and I've been kind of acting as their club leader as well. So that feels like a good success, because they were talking about how they didn't really have a space where someone understood or would just listen and I'm glad that they found that community with each other.

Supporting these students and pushing back against non-response from administrators, she started an important cycle of change at her school. The club not only provided a safe space for these students of color but gave them a voice to educate their classmates. She further described, "The club was doing really well this year. They ended up giving presentations to all the 9th grade biology classes on

microaggressions and identifying reliable sources. So they did a lot of really awesome things for the school, even just this year, and it's mostly freshman too." The club also helped provide feedback on a genetics unit that included conservations about the genetics of race, the history of racism in scientific history, and medical racism. With support from her induction mentor, the unit was well received by students and her grade level partner teacher. She further described, "At the end of the unit, myself and the other biology teacher asked the students if they had learned about any of this stuff in biology or any science class before, and they were all saying no, they've never seen it in a science class." While not a field-based lesson, this unit included components that incorporated social and racial justice discussions that are often left out of the science curriculum, as highlighted by students' responses to the lesson. While equity may not have been centered in the field-based lessons she taught, it emerged as a key part of the genetics unit and the club. During her time in the Program, Linda explored equity and genetics, the impact of that clearly translated into her practice. As teachers worked towards hybridizing EFBE, the emergence of other equitable science practices is an important part of the cycle of transformative praxis towards EFBE.

For Daphne, equity emerged in her approach to classroom management. Her past experiences working in a punitive school culture left her feeling uncomfortable with that style of classroom management. In her current position, she had received PD training around trauma informed, restorative justice approaches to classroom

management which had deeply resonated with her. She explained how she uses these practices:

> If the student's head is down or if the student's hood is on and they have a decent reason, like they're not feeling well, I am understanding of that. I'm not going to yell at them to take their hood off or take some detention for it if they just got a haircut or they're not feeling well. Because if you get a haircut, people are likely to say, nice cut G and then slap your head, stupid things like that. So it's helped me with relationships because I got a student who was kicked out of his first period every single day for having his hood on to do some work in my class because I was like, this is not the fight I want to pick with you.

These practices gave her the resources to build relationships with students centered through restorative justice. As building relationships with students was a key step toward EFBE for her, these practices supported her pathway toward EFBE through equity-centered approaches. As she explained, "And so, when you're thinking about anything ambitious like field-based, it's going to be difficult if you don't have these relationships with the students." Being a restorative educator became central to her work, so much so that she planned to attend a conference to share about these practices. While not a current aspect of the program, restorative justice practices would be incredibly valuable to addressing student resistance and the often prevalent 'just do it' stance to field-based experiences (Ash & Race, 2021).

Despite these successes, Linda and Daphne faced instances where they did not feel like their beliefs or voices were being heard. Linda was not asked to return back to the school after her short-term contract ended. She said it was for the best as it wasn't a good fit, "I don't really feel like the science department or the school in general really feels the same way that I do about all of these things we learned in the

program." Despite this, she did not walk away feeling discouraged about teaching equitable science lessons. She said, "I am very hopeful that it is something that I will carry into future years as well. The more experience I have, the more lessons that I can build on." Daphne, who faced instances of misogyny and negativity in her teaching practice, felt initially silenced by these dynamics. However, during our member check, granted power from a permanent contract, stated, "I remember saying this, "I'm a new teacher, I just want to duck my head." But then at the end of the year, after I signed my contract, I was like, ``You know what, this isn't right.'" She proudly mentioned that she had advocated for her students' needs (aides for IEP students) all the way to the superintendent and the union and had successfully gotten the support they needed. These teachers firmly saw themselves as social justice educators, an identity supported in both their TE and the PD program. While they might face tensions and barriers, so far, this identity has supported their moves towards EFBE and additional social justice/equity approaches.

Summary

In summary, this comparative case study shows how in the process of hybridizing equity and field-based education, hybridization can take multiple iterations towards transformative praxis before reaching the form desired by teachers. During this process, equitable practices can emerge elsewhere as teachers move to understand what equity work looks like for them in their local context. Given teachers' diverse understandings of equity, we expect this to emerge in many ways. The teachers presented in this comparative case study faced similar tensions in their

local contexts; (1) curricular/time, (2) microaggressions, and (3) issues in community. As they worked towards EFBE in their practice, these tensions uniquely shaped how they directed their energy when supporting equity and social justice pedagogy. For Daphne, her commitment to UDL, restorative justice, and research informed practice captured her commitment to equity. For Linda, a commitment to social, racial, and environmental justice emerged through a club and other science lessons. While both still are working towards a practice of EFBE that is supported in their local contexts and meets their conceptual understandings, these findings highlight how EFBE as a concept helps to support and solidify these teachers, and the others in this study, commitment to being equitable science educators, in some form or another.

