

Technology-Based Music Teachers as Practitioners of STEAM Teaching and Learning:

Music, Again, as a Liberal Art?

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Submitted in partial fulfillment of the
requirements for the Degree of Doctor of Education in
Teachers College, Columbia University

2024

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Abstract

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Technology-based music educators are uniquely situated within the shifting landscape of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. This dissertation investigates the lived experiences, perceptions, and teaching practices of secondary music teachers who teach through technology, exploring how they navigate the interdisciplinary connections between music, science, and technology. By employing a phenomenological methodology, the research reveals a transformation from an initially structured inquiry into a rhizomatic exploration, uncovering STEAM's potential to challenge and transcend traditional educational paradigms.

Drawing on metaphors of the tree and skunk, this dissertation contrasts hierarchical, binary models of knowledge with the rhizomatic thinking advanced by Deleuze and Guattari. Music technology educators thrive in these fluid, interdisciplinary spaces, which resist categorization and require constant adaptation. Situated in the epistemological ecotone between music and STEM fields, these educators embody a philosophical challenge to modernist, arborescent models of learning, embracing a post-humanist perspective that recognizes the interconnectedness and relationality of knowledge.

The findings highlight how STEAM education, particularly within music, dissolves rigid disciplinary boundaries, offering students new ways to engage with music beyond traditional frameworks of performance and composition. Technology-based music educators serve as agents

of change, creating opportunities for innovative teaching and learning that reflect the complexity of the contemporary world.

Ultimately, this dissertation argues for a re-envisioning of music education as a liberal art through the lens of STEAM, one that acknowledges the philosophical and post-humanist implications of our rapidly evolving, interconnected world. In doing so, it positions music technology educators as vital contributors to a new renaissance in education, leading the way with their rhizomatic, transdisciplinary approaches to teaching and learning.

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Dedication

To my first teachers, my parents, who modeled the richest ways of being and learning as a human. Through your love of books, art, music, and ideas, you showed me how to approach the world with both intellectual curiosity and aesthetic appreciation. You invited me into the Great Conversation, teaching me to engage deeply with the world around me. Mom, you lived to see me complete this nearly 10-year journey, sharing your wisdom—kind and constant—at every step. I only wish Dad could have been here too; he always hoped I would earn my doctorate as he did, and I carry this accomplishment with his spirit by my side.

To Randall Everett Allsup, my mentor and dear friend at Teachers College, Columbia University: your visionary guidance, wisdom, patience, and kindness carried me over dizzying peaks and through the darkest valleys. You were my Sherpa, guiding me with a steady hand and a generous heart, and for that, I am forever grateful.

To the late Frank Moretti at Columbia University, who walked with me in the early interdisciplinary stages of this work. Though you didn't live to see its completion, your influence and inspiration linger in every chapter, every thought.

To Thomas King Simpson, Ralph Swentzell, and James Beall, tutors at St. John's College, who opened my eyes to the world of classical thought and the beauty of ideas. Your teachings continue to guide me as I navigate the world.

Thank you to my editor, Fiore Sireci, whose insightful suggestions and steady guidance helped me reach the finish line.

This work is a testament to all of you.

NUMBER MAN

Carl Sandburg

He was born to wonder about numbers.

He balanced fives against tens
and made them sleep together
and love each other.

He took sixes and sevens
and set them wrangling and fighting
over raw bones.

He woke up twos and fours
out of baby sleep
and touched them back to sleep.

He managed eights and nines,
gave them prophet beards,
marched them into mists and mountains.

He added all the numbers he knew,
multiplied them by new-found numbers
and called it a prayer of Numbers.

For each of a million cipher silences
he dug up a mate number
for a candle light in the dark.

He knew love numbers, luck numbers, how the sea and the stars
are made and held by numbers.

He died from the wonder of numbering.

He said good-by as if good-by is a number.

(for the ghost of Johann Sebastian Bach)

CHAPTER I: EARTHLY ORIGINS

This dissertation begins with an assumption: that music teachers who primarily teach through digital technologies are different from other kinds of music teachers—different in a way worth studying. As practitioners within the field of music education, technology-based music educators are taken to be music teachers who, by definition, are primarily concerned with teaching and learning music *per se* and ostensibly share the same essential aims, goals, and ends of other forms and modalities of all other kinds of music educators. Nonetheless, I conjecture that there are significant differences in the discipline and practice of music technology (as it exists both in and out of the classroom) that distinguish it from its counterparts. As the “technology” part of music technology overlaps with other subject areas, music technology education can be thought of as occupying a unique interdisciplinary space. And as inhabitants of that special kind of space or environment, technology-based music teachers may differ from other music educators in the way they teach and learn. The music technology classroom itself (or “lab” as it is often called) is a different kind of space, more so, I think, than a band room or chorus room. It has increasingly become a virtual space as online platforms for music education and digital media production evolve while the physical spaces of schools were concurrently disrupted and uprooted by the COVID-19 pandemic (Benedict & Schmidt, 2020). To what extent might it be argued that physical differences in the music technology classroom (or laboratory) may be mirrored in epistemological spaces, the spaces of identity, and the cognitive spaces of teaching and learning? I have a hunch that the technology-based music teacher may occupy a distinctive garden of knowledge and practice, bringing about the potential for a singular outlook and identity as a music educator and that perhaps they might even teach and learn in ways that differ and deviate from other music educators.

It may seem obvious to state, but music technology is both *music* and *technology*, a fact that resonates with a distinction the ancient Greeks made between two modes of creation. First, I turn to *poiesis* (ποίησις), which is translated as “the activity in which a person brings about something into being that did not exist before” (Polkinghorne, 2004). *Poiesis* is the creative power of a poet, musician, or lawmaker (and the root of the word “poetry”), a faculty or orientation to imagine or think differently. For the ancient Greeks, and onward to the 18th century in Western culture, music was considered to be a form of *poiesis*. In their classical-era *Encyclopédie, ou Dictionnaire Raisonné et des Métiers*, d’Alembert and Diderot (1751) unveiled a “Map of the System of Human Knowledge” (Appendix A), in which music was subsumed under the category of narrative poetry. The ghost of J.S. Bach was only a year old in 1751, and Euterpe, the ancient Greek muse (μουῦσα) of lyric poetry, still guarded and tended his work as a form of her sisters’ collective namesake, *music*.

It might be argued that Bach was every bit a technician as he was a musical poet. In contrast to *poiesis*, *technae* (τέχνη) means “craft or craftsmanship.” *Technae*, importantly, is also the root of the word and contemporary idea of “technology” (Liddell & Scott, 1871), and connotes skilled action (Heidegger, 1954/1977). In my own experience and practice as a music educator, one who teaches through technology, I have always felt that music technology is situated and rooted in an especially enriched mixed soil that not only has the potential to nourish the cultivation of a powerful interaction between *poiesis* and *technae*, but also to inspire and encourage new understandings and conceptions of music education. The interplay between *poiesis* and *technae* is on full display in forms of music-making based in digital technology, at the forefront of which are DJing, remixing, the invention and discovery of new musical instruments, and the use of music sequencers for composition (Allsup, 2016; Frankel 2010). It is

also reflected in the often-unsung array of musical talents and refined aesthetic sensibilities required to make sound aesthetic judgments in the post-production processes of editing, mixing, and mastering (Rotondi, 2021). The *brico-logic* of musical genres such as Hip-Hop both demands and produces such a rich and fertile soil (Emdin, 2022). But the interplay between *poiesis* and *technae* must also be felt by the oboe teacher who teaches the fine handicraft of reed making as a necessary component for beautiful tone production and, in general, the art, craft, and practice of making, maintaining or tuning or any instrument within any musical tradition must also most certainly inspire the dance between *technae* and *poiesis*, technology and creating.

In the Western European tradition, the interplay of music and technology is especially well-documented from J.S. Bach's *The Well-Tempered Clavier* (1721) onward. Advances in science and technology played a profoundly transformative role in the development of the so-called "classical" Western musical tradition through the refinement and evolution of musical instruments, which in turn, brought about meteoric changes in the aesthetics of that musical tradition (Rosen, 1998).

Likewise, the furiously rapid expansion of technology during the 20th century has brought about equally dramatic changes in how music is produced and consumed—changes that have critically re-formed the aesthetic experience of music and have shaped its consumers accordingly (Adorno, 1990; Benjamin, 1969). With this shift in culture, new questions and theories grappling with the interplay between *poiesis*, *technae*, and the forces of capitalism began to germinate and seeded a fertile new field of philosophy for what would grow to become the abundantly fruitful discourse of *critical theory*, where power relationships are interrogated through blending of a Marxian philosophical framework and the lens of phenomenological sciences as pioneered by Sigmund Freud (Surber, 1998).

Today, the teacher, student, or practitioner of music technology is uniquely situated in a rapidly evolving and highly dynamic shared space between the arts, technology, and the sciences. This space is also situated politically, as academic disciplines are not inert and neutral bodies of knowledge, but rather intricately tied to power relations and systems of control, as Foucault (1980) argues. In the interdisciplinary soils of music technology, both music and technology are mutually evolving components, and music technology educators must keep up to date with the constant changes of both domains—yet it is students who are often the experts. In this reversal of hierarchical roles, Burnard (2007) recalls sociologist Margaret Meade’s description of “reverse heritage,” in which younger generations “encounter and familiarize themselves with innovations before their parents, and indeed teachers” (p. 201).

Aside from growing in their own practice and philosophies as pedagogues, music technology educators are likely to be knowledgeable in and curious about a number of diverse subjects and disciplines. In order to qualify for most school-based teaching positions, music teachers who teach through technology must demonstrate the same level of mastery of musical skills and understandings required of any other music educator. My hunch is that they must possess deep content knowledge, including music theory, music history, music performance, and aesthetics, as well as possess technical musical skills, abilities, and aptitudes. In my own experience as a technology-based music teacher, I have observed that my colleagues in the field are knowledgeable and proficient in many areas of science and technology, including cultivating an in-depth knowledge of the physics of acoustics, electronics, audio engineering, computer science, psychoacoustics, instrument design, fabrication, repair, and more. Finally, I have noticed that they are often the kind of teachers and learners who thrive in the richly fertile, still-steamy soils of newly formed volcanic earth. In this *terra nova*, there are most often not neatly tamped

and well-trodden pedagogical pathways. These pedagogues must constantly *make* (ποιέω) their own way forward on these ever new and shifting landscapes of youth culture and its technological means of production. Paradoxically, many such teachers must necessarily and simultaneously exist and function on older, deeper terrain—a substrate of rigid school organizational structures and policy agendas to which they are ultimately accountable, and which often treats them more like technicians rather than artists (Cuban, 1988; Firestone & Corbett, 1988; Fullan, 2001).

This dissertation therefore seeks to discover and understand something of the makings of these curious dwellers. What makes them “music technology” teachers? How did they make their way and form their identities as musicians, technologists, teachers, and learners? How are they different (if at all) from their more traditional colleagues? And how might they cultivate and harvest the mixed soils of music technology to create and craft uniquely educative and inherently liberative experiences for their students that may alter the implicit power relationships that exist between the academic disciplines? It is my conjecture that these questions may be effectively addressed through the lens of STEAM in its various conceptions and practiced forms.

Background: Sources of STEAM

STEAM is a riff on STEM. It remixes the juggernaut of STEM (Science, Technology, Engineering, and Mathematics) education by adding an “A” for Arts to transform the old STEM into a new substance: STEAM. Now, as an emerging, sometimes submerging, and often perennial movement in the field of education, STEAM is often taken to signify a critical counterbalance and revision to its underlying acronym of STEM (Burnard et al., 2019). For that reason, a discussion of STEAM must begin with an understanding of the original STEM movement it critiques.

One story begins with the initial impetus for STEM occurred in the United States during the mid-1990s, when the middling performance of American 15-year-olds on the Program for International Student Assessment's (PISA) standardized exam became a matter of rising public concern. Even though the average global ranking of American students' standardized test scores had not appreciably changed historically, the news media began to demand an answer to the question of why American students weren't leading the pack in mathematics and the sciences when compared to their counterparts in 64 developed nations (Catterall, 2017). By the early 2000s, the specific grouping of science, technology, engineering, and mathematics began to coalesce as a possible solution to the perceived problem of underperforming American students. In 2001, the unlikely acronym of SMET was first coined by Judith A. Ramaley (2002), who was then Assistant Director of Education at the National Science Foundation. Ramaley said she "always thought it was terrible. It made me think of many things, but none of them had to do with science and technology," so she changed it to STEM (Cavanagh & Trotter, 2008), suggesting stem cells, or clippings for new growth. Shortly thereafter, the term began to appear in American news media, with the first explicit mention of STEM in 2005 upon the creation of *The Congressional Caucus for Science, Technology, Engineering, and Math Education or STEM* by representatives Vernon Ehlers (R) of Michigan and Mark Udall (D) of Colorado (Loewus, 2015).

The revised acronym and portmanteau of STEAM signals a rethinking of a dominant educational structure, a system that has evolved to disproportionately reward scholarship in increasingly specialized and strictly defined STEM disciplines (Bloom, 1987; Bruner, 1962). The appearance of the new acronym suggests the promise of an emerging shift in the epistemological landscape of American education and a change in the power relationship between disciplines. In

the United Kingdom, STEAM is regarded as an educational movement, reflecting a surge of interest in pedagogical approaches that promise “innovation and societal renewal by means of education” (The Independent, 2016; Segara et al., 2018). The play on the common use of the word “steam” makes for a rich metaphor for transformation; it might be taken to signify a simple and natural form of untapped potential energy, evoking the image of a Yellowstone geyser issuing forth from deep within the earth; or perhaps of the steam engine—a powerful catalyst of social and economic transformation in the world or perhaps be taken in part as a reference to the underlying metaphor for Freud’s “structural model” of workings of the subconscious (Surber, 1998). In this sense, it may also be extended to signify, indeed rescue, the potentially transformative powers of liberal education in an age in which knowledge and culture have been increasingly separated into silos and dissolved under the pervasive logic of neoliberalism and globalization.

On the other hand, the metaphor can be taken to mean something quite the opposite: for all of its potential as a source of energy and power, steam is also elusive and amorphous, and its power can literally evaporate before our eyes. Much in the same way, it might be argued that a clear definition or unified vision of the STEAM movement has been as elusive, amorphous, and insubstantial as water vapor itself (Burnard et al., 2019). Both metaphorically and actually, the insubstantial nature of STEAM is indeed apropos to the increasing instability and mutability of the letter “A” as it steadily evaporates from schools and the American education system.

The metaphor of STEAM may be extended further to express its own fundamental dominant discourses on education, (e.g., the metaphors of *fields*, *areas*, *soil*, and *grounding*, as well as *cultivation*, *growth*, *decay*, *root*, *flourishing*, and of course, *stem*). Alternately, the metaphor of STEAM in education suggests an elemental difference to such earthen, territorial

images and conceptions of education. The classical idea of the fundamental elements of earth, air, water, and fire appears in the zeitgeist across multiple ancient world traditions, including Chinese, Indian, Tibetan, Babylonian, Hellenistic Egyptian, and Greek cultures, as a way of explaining the nature and complexity of all phenomena in terms of simpler substances (Ball, 2004). Within this classical framework, steam is not of the earth but rather, a product of the combination of the elements of *air*, the realm of ideas, problems, and knowledge, and *water*, the realm of emotions, arts, and creativity. STEAM is, after all, *steam*—it is atmospheric, vaporous and elusive by its nature. It exists only under certain special atmospheric conditions that may sometimes arise between the two elements. The metaphorical logic of the classical elements may be yet extended even further. The promises and prizes of STEAM education are spoken of in terms of the fourth element of *fire*, and its contemporary Promethean analog, *electricity*. Talk of *connectivity*, *sparks of creativity*, *induction*, *potential*, *light bulbs over heads*, *enlightenment*, and the like are used to describe innovation, invention, and discovery: the shared aims of both industry, industry-inflected sciences, and the conceptions of education designed to support them. The origins of STEAM education may be traced to such terrestrial sources.

Of Skunks, Ecotones, and Polymaths

In 2011, I had the opportunity to compose music for the PBS documentary series *Nature*. One of the programs I worked on explored the interactions between skunks and humans, and was called “Is That Skunk?” (Mangum, 2011). My contrabassoon and bass clarinet-rich score helped tell the story of a small town in California that for some inexplicable reason, had been overrun by skunks. They were everywhere, and scientists could not at first understand why. The town was bounded by a forest on one side, and grassy planes on the other.