Chapter 6: Discussion and Conclusion

To understand how teachers took up the goal of equitable field-based education, I looked at conceptual understandings, practical applications, and system tensions. As expected, teachers followed unique pathways that gave rise to a multiplicity of enactments of the goal of EFBE (Buxton et al., 2015). While Buxton and others have described this variability, the analysis presented here goes beyond and expands these findings in significant ways (Kayumova & Buxton, 2021). These pathways, shaped by histories, culture, activity systems and larger forces like neoliberal ideologies, lead to informative differences and similarities in how teachers conceptualized EFBE and the strategies of enactment that emerged in their classrooms. Some enactments were subtle and could have been easily missed if only taking a narrow look at where EFBE might emerge, like lesson plans. From my findings, organized broadly at first to showcase common themes across all cohorts of the Program and then narrowly to trace the pathways in a nuanced way guided by CE-CHAT, I was able to gather valuable insights into the hybridization process of EFBE and how innovative equitable science practices are enacted and responded to in a variety of contexts. As alluded to throughout, all the teachers I spoke with, regardless of where they were on their pathway to EFBE, strongly believed in the goal of EFBE and saw it as something they could accomplish over time. This in and of itself is a major achievement of the program. In this discussion, I focus on three main areas: (1) CE-CHAT as a transformative methodology; (2) Hybridization of EFBE; and (3) Reframing Resistance: Critical Hope. The first section focuses on the theoretical and

methodological commitments explored through CE-CHAT and the surprising

outcomes the methodology supported. In the second section, I outline the ways in

which the hybridization of EFBE emerged and how it was shaped in teachers' local

contexts. Finally, I introduce the concept of critical hope as a way (1) to better

theoretically frame teachers' strategic moves towards EFBE in their current and

future practices; and (2) conceptualize a pathway through the dialectic between

resilience and resistance.

CE-CHAT as a transformative methodology

Critical Ethnographic Cultural Historical Activity Theory (CE-CHAT), the

theoretical framework guiding this research, was patchworked together as I searched

for a research framework that was both systematic yet critical, centered on equity and

sociocultural theory, and attended to the past, present, and future (Higgins et al.,

2017). In theory, I saw it as a way to do research that is, as described earlier, equity-

driven, centers praxis, destabilizes neoliberalism and dominant ideologies, engages in

multi-sited sensibilities, and uses an intersectional analysis, exploring the overlapping

influences of power, identity, and more, to dialectically explore how science

education can be re-positioned for expansive, community-focused learning. In

practice, it turned out to be, in addition to those things, a stimulus in the cycle of

transformative praxis that extended the reach of the PD (Figure 1), supported

teachers' reflections, and provided hope and encouragement on their pathway to

EFBE.

As this study builds on three years of research collected during the Program, I had already established a level of rapport with most of the participants. I had interviewed many of them previously and followed their journeys through the Program, acting as a participant observer in the workshops and presentations. For some participants, I had just spoken to them four or five months prior; for others, I hadn't heard from them since they left the Program three years ago. Given this context, and the entrenched ideology of meritocracy in systems of education, many had come to see me as an expert in what 'counted' as EFBE. Despite my active pushback against this framing, teachers often still said things like "if this counts" or "if you count this." In response to this, I tried to take as expansive a view of EFBE as possible, pushing them to share whatever they thought was EFBE and to explain their process of hybridization of equity and the field. This process encouraged teachers to reflect critically on their practice, often reminding them of activities or lessons they had done that they hadn't initially considered an EFBL. It also repositioned them as the experts in defining and enacting EFBE, not the Program, recentering their creative agency in supporting EFBE in their local context.

These interviews and the corresponding member checks gave rise to several pivotal insights into the process of transformative praxis. In my model of transformative praxis, drawing from Maseko (2018), Engestrom & Sannino (2009), Sannino (2015), I theorized that as teachers moved towards transformative praxis through EBFE, they would need a process of double stimulation to support their moves towards transformative agency and action (Figure 1). While the Program

supported the first stimulus through the open-endedness of EFBE, as teachers moved

to their new contexts and faced new tensions, many became stuck. However, during

our member checks, I was surprised by how many teachers reported being able to do

more EFBE or how our previous conversation supported reflection and reinvigorated

their desire to try EFBE. Reflecting on why those conversations might have been so

impactful, I realized that many teachers had little to no culture of EFBE in their

current contexts, and thus very few people to discuss these ideas. By helping them

reconnect to ideas they explored in the Program and consider the challenges they

faced in their local contexts, the interview gave them space to think about what steps

they needed to take. While I did not necessarily offer specific suggestions, I did offer

encouragement and excitement, sharing how impressed I was by all the work teachers

had done during these challenging times. Critical hope requires nourishment, and CE-

CHAT moved to support that and transformative praxis. This supports the idea that

hybridization is an iterative process that is shaped by local context and tensions. It

also suggests that teachers may need additional secondary stimuli to move the

hybridization process forward, in this case, provided by our interview. In future

spaces, this could be supported by a community of practice or a collaborative

environment to discuss EFBE.