Therein lies the answer. Ecologists discovered that skunks thrive in ecological gradients, or borderlands between self-contained and otherwise homogeneous ecosystems. In the biological sciences, the term *ecotone* is used to describe such a space. The term was coined from the combination of the Greek word *ecos* (οἶκος), meaning “home,” for ecology, and the Greek word *tonos* (τόνος) meaning tension (as in the tension of a string), among its many meanings (Liddell & Scott, 1940). *Ecotones* are therefore spaces where ecologies are in tension. Similarly, the word *ecocline*, signifying a gradation between one ecosystem and another where there are no sharp boundaries. In this dissertation, I borrow both terms to describe the shared, overlapping spaces between disciplines.

Ecotones or *ecoclines* describe the liminal spaces and gradients caught in tension between distinct heterogeneous ecologies (or disciplines), and such spaces attract a certain kind of intellectual creature. In a paper delivered at the 2015 Research in Music Education Conference, Peter Webster pointed to the classical concept of *the polymath* as being of central importance and naturally inherent to the field of music education. The term *polymath* (n) and *polymathic* (adj) comes from the Greek *polymathes* (πολυμαθής): literally meaning, “having learned much” (Liddell & Scott, 1940). In its modern meaning, a *polymath* is a person whose expertise spans a significant number of different subject areas. Webster (2015) explains that the term first appeared during the Renaissance era as a feature of the humanistic movement—the idea that humans are limitless in their capacity for development. He notes that polymathic thinking should be differentiated from inter-, multi-, trans-, or cross- disciplinary work or collaboration between experts, since,

What I have in mind here is that an individual feels deeply about understanding another field personally and works hard at achieving a deep and lasting level of understanding about it and actively considers this “other field” from a polymathic perspective. (Webster, 2015)

Kline and Parncutt (2010) describe practitioners in the areas of music theory, music history, composition, and applied music as possessing an inherently polymathic character by necessity. At the 2015 RIME Conference, Webster added to their list and singled out his audience of music education scholars as having “some of the most compelling needs to be polymathic.” Webster points out that practitioners in the field of music teaching and learning are not only held accountable for an in-depth understanding of music theory, history, and performance, but they are also expected to cultivate rich understandings of a broad assortment of fields and areas, including children’s capacities for learning, specific pedagogies, philosophical positions, technology and related media, allied arts, political implications and realities, interpersonal skills, social context issues, and a host of additional domains outside music as a whole. This creates a most daunting array that leads to exciting challenge (Webster, 2015).

The growing body of literature on music technology educators, or now more precisely described “as music educators who teach through technology” (Friedman 2013; Rudolph, 2004) firmly establishes their position in the polymathic firmament. By simple definition, music teachers who teach through technology are simultaneously teachers, musicians and technologists. The technology-based music educator might add the following litany of disciplinary specialties to Webster’s list: computer science, history of electronic music, physics, acoustics, electronics and electronic repair, the mathematics of acoustics and electrical theory, psychoacoustics, and neuroscience associated with that field. These music educators also need to be familiar with musical styles associated with electronic music including extended techniques in electronic

music composition, audio engineering and experts in audio recording, video production and editing, and must also be knowledgeable about legal issues of intellectual property.

Peter Webster's image of the music educator as polymath might reflect the intellectual habits of mind, appetites, and broad disciplinary masteries that are implied by STEAM, but the aesthetic practice of such a person might be best captured in the concept of *bricolage*. The concept of bricolage was first introduced by French anthropologist Claude Lévi-Strauss who used it to describe patterns in mythological thought, specifically, the skill of using whatever is at hand and repurposing materials to create something new. Lévi-Strauss (1962) contrasts the bricoleur with the engineer. The bricoleur is a "savage mind" and works with her hands in devious and innovative ways, in contrast and opposition to the "engineer" who is a "scientific mind" who approaches problem-solving in a decidedly methodologic and rational fashion. Similarly, Deleuze (1968) points out that the bricoleur does not approach world with a predetermined idea of structure or method, but rather "works with the contingencies and multiplicities that present themselves," perhaps suggesting more the perspective of a scientist than an engineer. By contrast, Derrida (1978) argues that "the engineer is always the bricoleur," as she works to integrate elements that have been separated by "the rules and axes of differentiation," suggesting creative interdisciplinarity in her approach to problem solving through the process of deconstructing existing bodies of knowledge to create new ones.

IBM Engineer and STEAM advocate John Sealy Brown (2000) brings the concept of bricolage into the dialogue on STEAM, defining it as problem-solving in the concrete, rather than the abstract. He defines bricolage as "having do to do with abilities to find something—an object, tool, document, a piece of code—and use it to build something you deem important." Brown describes bricolage as a complex method of formulating judgement in the creative

process. He asserts that “judgement is inherently critical to becoming an effective digital bricoleur.” Brown observes that in postmodern digital learning environments, “the sheer scope and variety of resources befuddles the non-digital adult. But Web-smart kids learn to become bricoleurs” (p. 14).

I conjecture that like a skunk, the STEM polymath educator is a kind of unusual creature who thrives in the ecotones between the eponymous disciplines of STEAM, but is perhaps less suited to traditionalist, homogeneous environments. The polymathic STEAM practitioner rejects the constraints of traditional vertical logic for the more rhizomatic and horizontal practices of bricolage. The technology-based music educator must reach across disciplinary boundaries by burrowing under traditional walls and fences into the forbidden territories and domains of the Sciences, Technology, Engineering and Mathematics (or STEM subjects, as they have become known). It is only by virtue of the invisible network of roots that the digital luthier or audio engineer might be conceived as a branch of engineering as it exists in the academy. Hence, the emerging field of music technology may be thought of as a STEM-rich discipline. By definition, the name music technology necessarily includes the “T” in STEM for technology, but perhaps less obviously, the remaining letters in the acronym are equally essential to the study and practice of the field. The “S” is present for the requisite understanding of the physics of acoustics needed to gain full access the new generation of instruments and tools, as well as the inclusion of biological and behavioral sciences’ accounts of the perception of music as it relates to the tools and techniques of music production; the “E” stands for audio engineering including electronics, digital signal flow theory and the diverse traditional engineering skills required for new instrument design and creation; finally, the “M” that serves as the fundamental language of all the other above-mentioned sciences as well as the classical foundation and bedrock for harmonic

relationships in music. Considering the depth, extent and possibility for such interdisciplinary connections and their considerable potential to enrich the process of music making, some music educators are recognizing the potential for bridging the gap between an approach to the arts and sciences through music technology curricula (Morton et al., 2017).

STEAM is Not Inert

I conjecture that the metaphorical skunk of STEAM can be, as skunks often are – an unwelcomed guest – or at least one that has the potential to stink up the status quo. Critical perspectives within the multidisciplinary family of Cultural Studies would argue that art is always situated politically and inherently reflect and engage with political dimensions. A Marxian perspective would argue that art is shaped by modes of production and consumption. As Jameson (1981) puts it, “all art is ...a social and collective activity that takes place in specific historical and economic contexts, and as such, it is always implicated in larger social and political structures.” A feminist critique would argue that “all art is gendered, and all gender is political,” (Pollock, 1988), while from Edward Said’s (1994) post-colonialist perspective, “all art is involved in the politics of representation and identity,” and critical race scholar bell hooks (1990) argues that, “all art is political because it engages with issues of power, privilege, and oppression.”

On the other side of the claim that all art is inherently politically situated, are older perspectives that advocate for the neutrality or autonomy of the arts. Immanuel Kant, for instance, argued that art should be judged only for its formal and aesthetic qualities, separate from social or political context (Kant, 1790), as did artists in the Formalist movement, who emphasized “defamiliarization and estrangement” from content and context in favor of a focus on the formal qualities of composition, color, and technique (Shklovsky, 1917). Additionally, the

“arts for art’s sake” movement of the late 19th century argued that the arts should be autonomous and neutral and that a work of art should be valued for its own sake, separate from any moral, political, or didactic agenda. The British art critic Walter Pater (1873) wrote that “all art aspires to the condition of music,” suggesting that music is a pure and transcendental form of art that exists beyond earthly signification.

When it comes to the role of arts in education at least, John Dewey (1934) would beg to differ. In his view, the educational role of the arts, and music in particular, were of significant social value to a democracy. “By engaging with music,” he writes, “students learn to appreciate diversity and cultivate democratic values such as to tolerance, empathy, and respect for others’ perspectives.” Dewey (1916) believed that music itself had “the ability to unite people and foster social cohesion within communities,” and that through music education, “students learn to work together, listen to one another, and appreciate the contributions of others, promoting a sense of belonging and solidarity.” Maxine Greene (1995) takes Dewey’s argument further, as she brings the discourse on arts education back to the flickering shadows of Plato’s cave where it began. For Greene, the role of the arts is anything but neutral. She argues that the arts create openings for critical inquiry and reflection, and invite students to grapple with questions of identity, power, and justice. Greene asserts that the arts in education have the power to disrupt dominant narratives and inspire collective action.; the arts can also be the catalyst for social transformation. In her essay “Wide-Awakeness and the Moral Life,” Greene writes “Arts education has the potential to awaken students to the moral imperatives of our time, challenging them to confront injustice and work toward as a more just and equitable society.” This is the same philosophical and political wide-awakening, or *anagnorisis* (ἀναγνώρισις) that the prisoner in Plato’s (n.d.) allegory of the cave experiences when he escapes to the sunlit uplands outside the cave.

To the arts educators who still remain as prisoners inside of Plato’s cave, the role of the arts in education may appear to be a neutral and apolitical one. As Wainwright (2013) observes, they “may shy away from political engagement, preferring to focus on aesthetic values and formal techniques” and as Davis (2010) adds, they may “overlook the political dimensions of art-making” because “there is a tendency to view art as a form of personal expression rather than a tool for social change.” From the perspective of the stable molecule of STEM education, the lone, atomic “A” for the arts might appear to be inert, and therefore an inconsequential element to bond with. However, I posit that within the new molecule of STEAM the arts become politically charged, especially as they react with STEM education, with its powerful ionic bonds. The bonds of STEM are not all positive, as they are deeply inflected by historical and political context. As Calabrese et al. (2018) argue,

The politics of STEM education cannot be divorced from the broader social context in which education policies and practices are situated. Issues such as institutional racism, cultural hegemony, and neoliberalism shape the landscape of STEM education, influencing who has access to opportunities, recourse, and power within the field.

The emancipatory potential of the arts makes them a radical element in this context. Within the arts, the polymathic teacher, learner, and thinker might be cast as a similar figure to Plato’s philosopher in the cave: a heroic, radical actor who is able to use the alternative logic and spirit of bricolage to liberate themselves and free others from (or break into) the entrenched disciplinary silos of STEM. They arrive on the scene as artists, philosophers, hackers, disruptors and *skunks* who are critically aware of the hegemonic neoliberal, military, and social forces and that produce and reproduce STEM. They thrive in borderlands and feed off the tensions that exist between established, homogeneous epistemological “areas” and “fields” and infiltrate them

through an invisible, complex, underground network of roots. As artists, they are *liberal* artists who leverage the liberative, humanistic powers of education through their practices. They render intelligible the inclusion of music as one of the seven classical liberal art in Boethius's scheme and provide a possible clue about why the 14th-century thinker grouped music together with geometry, arithmetic, and astronomy in his *quadrivium*, the historical predecessor to STEAM.

Music as a Liberal Art: An Interregnum

This inquiry is born from my own lived experience: it is generated by my desire to gain a deeper understanding of myself as an artist, a teacher, a student, a thinker, and human being. It echoes my interest in philosophy, particularly aesthetics, and philosophy as a “way of life,” as thinkers such as Augustine, Marcus Aurelius, Montaigne, and Schopenhauer engaged with advanced ideas that now define the branch of philosophy known as aesthetics. Because this paper explores a space that I happen to occupy both professionally and intellectually, a short autobiographical background is apropos of the context, origins, and purpose of my study.

For the past two years of my teaching career, I have worked at an International School in Hangzhou China, where I teach music and serve in an administrative role. As part of an interdisciplinary Project Based Learning (PBL) course that my colleagues and I designed, students are exposed to topics such as psychoacoustics, mathematical foundations of acoustics (including Fourier analysis of waveforms), digital music technologies, and physics and mathematics of harmony as part of the unit design. In a previous role in at a charter high school in the Bronx, New York, I also taught physics and engineering in addition to music through technology courses. Wait...*physics and engineering? How is this research in music education?*

Allow me first to state clearly that my primary professional identity is as *a music educator*, and I have worked as one for the vast majority of my teaching career. My choice to

add the subjects of physics and engineering to my own teaching and learning repertoire is part of a much larger project—an exploration of how the sciences and the arts relate to each other as ways of knowing and to what extent they might be able to coexist in the same teaching and learning spaces...but allow me to digress (which itself, is of the essence).

Thinking back to my previous career as a composer for documentary films, I recall the moment that I understood myself as a *skunk*. As a composer (and sometimes producer, and sometimes a writer), I found myself situated in a specialized ecocline between the environments and communities of science, filmmaking, music, and technology. Writing *science music* was an ideal occupation for a person like me; it required a special mix of disciplines, aptitudes, talents, and interests that were already part of my repertoire; namely, years of classical musical training; academic preparation in science and the history and philosophy of science; experience as a science journalist; technical interest and knowledge in the filmmaking process, and a passion for music production and electronic music. Like a skunk, I am drawn to and thrive in disciplinary gradients. I have also discovered that my best teaching and learning thrive in disciplinary ecoclines, and moreover, that to the extent that my own teaching and learning are inherently tied to each other, I strive to situate myself in the in-between spaces in order to cultivate my own best teaching practices.

For these reasons, and after many years teaching music, I decided to go on a reconnaissance mission and become a high school physics teacher. This was no small undertaking. It has been an ongoing learning project that has required me to reacquaint myself with and regain mastery of a challenging subject area that I have not spent time with since my undergraduate days. In order to obtain state certification, I needed to puff the dust off my old math textbooks, go back to school for intensive training in engineering, and study for the New

York State Content Specialty Exam (CSE) in physics. My mission behind enemy lines and in the no-man's land in between the lines did not fail to provide me with some insights into the problem of STEAM and other efforts to promote critical interdisciplinary teaching and learning. As a physics teacher, I learned that student performance on the state standardized test was the top priority at my school and the only accepted measure of my work and my students' achievement. This expectation came as no surprise to me as this value has become a virtually universal practice, as it is reported and supported in the literature. The physics curriculum was rigorous and so broad that it covered more content than most teachers can practically cover within a single academic year.

While the curriculum was designed to emphasize analytical reasoning and minimize rote memorization, it left little time to linger and “notice what there is to be noticed,” as we are invited to do so by Maxine Greene (2007). Perhaps not surprisingly, it seemed devoid of an aesthetic sense of the discipline of physics, or in other words, how a professional physicist might determine what a “good” question is or what an “elegant” proof or expression might be. In this sense, and by default, the gatekeepers (in this case, the creators of the Regents curriculum) keep the gates of the “hard” sciences in education firmly closed to potential invaders and imposters like me.

My life as a STEM imposter began in my undergraduate experience at St. John's College, an institution known for its intensive traditional Western *Great Books* curriculum. At St. John's there are no majors, no electives, and no specialties. Over the course of four years, all students read and study the same list of about 100 books that comprise the curriculum. The books include seminal (and often prohibitively difficult) works from every disciplinary tradition in the West, including the fields now labeled as philosophy, history, literature, mathematics, physics,

astronomy, biology, chemistry, language, political science...and the list continues to broaden. The faculty at St. John's are not called by the usual academic honorifics of "professor" or "doctor" instead, they are addressed simply as Mr. or Ms., just as all the students are called. They are referred to as "tutors" rather than professors and are required to lead study in all disciplinary areas, regardless of their academic specialty or preparation. My freshman-year language tutor was a gentleman named Mr. James Beall, who led our class in a demanding and rigorous exploration of Attic Greek and who would later become a mentor. Mr. Beall's academic and professional background was as an astrophysicist and held a prominent position at the Naval Research Lab. He also happened to be a gifted poet whose work appeared regularly in publications like *The New Yorker*. Mr. Beall was and is, without any doubt, a *polymath*. As an Attic Greek tutor, he was certainly no expert, but he was indeed an apt and passionate life-long student of language, and most of all, he was (and continues to be) an expert learner.

Another polymathic tutor at St. John's College who had a tremendous influence on me was Thomas Simpson, a philosopher and historian of mathematics. It was with him that I studied the classical texts of the ancient mathematician Euclid and astronomer Ptolemy. For Mr. Simpson, ancient Greek cosmology was anything but the stuff of cryptic ancient texts and dusty astrolabes. Ptolemy was concerned with the vital, urgent business of "saving the phenomena." In his work, Ptolemy brings a chaotic cosmos to order. He *saves* or makes orderly sense of the "wandering stars" called *planetes* (πλανήτης) or planets by accounting for their zig-zag paths in the night sky with an elegant system showing that the motions in the heavens are ultimately reducible to uniform circular motion.