Hybridization of EFBE

In this study, I aimed to understand how the hybridization of EFBE was

shaped and the ways teachers responded to the various forces they encountered, such

as neoliberal tendencies, power inequities, and the epistemological hegemony of

western science. I drew from Bhabha (1994), Moje et al. (2004), and Gutierrez et al. (1997) to understand how the hybridization of EFBE might occur as teachers moved from their time in the Program to their classrooms. I hypothesized that the hybridization of equity and the field would emerge in three simple ways, with either one of the concepts being emphasized more than the other or an equal representation of the two (Figure 5). While this was a good generalization to capture pieces of how EFBE emerged in theory and practice, my projected outcomes failed to account for the nuanced and diverse ways in which teachers created third/hybrid spaces within their local contexts to address tensions and the exciting and unexpected ways in which EFBE evolved.
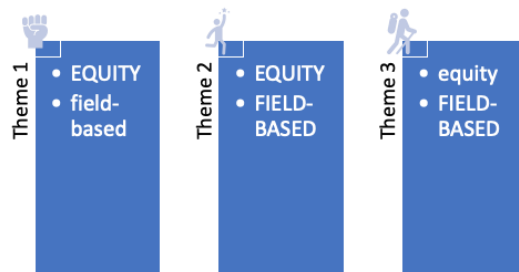
Figure 5. Potential Hybridization Themes

While in the Program, teachers were actively engaged in the process of attempting to understand and organize their teaching around equity and field sciences. Space was given for them to think about how their growing conceptions of equity and past experiences with field-based learning might be negotiated to support equitable field-based education in their future classrooms. Workshops, lesson plan development and discussions with faculty and teachers all worked to support these pre-service teachers to take this newly formed concept of EFBE into their own classrooms. While

this was incompletely supported for some teachers, like Grace who mentioned leaving the Program feeling confused as to what the 'field' was, by and large teachers left the program with an idea of what EFBE might look like in practice, even if they had never actually practiced it themselves. Not unexpectedly, as teachers worked to introduce this concept of EFBE in their classrooms, they were met with new tensions as they tried to create a culture of EFBE.

As teachers entered their new classrooms, many found that their previous understanding of EFBE came into tension with their current activity system. For example, they might have conceptualized the field as a natural reserve, but in their local context, it would be impossible for them to visit one or imagined equity to involve social justice topics, only to receive pushback from their local community. This was expected, as hybridity theory and CHAT tells us that when new concepts are introduced into an activity system, tensions are expected to arise, and the previous meanings of the concept will be renegotiated (Engestrom, 2001; Bhabha, 1994). The tensions highlighted in this research, from neoliberal policy and structural constraints like time and scheduling to community pushback, not unexpectedly shaped the individualized hybridization pathways teachers created on their journey toward EFBE. For example, Emily, who worked at a school with minimal green space, had to reevaluate her previous understanding of the field to work within the structural tensions of her school, moving towards a definition that included providing nature-based experiences in the classroom through plant samples. Daphne, similarly, utilized an online field when unable to take her students outside due to a lack of green space

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and short class periods. Teachers also had to consider the population of students they worked with, recognizing that their own epistemological orientations towards nature and knowledge might not be the same as their students. While teachers were exposed to literature that highlights examples from Indigenous epistemologies of nature, like dismantled nature/culture binaries (Medin & Bang, 2014), it was hard for them to know how this might look in practice. Thus, it proved to be a difficult tension to resolve, as teachers like Linda mentioned they felt under-prepared to support epistemologies beyond the western science they had been trained in (Bang & Marin, 2015). These dueling epistemologies show us that teachers often 'don't know what they don't know' when it comes to implementing epistemologically heterogeneous spaces of learning. This suggests that more mediational means be provided to support teachers' work towards this and ongoing reflection with collaborators.

Research tells us that teachers face increasing challenges when trying to incorporate social justice/equity driven pedagogy in their classrooms (Agrawal et al., 2010; Dover et al., 2016; Paugh, 2006). For teachers trying to hybridize EFBE in their classrooms and create a culture of EFBE at their schools, this was no different. While conceptually, teachers may have come to an understanding of equitable field-based education, in practice, this often emerged towards more a field-based practice with less emphasis on equity. As discussed earlier, teachers did not view this as failure, but rather an 'almost' or a 'stepping stone,' a move towards hybridization and the associated transformative praxis. Interestingly, for some teachers, this hybridization process did not remain confined to the practice of EFBE. For example, as discussed in

the case study, the lessons Linda described largely approached field-based learning through an equality vs. an equity lens, equity to her coming to mean equal access to practices during the lesson. While she mentioned that she is still working to improve and expand her EFBL, equitable practices emerged for her elsewhere. The forces she faced in her school context, such as racist microaggressions against students of color, lack of time, and an unsupportive administration, we can hypothesize pushed her focus on equity into other adjacent spaces, such as her genetics lessons and the sociopolitical club created to support students of color in her majority white context. The Program provides teachers with one example of a general interpretation of what equitable science instruction might be, as framed by the Equitable Field-based Learning Opportunities (EFLO) Criteria. These criteria, framed largely in a western science epistemology, do try to break away from this framing but still delegate equity and the field to a specific pedagogical space. Teachers must navigate the dialectic between what was previously presented in the collective of the Program and the realities of working towards EFBE in their current context. While both shape and guide the hybridization process, teachers must take what was presented and what is, and find an understanding of EFBE that supports not only the goal of EFBE but supports their students.