My year reading ancient Greek astronomy with Mr. Simpson was also the year that synth-pop was at its apogee, with bands like *New Order*, *Orchestral Maneuvers in the Dark*, and

Depeche Mode with hits like and hits like *Blue Monday*, *If You Leave*, and *Enjoy the Silence*

Unlike kids who saved up for a car or electric guitar, I saved up for a new kind of musical instrument, a digital sampling synthesizer. After a summer of mowing grass, I had enough to buy a Korg DSS-1. But what does this have to do with Ptolemy? “Everything,” said the wizardly Mr. Simpson. When I showed him how the instrument worked, Mr. Simpson exclaimed it was a “Ptolemy machine,” as it could model the complex phenomenon of a musical instrument’s sound through the application of elegant mathematics. By doing so, it “saved the appearances.” “That’s exactly what Ptolemy is doing, and that’s what philosophy is doing!” he exclaimed.

Another gift came from Mr. Ralph Swentzell who was an engineer by training but also every bit a philosopher. He helped me to connect Kant’s ideas of epistemology to Newton’s purely *a priori* and decidedly non-phenomenological arguments in *Principia Mathematica*. Somehow a faltering and unlikely math student had learned to love calculus this way. Later that year, Newton’s God, a watchmaking creator, became a composer and instrument maker as Kepler revealed the harmonic relationships and the cosmic music played between what turned out to be the theorized tuned spheres of the “wandering” planets. In my view, these three teachers were practitioners of what many now refer to as STEAM, but what Newton and Kepler would have called “Natural Philosophy” and what Aristotle or Pythagoras would have simply called nature φυσική (physics). Many would herald this kind of interdisciplinary (and transdisciplinary) teaching and learning as the kind of thing that Liberal Arts can do best.

As I set out in this dissertation to discover how contemporary music teachers in schools might be rooted in the same soils and contributing to the same tradition, I am struck by the fact that my work here amounts to a kind of “Ptolemy machine” yet again. As I will discuss in

Chapter III, my aim is to offer an account of the phenomena and attempt to “save” it through analysis and interdisciplinary thinking.

Returning to Mr. Beal, Mr. Simpson, and Mr. Swentzell, I believe I somehow learned how to learn polymathically and trans-disciplinarily at St. John’s. So many of the tutors there seemed to have a kind of glow about them, which I suspect must have come in part from the freedom they were afforded by the college to regularly shed the protective armor of their expertise and continue their academic careers as vulnerable learners. I imagined that such an atmosphere was one of the liberties implied in the phrase “liberal arts,” and I went out searching it in my own career. It has always been my dream to be rooted in the same kind of ecotone afforded by the rarefied community of practice like the one that exists at St. John’s, but such environments are few and far between. Yet in my career as a teacher, I have worked in a few environments that have come close to that ideal, in particular, one teaching job that may be a more clearly recognizable part of music education. For six years, I worked at a public high school for the arts in the New York City area, where I taught Advanced Placement music theory, music history, composition, digital music production, and an interdisciplinary course I designed called *Science and Music*. When the School for the Arts started to face a funding and enrollment crisis, it was announced that the campus would be shared with a newly established magnet STEM program for gifted and talented students. That year, a portion of my teaching assignment was to teach engineering design to gifted students in the sciences. I was sent to the University of Texas that summer for teacher training in engineering design and told that I was selected for the position because members of the district board of education had identified my music classroom as one of the “STEAMiest” they had ever seen. I immediately saw the shared physical space as an opportunity to create a shared intellectual space, and it became my objective to find and build

intellectual, cultural, and curricular bridges between the two schools. Without any explicit aim of setting out to implement STEAM education, my students and I were exploring intersections between the engineering design process and composition, musical instrument design, acoustics, psychoacoustics, music cognition, electronic music, sound reinforcement, audio engineering, and technical theatrical design.

Concerning democratic education, a memorable learning experience along these lines was a student-initiated interdisciplinary project to design and build special glow-in-the-dark costumes illuminated with electroluminescent fiber-optic wire and to choreograph a live theatrical dance performance piece to originally composed and produced music. The design team consisted of students from my engineering design class, music students, dance students, technical theatre students, and students from our CTE (Career and Technology Education) program in fashion design. There were no assigned student roles in the design team, and the students did not stay in their own discreet nominal disciplinary “lanes” for long. Theatre students studied electronic circuit design and engineering students danced and choreographed, and more of the like. Both the process and the final product of this project were exceptional learning experiences and were executed at a professional level. This reordering of the social roles re-minded me that STEM and STEAM are political, emancipatory, and an exciting possible way forward for democratic education.

In the end, it was in this exciting, free, and arguably luxurious teaching environment that I began to encounter more and more convincing correlations between teaching and learning across the so-called boundaries between STEM disciplines and the arts. Incidences of overlap appeared to be robust and increasingly clear, and I began to recognize similarities in the cognitive challenges students faced across disciplinary boundaries. For example, I noticed that as

my music theory students learned to write four-part harmonies in the style of Bach, they were developing the same cognitive skills they would need to factor a polynomial in algebra. Through my own practice, I began to develop an intuitive idea of what STEAM education could be, and I suspected others in similar teaching situations might share similar experiences and outlooks. The proposed research described in this dissertation is concerned with testing that suspicion by exploring the lived experiences, learning characteristics, teaching practices, positionalities, attitudes, environments, and philosophies of technology-based music educators as a potential site for STEAM education.

To Capture a Cloud

The benefits of STEAM education remain undertheorized and inequitably distributed in society, and the meaning of the construct remains a complex and highly contested (Burnard, 2024). As result, the case for STEAM education has not gained as much steam as its proponents had hoped. Since its first appearance in print as an acronym intended to reimagine STEM education in 2009 (Yakman, 2011), the discourse on STEAM education has propagated across the American educational landscape, beginning with the introduction of legislation to recognize the educational value of STEAM (Maeda, 2010); conferences dedicated to exploring STEAM (Teachers College, Columbia University 2015); a surfeit of scholarly articles extolling the benefits of STEAM; and the appearance of brick-and-mortar school programs that promise STEAM educational experiences to students (Kim et al., 2018) due to increasing parental demand (Darling-Hammond, 2017). Nonetheless, there is a considerable problem—a proverbial elephant in the room. Little consensus exists about what STEAM education looks like, or what it’s qualities might be. Defining STEAM as a concept has become a “complex and contested” undertaking (Burnard et al., 2019). The basic ontological crisis of STEAM is perhaps

reminiscent of American Supreme Court Justice Potter Stewart’s classic quip about defining his threshold test for defining obscenity in *Jacobellis v. Ohio* (1964): “I know it when I see it.”

Therefore, I believe the problem is two-fold. While STEAM is a palpable, observable phenomenon as a movement in education, there is no clear vision of what STEAM is or what it could be other than what’s in its name. The acronym is either a scarcely clever—or perhaps deeply profound play on words to express an imperative for some kind of transformation through the nominal addition of the arts to a decidedly industrial-sounding grouping of pure and applied sciences. STEAM is known at least nominally, but its practitioners are not. There has been little research conducted in music education scholarship on the *whos*, *hows*, *wheres*, and *whys* of music technology education and educators, let alone music technology educators who profess to embrace STEAM.

Cloud Navigators

This study investigates the lived experiences of four primary and middle school music teachers in the United States who self-identify as both “music technology” teachers or “music teachers who teach through technology” and by implicit and explicit extension, as practitioners, proponents, or advocates of STEAM education. The classroom schoolteachers were selected over post-secondary music technology educators and college professors, because although post-secondary educators often possess specialized expertise, from my experience as a K-12 teacher, I believe that the middle school classroom is, by definition, the kind of in-between space, or ecotone. The middle-school is often an uneven, transitional middle ground between primary and secondary school, as well as childhood and adolescence. Consequently, my hunch has always been that the middle years are truly where “the rubber hits the road” when it comes to evaluating educational theory. The four participants represent broad diversity in race, gender, ethnicity, age,

and personal, professional and educational backgrounds. The social and economic contexts of their respective schools, educational institutions, or communities of learning are equally diverse, serving students from urban, suburban, and rural settings. Participants were recruited through “snowballing” or “snowball sampling” (Biernacki & Waldorf, 1981) through active online professional learning communities and forums for music technology educators, including TI:ME (Technology Institute for Music Educators) and social media forums for music technology educators, such as *I Teach Music Technology!* and *Teaching Music Through Composition* Facebook groups. Participants were selected according to criteria described more fully in my discussion of research methodology in Chapter III.