Reframing Resistance: Critical Hope

Teacher attrition is at record highs, with the stress of the pandemic, unstable working conditions, and incommensurate pay all compounding into a mass exodus of teachers from the profession (Bartlett et al., 2021). While public narratives push a

'teacher shortage' perspective, many have begun to push back, stating there are plenty of teachers, but they refuse to work in an unjust and unsustainable system of education. Many of the teachers I talked to in this study reflected on their colleagues leaving the profession, as we saw with Dylan, who was critical of the burnout culture that exists in teaching; she explained, "especially through these last three years, there's just been such a colossal loss of educators in the profession because we're being forced to be martyrs and choose our students over ourselves." While the teachers I talked to had persisted, their pathways showed some form of strategic resistance to burnout and tensions that were created by unsustainable working environments. For some teachers, this meant moving schools to find one that had a more supportive environment. For others, it meant creating collaborative relationships outside their departments with other more collective oriented educators. Some teachers created spaces of resistance for their students, like clubs. For some, it meant keeping their head down until they had tenure.

In the context of the pandemic, it is easy to frame teacher retention and work towards EFBE through resilience and grit. Teachers are often viewed as martyrs, persisting due to the strength of their "calling to teach" (Hansen, 2021). However, as Slater (2022) has highlighted, terms of resilience and grit perpetuate neoliberal ideals in education systems, centering individual versus collective struggle. As Torres-Olave & Gonzalez (2021) remind us, "dominant neoliberal logic squeezes abilities to act and think collectively out of us, through the production of non-collective subjectivities (Rodriguez, 2019)" (pg. 1048). Additionally, resilience perpetuates a

normative view of harm and burnout in teaching, teachers are encouraged to, as one participant noted, place their oxygen masks on everyone else before themselves. Teachers resisting this burnout narrative felt they had to choose between being the teachers they wanted to be and survival. As Brandon explained, "I can choose to be passionate and also burn myself out. I feel as though the situation that I, myself, and maybe a lot of other people are in is just trying to recover from three years of instability." This praxis crisis, between choosing to be the educator they want to be or burning out, puts teachers in an extremely difficult situation as they navigate the dominant narratives of resilience and acts of resistance (Tolbert, Spurgin & Ash, 2021).

To understand the dialectical relationship between resilience and resistance and better name teachers' pathways to EFBE, I use the concept of critical hope. Critical hope "reflects the ability to realistically assess one's environment through a lens of equity and justice while also envisioning the possibility of a better future" (Bishundat et al., 2018, p. 91). The concept of critical hope, both action-oriented and theoretical, opens space for teachers to resist the narrative that teachers must do it all while also creating a pathway towards future practice and change. In the neoliberal context systems of education as it currently exists, teachers face many tensions/contradictions to their desired practice, as highlighted in my findings (Cahill et al., 2010). Critical hope helps me connect theoretically to how teachers unanimously believed in their ability to practice EFBE, though it was often couched in time and context constraints based in a realistic rather than dreamed of future.

For Nancy, who worked at a charter school that served Latinx students, she felt jarred by the proleptic schemas that emerged when it came to the school administration's lack of priorities for their current student population and instead focusing on future gentrification. Proleptic schemas, or overly future oriented ontologies, where the future is seen as happening before it even does, are a threat to equity and social justice work (Bunn & Bennett, 2020). As Bunn and Bennet (2020) explain:

> Prolepsis – a specific vision projected about what is valuable about [education] – serves to erode the struggle over character of the future, reducing it to hegemonic versions that appear as common sense. This makes invisible the myriad constructions and contestations of and over the future within different groups and social positions. (pg. 701)

Nancy, who, despite minimal support from her school, was able to create a Field-Based Elective course for her students, eventually had to leave before she reached a level of burnout that was no longer sustainable. When schools fail to support their current students, teachers must make a difficult choice on how to manage their efforts towards equity and their own mental health. Through critical hope, this study aims to reframe teachers' reflective capacity towards their work to include a practice of resistance. As Jarvis (1999) described, "reflective practice begins where practitioners are problematizing their practice and learning afresh about both the knowledge and skill and attitudes that their practice demands" (pg.5). Part of this process requires resistance against the resiliency narrative of just pushing through an unsupportive administration and school culture. Nancy, and others, show us how teachers are

agentic in their practice and make strategic moves of resistance to persist as educators.