Purpose Statement

The purpose of this proposed study was to explore a group of secondary music technology teachers’ perceptions, practices, and attitudes toward STEAM education, their understanding of their own communities and ecologies of learning, their preparedness to teach in this emerging field, and their strategies for implementation of STEAM in the classroom. This/these phenomenon/a were studied so that STEAM might be further enlarged and enriched within the discourse on music education, and in turn, be of potential value to a broader, more critical discourse concerning the influence of economic forces on knowledge, culture, and education.

Hypothetical Framework

My own experience, intuition and curiosity have led me to investigate claims of STEAM situated in the special disciplinary ecocline that music technology teachers inhabit, as well the habitats and habits of mind that may be found to be common to music technology teachers. I begin with a few hypotheses.

I suspect that STEAM education has remained elusive because we haven't been looking at it—or for it—in quite the right way; we have not yet understood it through the framework or paradigm to which it is native. If STEAM education can be correctly understood metaphorically as the product of the classical elements of air, water, and fire then why do both proponents and critics of STEAM continue to attempt to grasp and capture it as if it were earthen solid and permeant, and as if it could be cultivated, harvested and brought to market, via the familiar *entrenched* agricultural and horticultural metaphors of education? My hunch is that STEAM education may be more likely situated in the uniquely developed cognitive modalities of those who are drawn to (or exiled to) disciplinary ecoclines.

The early first blossoms of literature describing STEAM education or STEAM educators in music education calls for open-ended qualitative phenomenological research. An observational approach provides an alternative to searching for definitions or “hard evidence” of effective STEAM education in the specific, ostensible artifacts of curricula, observed brain activity, or metrics of transfer. I believe it may be more productive to open the iris (of the camera, or the eye, or perhaps the flowering iris on the border between land and water) with fewer formalistic constraints and observe the phenomena of identities, attitudes, experiences, and learning ecologies of potential or self-described STEAM educators themselves.

Research Methodology

The methodology used in this study is an open-ended qualitative phenomenological method in which four secondary music educators who self-identify as practitioners of STEAM education were interviewed over a one-year period. Myriad in-depth interviews were conducted with each educator on separate occasions throughout a two-semester school year. Follow-up interviews took place until full saturation was achieved. After the data was collected, it was

transcribed and coded for the analysis of keywords and ideas. Supporting documentation such as curricula, syllabi, lesson plans, and examples of student work was also collected to support triangulation. A more extensive description of the proposed research methodology is provided in Chapter III.

As we will see in Chapter III, the phenomenological method is conceived of as a way of avoiding commitment to a particular framework and calls for the suspension or bracketing of preconceived notions (Creswell & Poth, 2018; Moustakas, 1994; Yin, 2014). In keeping with the dynamic qualities of qualitative research (Yin, 2014), I anticipated that essences and themes that emerged from the data would recursively revise the conceptual framework to yield new and unexpected meanings. The purpose of the initial framework described above and expanded upon in Chapter II was to bracket my hypothesis so that the reader might be able to contrast it with the actual data and findings.

Research Questions

Phenomenological research methodology, as it was intended for this study, was designed to best address two basic research questions: (a) *What* the phenomenon is that the participants experience, and (b) *How* they experienced it (Creswell & Poth, 2018; Yin, 2018). Therefore, the research questions below are designed to address *what* and *how*, while remaining as open-ended as possible. The proposed study will research the following questions:

1. How do participating music teachers in this study understand, discover, invent practice, and implement STEAM education?
2. How do the participants perceive their own community of practice (Lave & Wenger, 1991), and how do they make sense of their own ecology of learning specific to music technology as a discipline?

3. How and to what extent has their experience teaching, learning, and artistic practice led to engagement with STEM subjects? (In other words, just how “STEMMY” are they?) In what ways is their learning in STEM areas supported by their environment?
4. What are they doing? What do they consider the most STEAM-like elements or aspects of their teaching and learning practices to be, and how do they relate their praxis to the goals of music education? How do they relate to STEM education and STEM?

Timeline

Recruitment, planning, and IRB submission took place in November and December of 2018. Data collection for the study took place between February 2019 and January 2022. Follow-up interviews and participant transcript review took place in May 2022. Coding and analysis took place between May 2022 to January 2024.

Condensation

In this chapter, I attempted to provide an overview of the phenomenon of STEAM from historical, philosophical, and personal perspectives. My interest in studying STEAM comes out of my desire to understand my own experience of STEAM as I perceive it, just as my strong interest in research in music education grows out of my experience, practice, and passion as both a musician and an educator. My preference for disciplinary ecoclines comes from my own nature as a transdisciplinary, epiSTEAMological “skunk.” For this reason, the proposed research is, in many ways, a self-study. I cannot pretend to be neutral as an investigator, but I am willing to embrace the rigors and complexities that may come with seeking truths about the phenomenon of STEAM wherever they may lead. In this chapter, I have advanced historical, theoretical, and hypothetical frameworks for this study, and attempted to disclose my biases as a researcher

through a biographical narrative. I have also selected a methodology that emphasizes the expansion of the researcher's consciousness through the curation of other lived realities.

In matters of state a change even for the better is distrusted, because it unsettles what is established: these things resting on authority, consent, fame and opinion, not on demonstration. But arts and sciences should be like mines, where the noise of new works and further advances is heard on every side.

-Francis Bacon (Novum Organum 1.129)

CHAPTER II: A GATHERING CLOUD

Formation

When I first began researching the literature on STEAM and music education, only the first few vapors of substantive peer-reviewed literature had been emitted on the topic. In the decades that have passed from its original conception, scholarship on the subject has expanded considerably. The literature reviewed in this chapter is cloud-like as its body is amorphous and fragmented across the discourse on music education, the evolving dialogue on the interdisciplinary approaches of arts integration and STEAM, and the history and critical theory of Western education. In addition to bringing forth relevant conversation in the literature regarding the history, philosophy, practice, and aims of interdisciplinary education in schools, I will seek to define key terms and offer a web of conceptual and symbolic frameworks that will be useful as touchstones in later chapters. As often occurs in phenomenological research, such frameworks must be open to evolve as the data is collected, analyzed, and understood (Moustakas, 1994). Nonetheless, in this chapter, I will attempt to round out the dialogical cloud of STEAM as it permeates the field of music education.

Disciplines on Disciplines

As I set out to investigate the complex and ill-defined phenomenon of STEAM, my efforts to define key terms at the outset may appear to be a kind of tautology (or circular logic). As Pamela Burnard asks, “What thoughts think thoughts? What description describes descriptions? What ties tie ties?” (Burnard, 2024). In an effort to break the loop and attempt to adequately address STEAM, we must at least begin with a discussion toward and around a definition of the foundational ideas of *discipline* as it appears in multiple forms and meanings in the discourse on education. The most cursory investigation yields immediate surprises: The

online Merriam-Webster Dictionary (2024) explains that the term derives from *discipulus*, the Latin word for pupil, which is also the source of the word *disciple*. The earliest English use of the word in the 13th century appears to be “punishment-related,” as it was used to refer to “chastisement of a religious nature, such as self-flagellation” (Merriam-Webster 2024). Although only etymological roots, these first meanings of *discipline* conjure images of both monastic devotion on the one hand and the historical instruments of punishment and torture on the other. The first image conjured by the dictionary definition recalls the monastic environment of a conservatory in which practice rooms are occupied at every hour of the day for the ritual of practice. These daily devotions may be driven by a divine yearning for musical virtuosity and virtue or, more darkly, by a desire for musical purity as novice music disciples self-flagellate in the purgatory of a practice room.