As discussed in the case studies, Grace and Daphne, both women of color, showed strategic resistance in their local contexts. Grace, for example, was waiting until she had tenure to incorporate equitable content in her EFBL that was rejected by her local community. This strategic move allowed her to move towards a position of power before working to resist the culture of silencing that existed at her school. This 'watch and wait' strategy is not uncommon in educators trying to enact social justice pedagogy, especially for female educators of color who face additional racial and gender biases (Martin, 2015; Osei-Kofi et al., 2010). Similarly, Daphne, as discussed during our member check, reflected on the new power and agency granted from a permanent contract. No longer feeling like a novice teacher who needed to keep her head down, she found her voice in calling for equitable resources for her students. Critical hope reminds us that moves of resistance may initially be categorized as inaction, waiting for the ideal conditions for action. As Glass (2013) reminds us, "Critical hope cannot be animated by a righteous perfectionism nor by wishful idealism; rather, it is grounded in actual situations with their particular limits and possibilities, and it clings to the truth of the human power to change what is within reach" (p. 102). These two teachers were strategic in their inaction, waiting for the limits to be removed, so the possibilities could be enacted.

When it came to implementing EFBE, teachers faced multiple tensions, such as a lack of curricular resources or the time to create them, a common phenomenon in

schools (Tobin et al., 1997). This was in addition to curricular instability caused by the pandemic or local contexts where curriculum was not available, or what was, was not aligned with NGSS, or was out of date. When met with a lack of support for EFBE, teachers had to choose their battles in where their time and effort might go. Here we are reminded of Brandon, who felt jarred by the neoliberal framing of STEM at their school. Similarly, to the teachers waiting for tenure, it was only when they decided to leave the school and the consequence of getting fired was removed that they felt the freedom to do what they wanted. Reflecting on turnover, Simon and Johnson (2015) remind us, "when these teachers leave, it is frequently because the working conditions in their schools impede their chance to teach and their students' chance to learn (Johnson, 1990, 2006; Johnson & Birkeland, 2003)" (pg.3). By shifting the conditions of their school to one that removes the expectations of a certain approach to STEM, Brandon was able to support EFBE through the organization of field trips to local parks. They bided their time until the conditions were possible for them to move towards the type of pedagogy they envisioned. This pathway to EFBE through critical hope showcases another strategy of enactment teachers took when navigating the tensions of the local context.

Often teachers were not able to mitigate the barriers and tensions that limited their practice of EFBE. However, this did not mean they did not imagine how they might incorporate EFBE in the future. Teachers' self-awareness that their path towards EFBE may be slow, during which starting small and each lesson, even if not perfect, can act as a stepping stone towards what their practice eventually may grow

into is an instantiation of critical hope. We see that here as Cameron reflects on his EFBE practice so far, "Am I doing the stuff that I want to do exactly? Not really. No, but I'm at least taking the opportunity whenever I can to take them outside of the classroom. Which I think is at least a good stepping stone." Critical hope is a key piece to the cycle of transformative praxis teachers work through as they move towards dismantling normative practices of science education towards equitable, community-driven education. It provides them a liminal space where they can place their goals of EFBE; as Brett describes, "I really do believe in it. Once we start going more project based, I'm very very excited about doing things like water testing, getting out, and actually getting involved and using more [EFBE]." In this specific case and others, critical hope supports a pathway to ''where what could be is sought; where what has been, is critiqued; and where what is, is troubled'' (Torre et al., 2001, pg.150). Teachers recognize that their current situations or practices might not be exactly what they imagined for EFBE. Through critical hope, they can move slowly and strategically to the practice of EFBE that emerges as their activity systems move towards a culture of EFBE.

Many of the teachers in this research study hoped for a collaborative space to discuss and share ideas about EFBE. Since many of them did not have a school site where equitable, outdoor teaching was the norm, they hoped for a community of practice amongst their program peers. This aligns with recent research from Kang and Nation (2022), who claim:

> The fundamental challenge resides in the complexity of supporting teachers to enact the abstract ideological commitment in local contexts, rather than lack

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of clarity in theoretical ideas (Tzou et al., 2021; Young, 2010). To create powerful learning contexts for students in K-12 science classrooms, in particular minoritized students, we must support teachers in designing and facilitating learning experiences in local contexts.

Critical hope requires nourishment (Anderson-Nathe et al., 2011). Teachers need to know that what they imagine is possible and see that others have had success carrying out similar goals. While many participants mentioned that they did keep in touch with some others from their cohort, it was difficult to find the time to coordinate it all. Programs like the one studied should consider what happens after teachers leave. As others have noted, it is not uncommon for there to be a lack of follow-up or support after a PD program is over, yet it is important to sustain the goals of the program (Mouza, 2009). Thus, for the EFBE community of practice to be sustained and supported, space should be actively created and maintained by those with the time and resources (i.e. PD program leadership). Then teachers can discuss not only the practice of EFBE but also the associated tensions, fears, and contexts they've encountered. Transformative praxis is a collaborative, multisited process that needs a collective of teachers supported through critical hope and connection through shared EFBE experiences. I plan to support this through the creation of a community of practice, creating a space where teachers can share lesson plans, meet to share strategy, and support each other in the building of a culture of EFBE. Research into the ways teachers support each other to do social justice oriented, equitable science instruction is an area I would like to explore further.

Conclusion

Simply, this research aimed to understand how teachers took up and translated PD goals into practice in their classrooms. I wanted to capture the barriers and strategies that teachers took to enact EFBE as a way to improve the Program and to inform future teacher education and professional development efforts to support equitable science instruction. Through the theoretical framework of CE-CHAT, I was able to better understand the dialectic, nuanced pathways that teachers take when trying to hybridize and enact EFBE in their classrooms and the tensions they might face. I was able to capture the ongoing prevalence of neoliberal ideologies as they shape teachers' practices and their ability to collaborate. This finding contributes to others who have called for similar attention to how to navigate the neoliberal agenda in the classroom (Bartell et al., 2019; Reagan et al., 2016).

As expected, EFBE is not a norm in K-12 classrooms. The Program tried to change this by preparing pre-service teachers to introduce and spread a culture of EFBE at their schools. While some teachers were lucky to work in schools where they met little tension when trying to implement EFBE, most were met with barriers that came into contradiction with their goal to enact EFBE in their classrooms. Through the lens of critical hope, the "teach the teacher" model used by the Program was a successful approach, though it does take time, and additional support is needed. Translating previous theoretical conceptions of EFBE into local contexts is not as easy as some might assume, highlighting the need for additional support beyond the end of the Program.

The concept of equitable field-based education started a cycle of transformative praxis for teachers as they moved to support equitable science instruction in their classrooms. By providing one pathway towards social justice oriented instruction, teachers were able to think collaboratively about how they might enact the culture of learning they wished to support in their future classrooms. While met with tensions and barriers in their local contexts, teachers approached EFBE with critical hope, creating stepping stones toward the practice they wished to accomplish. As these novice teachers navigate the challenges of becoming teachers, this research speaks to the importance of early exposure to social justice oriented pedagogical approaches and collaborative spaces to continue this work.

Appendix

Teacher Interview Protocol
1. What teaching experiences have you had since you graduated?
    a. Where have you taught? What grades? What subjects?
    b. If you have changed schools, what led to the change?
2. What have been the greatest challenges? The greatest successes?
3. What is your teaching philosophy? Has it evolved since you started teaching?
4. How much impact has your teacher education had on your teaching?
    a. Did you feel prepared to start teaching? Can you give me an example.
    b. What do you wish you knew now? (i.e. where did you feel not prepared?)
5. What type of curriculum do you use in your classroom?
    a. Is it given by the school? Do you have freedom to change/adapt?
    b. Can you create your own curriculum? Did/do you?
6. Who are your students? Be specific (i.e. BIPOC, low SES) What strategies do you use to ensure they all have equitable access to learning?
7. Who are your colleagues? Be specific (POC teachers? Gender?) Do you collaborate with them?
8. How would you describe a quality teacher? ANDDDDD??

Let's now talk about your reflections on FBLI and how it has impacted your current teaching.

9. Reflect on your experience in the program. What has stuck with you? Can you name three things that specifically were important to your current teaching?
10. How have you positioned, by that I mean, percentage of instruction, to equitable field-based education in your classroom?
    a. What do you see as the value of this approach?
11. If you have not been able to use field-based approaches in your classroom, why not? (JUMP TO OTHER PROTOCOL)
12. Can you give me an example of a lesson that you have taught?
    a. What criteria were used to make it an equitable field-based lesson?
        i. What specifically made it equitable?
    b. What did the field mean in your lesson?
    c. What type of assessment did you use?
    d. How did ALL students respond to the lesson?
13. What makes a lesson an equitable field-based lesson rather than just a field-based lesson?
14. Have you encountered any barriers to creating equitable lessons? Be specific.
15. What resources have you used to inform your lessons?
    a. Have there been any barriers to obtaining the resources you need to your equitable field-based lesson?
16. How have your ideas changed about how to do an equitable field-based lesson?

a. Has the pandemic affected this?
17. Have you been supported, either financially, with resources, etc. to do this work?
   a. If not, have you felt like you can still teach EFBL?
18. Have you worked with other teachers at your school to help them incorporate more equitable field-based lessons into their curriculum?
   a. If so, what have you shared with them to prepare them to teach equitable field-based lessons? Like what three things do they need to do know.
   b. If not, what might be limiting this collaboration? Have you felt supported by other teachers to do this work?
19. When you were in the program, you defined equitable field-based learning as this _____. Has this definition changed for you?
   a. Reflecting more on this: What do you feel shaped this definition for you, both currently and in the program?
20. The lesson you developed during your time in the program was _____. Have you had the chance to use or expand this?
21. (FOR SS) You wrote your research paper in ED230 on _____. How has it shaped how you have come to understand equitable field-based education?
22. What else would support your ability to teach equitable field-based lessons?
23. If you plan to teach an EFBL in the future, are you open to me coming and observing?
   a. If it is before I have IRB approval, would you be willing to share your reflections with me, either as an audio file or through another short interview?