The latter understanding of discipline is most eloquently described by the French philosopher and social theorist Michel Foucault, who explores ways in which knowledge and power are interlinked and how disciplinary mechanisms control and regulate individuals and societies (Rabinow, 1983). Although Foucault does not focus on academic disciplines in a narrow sense, his theories provide a critical framework for understanding how disciplines might be conceived in schools and academia. In *Discipline and Punish* (1972), Foucault describes how institutional forms of discipline in the military, prisons, hospitals, and schools regulate behavior and serve as gatekeepers for social recognition and legitimacy. In *The Archeology of Knowledge* (1977), Foucault’s thought is central to discussing academic disciplines. He argues that discourses are knowledge systems constructed by social practices, rules, and institutions. Hence, academic disciplinary discourses may establish the borders and boundaries of what is knowable and reachable. Foucault famously argues that knowledge and power are inseparable (1972). With

this supposition, academic disciplines may be seen as producing and controlling specialized knowledge, wielding power to define truths, and including or excluding to normalize certain viewpoints while marginalizing others (Bourdieu, 1993).

Alternatively, the dictionary definition of *discipline* may take root and flourish in ecological and geological metaphors unearthed in the previous chapter. The straight rows of earthen trenches and entrenchments eroded by a centuries-long litany of musical disciples may also be taken to be the furrows of row crops tilled and plowed in the hope of the next great musical harvest. The agricultural metaphor brings us back to the “field,” “area,” which may be extended to mean the parcels of farmland comprising domains and dominions. As he is quoted in Janet Barrett’s (2023) seminal book on interdisciplinary teaching and learning in music education, arts educator Michael Parsons (2004) uses such ecological images as he echoes Foucault’s thinking in his description of disciplines:

Disciplines are more often thought of as “fields” or “domains,” as having boundaries in the way that kingdoms and other domains do, boundaries that are historically arrived at are somewhat arbitrary and reveal the exercise of power. We are more aware that the academic disciplines are the constructions of self-promoting and powerful elites that require varied acts of exclusion for their maintenance. And, in a further step, boundaries like this are likely to be impediments to knowledge, just as boundaries to real domains are obstacles to travel. Meaning, the metaphor suggests, is as likely to be found in crossing borders as in remaining in the center. (p. 785)

Parson’s critical perspective underscores the idea that disciplinary boundaries are socially constructed and politically maintained and invites us to a critical view of these lines in the sand as unchallenged, uninterrogated, and seemingly immutable fixtures of disciplinary thinking in

educational thought. In the spirit of Foucault, Parson underscores the fallacies of disciplinary boundaries, pointing out their historically shifting footprints, hidden agendas of power, and their tendency to obstruct what Barrett (2023) describes as the “deeply coherent thought” that can result from an interdisciplinary approach. Barrett describes music education as a “field” within “the all-encompassing parent discipline of music in all its manifestations.” The body of knowledge of music and music education is “far from fixed” as music educators constantly expand it by dynamically responding to new musical genres, styles, and ways of making music. Through this ongoing, generative process, teachers are called to redefine what it means to know music and are prompted to expand their own capabilities (p. 6).

As Barrett describes it, the expansion of teachers’ capabilities and, hence, their disciplinary footprints change how teachers see themselves and construct their own identities as educators. As music education pushes beyond the traditional delimitations of band, chorus, orchestra, and general music teachers, a cadre of “sub-specialties” is forming around “new strains of expertise in digital production, composition, hip-hop, and other promising curricular variations” (p. 7).

Plots of Earth

The topic of disciplinary territory brings to mind the agricultural and ecological images of soil, earth, and parcels of land evoked in Chapter I. These metaphors take on a fresh philosophical context when they are considered through the lens of critical theory. The discourse begins with a critique of propriety, property, and ownership of terrestrial land. In *Das Capital* (1867), Karl Marx famously argues for abolishing the private ownership of land to transform it into a shared commodity. Nearly a century later, Horkheimer and Adorno (1947) extended Marx’s critique of capitalism to apply to Western epistemology, offering a “critical theory” that

reveals a “culture industry” that commodifies and standardizes knowledge. The commodification of the culture of STEAM educators resonates with Jasper’s disappointment that STEAM has been commodified and packaged for sale into close-ended and reductionistic kit-like projects. Habermas (1968) and Marcuse (1964), and most notably, Freire (1970) further extend the Marxian critique to apply to education to illuminate how the forces of capitalism limit and control knowledge production and education through hegemonic structures, thereby suppressing the pursuit of emancipatory interests and critical consciousness while shifting power and agency away from the learner. In the critical discourse on music education, the topics of transgression, gates, gatekeepers, and territory are addressed, particularly around the issue of exclusivity and access in music education. Allsup (2016) recounts Franz Kafka’s 1915 parable “Before the Law,” in which the grim gatekeeper of “the Law” explains to a dogged supplicant who wants nothing more in life than to gain entry that “this gate was made for you. I am now going to shut it.” The parable may be taken to portray the twisted logic of hegemonic gates and gatekeepers that fetter teachers and learners to prescribed territories and domains.

With such forces at play, it can be understood how and why the increasingly impenetrable gates, doors, and epistemological silos that define school content areas are constructed as perpetually self-reinforcing barriers. These are the obstacles teachers face when they attempt to leave their disciplines’ safe, reinforced spaces to venture into unfamiliar territories. If they manage to transgress these boundaries, they may find themselves straddling two territories with one foot in each, but such a posture may not be sustainable or desirable. As Barrett (2023) observes, many music teachers are reticent about exploring or even mentioning music’s potential relationships with other subject areas for fear of losing their footing in the curriculum or even at work, as they may risk being “displaced or even replaced” as teachers (p.

7). With limited resources and job security as a foundational concern, it becomes clear why music educators may resist confronting the gatekeepers as they patrol the perimeters and defend their fields, areas, and territories of knowledge.

With the critical discourse on disciplinarity as a backdrop, I turn now to a discussion of the variety of ways that disciplines may be combined in various modes and configurations in teaching and learning.

Bricks, Blobs, and Cells

Appreciation for an integrated disciplinary approach to learning is nothing new. More than a century ago, in *Democracy and Education*, John Dewey (1916) writes, “Education should not be a mere accumulation of disconnected facts and skills, but should seek to integrate knowledge across disciplines, fostering a deeper understanding of the world.” In other words, connection-making and relational thinking across disciplinary boundaries are among the goals of education. That said, disciplines by themselves are also “to some degree integrative in nature. Every discipline makes uses of materials from other disciplines. They do not exist in water-tight compartments,” as Phenix (1964) states. As the academic meaning of *discipline* has evolved, the word has become increasingly hyphenated as it is used to describe a core taxonomy for understanding the degree and modality of interaction and integration that may occur among two or more disciplines (Klein, 2010). What are the various modes of disciplinaries, and what are their differences? In this section, I will briefly explore three widely used concepts associated with interdisciplinarity: *multidisciplinary*, *interdisciplinary*, and *transdisciplinary*, together with the descriptive terms *intradisciplinary* and *cross-disciplinary*. These terms demand clarification and definition as they are used widely in the literature on STEAM education and by the participants in this study.

As we set out to consider the advantages and possible snares that the various configurations of disciplinarity might offer to music educators, a useful conceptual framework for the first three modalities of multi-, inter-, and trans-disciplinary teaching and learning comes from music education scholar Janet Revell Barrett (2023), who offers a triptych of three visual metaphors: The first is of a brick wall, with each brick firmly held in place in an orthogonal grid that is spaced and reinforced by uniform borders of mortar. A second image is of the floor of a painter's, which is covered with a kaleidoscope of drips, drabs, and splatters of every color of paint imaginable—some new, some years old. In places and in frames, the textured, irregular, and multicolored surface may even recall the controlled chaos of Jackson Pollock's works. The third image is of a living cell as it is suspended in plasma; an ensemble of functioning organelles is visible through its layers of membranes. The cell is surrounded by various other cells as it travels throughout a body via the bloodstream. Barrett offers these three visual metaphors to represent three different stances of music in the curriculum, but her use of metaphors also serves as a model of interdisciplinary and transdisciplinary meaning-making.