Alternative questions for teachers who had not done an EFBL

1. If you have not been able to use field-based approaches in your classroom, why not?
2. Hypothetically, If you were to teach an EFBL, can you give me an example of what that might look like?
   a. What criteria were used to make it an equitable field-based lesson?
      i. What specifically would make it equitable?
   b. What would the field mean in your lesson?
   c. What type of assessment would you use?
   d. How do you think ALL your students would respond to the lesson?
3. What makes a lesson an equitable field-based lesson rather than just a field-based lesson?
4. Have you encountered any barriers to creating equitable lessons? Be specific.
5. What resources do you need to have a successful EFBL?
6. Did the pandemic impact your ability to teach EFBL?
7. Have you been supported, either financially, with resources, etc. to do this work?

a. If not, do you think you could still teach EFBL?
8. Have you talked to other teachers at your school about equitable field-based teaching?
    a. If not, what might be limiting this collaboration? Have you felt supported by other teachers to do this work?
9. When you were in the program, you defined equitable field-based learning as this _____. Has this definition changed for you?
10. Reflecting more on this: What do you feel shaped this definition for you, both currently and in the program?
11. The lesson you developed during your time in the program was ____. Have you thought about potentially using this in your classroom?
12. (FOR SS) You wrote your research paper in ED230 on _____. How has it shaped how to have come to understand equitable field-based education?
13. What else would support your ability to teach equitable field-based lessons?
14. If you plan to teach an EFBL in the future, are you open to me coming and observing?
    a. If it is before I have IRB approval, would you be willing to share your reflections with me, either as an audio file or through another short interview?

Program Leadership Interview Protocol

1. What has been your involvement in the FBLI program?
2. What inspired you to join?
3. What have been the greatest strengths and weaknesses of working in an interdisciplinary collaborative program, like FBLI?
4. What do you see as the goals of the program? Short term? Long term?
5. How have you seen the program evolve over the years?
6. What do you feel has been the most impactful part of the program for teachers and program leadership?
7. What areas of the program do you think have room for improvement?
8. Do you feel there is space for the participating teachers to shape and contribute to the program goals and objectives?
9. If you had to tell a teacher three things they needed to know to do equitable field-based teaching, what would they be?
10. How do you define equitable field-based learning and teaching?
11. What advice would you give to other teacher education programs that want to implement a similar program?
12. Any other thoughts to share about the program?

Survey Questions

1. Name
2. Undergraduate Degree and Year of Graduation
3. Year Graduated UCSC MA/C Program
4. Positions
5. Any other positions you've held since receiving your credential?
6. Gender
7. Ethnicity

Please rate the following statements from 1- strongly disagree to 5- strongly agree

1. I will be incorporating outdoor learning experiences into my teaching
2. I will be teaching STEM-related subjects outside
3. I will be planning and delivering outdoor learning experiences for other subjects within the curriculum
4. I am confident in my ability to deliver outdoor experiences
5. I am capable of planning and delivering outdoor sessions
6. I am able to plan my own outdoor learning experiences linked to the curriculum
7. I am able to meet the challenge of delivering meaningful lessons in nature now

Please Rate your confidence in your own ability to (1-very low 5-very high):

1. Use hands-on instructional strategies
2. Use inquiry-based teaching strategies
3. Use field-based teaching strategies
4. Address inequity through instruction
5. Find guest speakers (local, university, etc.)
6. Use natural environment field sites
7. Address social or environmental justice issues through instruction

To what extent do you: (Never, 1-2 3-4 5-6 Over 6)

1. Use hands-on instructional strategies
2. Use inquiry-based teaching strategies
3. Use field-based teaching strategies
4. Address inequity through instruction
5. Find guest speakers (local, university, etc.)
6. Use natural environment field sites
7. Address social or environmental justice issues through instruction

Please rate the following statement from 1-strongly disagree to 5-strongly agree

1. My relationship to nature is an important part of who I am

2. I am not separate from nature, but a part of nature
3. I am very aware of environmental issues
4. Humans have the right to use natural resources any way we want
5. Nothing I do will change problems in other places on the planet
6. I enjoy being outdoors, even in unpleasant weather
7. I don't often go out in nature

Check all that apply. A nature experience to me is:
- Beneficial to my health
- Relaxing
- Stressful
- Spiritual
- Not impactful
- Where I feel connected to the environment
- Where I learn more about nature and other living things
- A teaching opportunity

Please rate the following statements from 1- strongly disagree to 5- strongly agree
1. The FBLI program fundamentally shaped the way I approach teaching
2. The FBLI program was important for my future teaching
3. The FBLI program gave me ideas I will use in my teaching career
4. The FBLI program prepared me to teach equitable field-based lessons
5. The FBLI program was designed in a way that supported my learning
6. I had a big role in shaping the FBLI program
7. I felt I could express concerns about the FBLI program

Open Ended Questions:
1. What does equitable field-based education mean to you?
2. What, if any, have been barriers to your ability to teach equitable field-based lessons?
3. What do you think are the benefits to teaching equitable field-based lessons?

Observation Protocols

Post-Observation Interview Protocol
1. What was the goal of this lesson?
2. Why did you choose this lesson to be field-based?
3. Why do you think this an equitable field-based lesson?
4. Where did you get the idea for this lesson?
5. How did you incorporate the field into this lesson? What did "the field" mean to you?
6. What steps did you take to create an equitable field-based learning environment?
7. How did you prepare the students for the lesson?
8. How did you feel the students responded to this lesson?
9. What worked?
10. What do you want to improve?
11. Were there any barriers you encountered?
12. Did any other teachers participate or express interest in this lesson?
13. What do you think are the short-term benefits for students for this type of lesson? Long-term?

Teacher Reflections on an EFBL Protocol (not observed)
1. Before teaching the unit, reflect on (either via a voice recording or written response):
    a. What is the goal of this lesson?
    b. Why did you choose this lesson to be field-based?
    c. Why do you think this an equitable field-based lesson?
    d. Where did you get the idea for this lesson?
2. At the end of each day of teaching the unit, reflect on the following:
    a. How did you incorporate the field into this lesson? What did "the field" mean to you?
    b. What steps did you take to create an equitable field-based learning environment?
    c. How did students respond to this lesson?
    d. What worked?
    e. What do you want to improve?
3. After the completion of the lesson:
    a. Reflect on the following:
        i. Were there any barriers you encountered?

ii. Did any other teachers participate or express interest in this lesson?

iii. What do you think are the short-term benefits for students for this type of lesson? Long-term?

Summary of Program Components: Years 1-3

Year	Workshops	Coursework Integration	CT involvement	Lesson Plan Development	Leadership
1	Two in-person Saturday Workshops(Fall & Winter) focused on providing field-based approaches as modeled by the Biology faculty or local nonprofits geared towards K-5 students. One took place at a UC Reserve and the other at a local campus.	Science Education: Research & Theory: Final paper focused on field-based approach Science Methods: Field trip experience at local informal science institution	PST were paired specifically with CT that had experience (though at varying levels) with field-based education. CTs were invited to workshops.	PSTs were expected to develop a lesson and teach it in their placement. These experiences were shared at a final meeting in the spring at a local high school.	Largely organized by Biology Faculty
2	Two in-person Saturday Workshops (F&W). First hosted at a local reserve, which focused on field-based research techniques. The second was hosted at the local county office of education, and featured guest speakers speacializing in	Science Education: Research & Theory: Final paper focused on field-based approach Science Methods: Field trip experience at local informal science institution 2-unit Program	No official CT involvement	Lesson plan development was integrated into an existing MA/C lesson plan requirement, students working in groups to develop either an EFB project based learning lesson (SS);	Program Coordinator hired (Ed.D and 6th grade science teacher involved in program previous year)

	garden education, Traditional Ecological Knowledge (TEK) and environmental identity.	Course: Students met to share lesson plan development progress and get support		or a lesson unit (MS). Lessons were shared online at a final meeting, each group presenting how the lesson met the criteria for an EFBL.	
3	Two Virtual Saturday Workshops (F&W). First workshop focused on community/ social justice examples of EFBE. The second workshop support lesson plan brainstorming and featured a guest speaker who was experienced in TEK.	Science Education: Research & Theory: Final paper focused on field-based approach Science Methods: Field trip experience at local informal science institution 2-unit Program Course: Students met virtually to share lesson plan development progress and get support	No official CT involvement	Lesson plan development was integrated into an existing MA/C lesson plan requirement, students working in groups to develop either an EFB project based learning lesson (SS); or a lesson unit (MS). Lessons shared online at a final meeting, sharing how the lesson met the criteria for an EFBL	Organized by Program Coordinator and Education Faculty

EFBE Program Participants 2018-2021

Year	Name	Level
2018-2019	Dylan	Secondary
2018-2019	NR	Secondary
2018-2019	Brett	Secondary
2018-2019	Nancy	Secondary
2018-2019	Brandon	Secondary
2019-2020	Priscilla	Elementary
2019-2020	Felicity	Elementary
2019-2020	Cassie	Elementary
2019-2020	Mindy	Elementary
2019-2020	NR	Elementary
2019-2020	RNI	Secondary
2019-2020	Ingrid	Secondary
2019-2020	NR	Secondary
2019-2020	Daphne	Secondary
2019-2020	RNI	Secondary
2019-2020	Emily	Secondary
2019-2020	NR	Secondary
2020-2021	Grace	Secondary
2020-2021	Cameron	Secondary
2020-2021	Linda	Secondary
2020-2021	Larry	Secondary
2020-2021	NR	Elementary
2020-2021	Georgia	Elementary
2020-2021	NR	Elementary

NR- No Response
RNI- Response, No Interview

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