In the first image of the wall, any given brick may represent how music may be walled off, sequestered, and isolated in a school's curriculum and thought of as a discrete and self-contained discipline (p. 3). At the same time, the brick wall may also be taken to represent either a disciplinary or multidisciplinary approach, in which each brick represents a distinctive disciplinary field or way of knowing. A neighborhood of adjacent bricks might represent *multidisciplinary* education, in which teachers from different disciplines collaborate in order to design integrated learning experiences that address the complex needs of students (National Research Council, 2002). This definition reminds me of the international school where I teach, where our curriculum is divided into traditional academic "Disciplines" and "Collaboration,"

where the arts, the sciences, the social sciences, and engineering are integrated into project-based learning (PBL) units. Oftentimes, the integration takes the form of multidisciplinary learning as a few discreet bricks are placed side-by-side, allowing students to synthesize the discreet perspectives of the disciplines. While some of the literature champions a multidisciplinary approach to education for its advantages over monodisciplinary approaches as it “emphasizes the interconnectedness of knowledge and the integration of diverse perspectives to deepen understanding and promote innovative approaches to learning and problem-solving” (Jackson,1998), most of the reviewed literature emphasizes its comparative limitations to more integrated approaches. Page (2006) concedes that “putting two subject matters together is no easy task” but warns that the effect is most often “simply a conglomerate in which opposing ideas, set side-by-side, cancel each other out and, thus, contribute to a student’s sense that there’s little knowledge to learn in school.” This is not the same as “a generative hybrid that has its own integrity” (p. 59). A similar critique of multidisciplinary in music education is advanced by Barrett (2023), who begins by acknowledging that music, as a discipline, is inherently multidisciplinary by nature, as it “certainly has distinctive ways of knowing and feeling,” and that “becoming a musician certainly involves the cultivation of distinctive skills, understandings, and dispositions” (p. 9). However, she notes that many music teachers feel justifiable hesitation about participating in multidisciplinary projects as they felt the approach often “diminished music’s role in the curriculum, trivialized its importance, or used music in subservient ways toward irrelevant ends” (p. 15). Barrett echoes Page’s concern that in multidisciplinary schemes, “the carousel never stops long enough” for students to gain a substantive understanding of each subject area, and that consequently, superficial exposure is more likely than deep understanding (p. 9).

While the multi-brick multidisciplinary approach may seem like a radical departure from monodisciplinary dwelling within a single brick, it is also part of a further-reaching continuum of integrated teaching and learning. Barrett's second metaphor of a paint-splattered atelier floor comes to mind, as it suggests the idea of interdisciplinarity. On the floor of the bricoleur's workshop or studio, blobs of paints of different colors may be understood as a kind of melting pot or "mash-up" of discreet yet intermingled disciplinary drips. The splatters are amorphous and of variable sizes. In some places, the floor is covered with many years of layers of splatters; some old and faded, and others fresh and brightly hued. By and large, the colors remain discreet, but there are still some places where they run together to create gradients. Importantly, according to the definition of interdisciplinary education advanced by the Association of American Colleges and Universities, the purpose of the paint must be to "advance understanding beyond what can be achieved by any single discipline alone" (AAC&U, 2024). That is, the whole must be greater than the sum of its parts. "Interdisciplinary projects 'work' when $1 + 1 > 2$," as Barrett quotes the education scholar Claire McCoy (p. 15). To achieve the promising results of this equation, Barrett identifies several criteria that may be used to judge the quality of an interdisciplinary project. These include *disciplinary validity*, which Barrett describes as "the goodness of fit with the content, processes, and dispositions of music study and the practices of its members; *interdisciplinary validity*, the goodness of fit with other disciplines; *mutuality*, the shared benefits of combining the disciplines; and *generativity* or "the way that meanings enable students to create, analyze, produce, evaluate, and pursue additional knowledge, understanding, and experience" (p. 15). Barrett adds that it is through generativity that curriculum can be judged as emancipatory and *releases the imagination*, as Maxine Greene (1995) put it.

Barrett's third metaphorical image of a living cell circulating in the bloodstream of a living being is taken to represent *transdisciplinarity*. The image connotes a complex ecology in which the genetic materials of familiar and foreign knowledge are both retained and transmitted through a porous membrane of a cell, a process that is vital for the survival of the cell and, in turn, for the body that it occupies. As it courses through a body's vascular system, it both transforms and is transformed by other living cells as it exchanges and retains ways of knowing through its porous membrane. Barrett's image captures the dynamic and complex interplay of knowledge possible in interdisciplinary teaching and learning and emphasizes the ambiguity of boundary membranes that double as portals and the paradox that the integrity of a cell depends on constant exchange with the otherness surrounding it. I will discuss the central role of transdisciplinary in more detail later in this chapter, but first, I will take up the task of exploring the dialogue on *technology* as it has been of interest and concern in the field of music education.

Critical Perspectives of Technology

As we began to explore in the previous chapter, the relationship between the musician and technology is historically fertile and generative. However, as some scholars observe, the role of technology in music education is still inadequately interrogated to the extent that it has become "disabling for the profession and for music students" (Lines 2013). As an early voice in the critical discourse on technology, German philosopher Martin Heidegger's thinking is an apt reference point for growing scholarship on the essential question of what is and isn't technology, as Mantie (2017) establishes. While Heidegger's philosophy of technology has been contested and criticized in the larger arena of contemporary philosophy, it is still of great value not only to the discourse on technology, but to musicians and music educators in particular, who may benefit from a critical examination of the tools they use to teach (p. 17). In his essay *The Question*

Concerning Technology (1954/1977), Heidegger builds on the Greek distinction between technology, or *techne*, the supporting crafts that support the process of making art as “instrumental” (p. 5) tools, and art itself, or *poiesis*, a kind of “bringing forth,” or what he describes as “the bursting of a blossom into bloom, in itself,” (p. 10), suggesting the presence of fragrance and other elusive and ineffable aesthetic qualities. Because the skills and crafts (*techne*) that support the artistic process of “bringing forth” (*poiesis*) require know-how, understanding, and artistic decision-making, Heidegger defines *techne* as a way of knowing (*episteme*). Hence, the most significant aspect of technology does not lie in its means of production but rather in its capacity to “bring forth” and “reveal” truth, a blossoming. In a modern context, Heidegger views technology as more than machines or tools. He sees them foremost as a means of “revealing” (p. 13) the world and shaping human existence. As such, technology wields the power to order and “enframe” (*gestell*) our understanding of the world, but often as a potential resource to be exploited and controlled. It has only been in recent decades that the concept of mining has shifted from digging out minerals from the earth to a new meaning of distilling drops of data from virtual clouds. In Heidegger’s view, modern technology is revealed to possess the darker tendency to reduce nature — even human nature — to a market commodity or *standing reserve* (*Bestand*) (p. 17) driven by a capitalistic desire for accumulation, exploitation and profit, now on full view as multinational high-tech corporations bring about new “wicked problems” of poverty, equality, wellbeing, and sustainability (Burnard, 2014; Klein, 2006) as they expand and consume, and bring us along for the ride as consumers.

What might a capitalist critique of technology like Heidegger’s mean in the context of the music technology classroom? What would be the standing reserve of natural resources that might be exploited for profit, and how might human perspectives be enframed by the production and

consumption of the aesthetic products of music technology? It might be argued that the concept of property has also shifted meaning to include the production of “intellectual property” as a version of music education. Giroux (2014) points out that neoliberalism promotes the marketization of education, favoring corporate interests of profit over educational values and social justice, begging the old chicken-and-egg question of whether technology is merely supporting music education or driving it many music tech classrooms, or, more precisely, whether technology-based music education is promoting the production of new artistic ideas through technology or the consumption of new technologies through the exploitation of the arts.

Heidegger’s critique of technology may itself be an instance of *poiesis*, as it has “brought forth” a rich cross-disciplinary critical discourse on technology that has spanned across the arts and philosophy. But as Roger Mantie (2017) observes, Heidegger is hardly alone in his concerns about the relationship between humans and technology. The dystopian fantasy of technological determinism and dehumanization finds its roots in the Industrial Revolution of the late 19th and early 20th centuries. Films such as Fritz Lang’s *Metropolis* (1927) and Charlie Chaplin’s *Modern Times* (1936) helped embed a playful yet pervasive perspective of technology into the zeitgeist of the time. A few decades later, in the 1940s, a more serious philosophical discourse on technology, art, and culture came from thinkers of the Frankfurt School (e.g., Adorno, Benjamin, Horkheimer, and Marcuse) who grounded their thinking in Karl Marx’s concept of alienation (1996) and extended their critique to the role of technology in the art and culture of their time. Essays such as Benjamin’s *The Work of Art in the Age of Mechanical Reproduction* (1936), Adorno’s *On Jazz* (1936), and Sousa’s *The Menace of Mechanical Music* (1906) warn of the potentially dehumanizing forces of technology as it is used in the production of music and art.

The prescient critical perspectives of Benjamin, Adorno, and Sousa have endured in the near century since they wrote. One might imagine that their critical perspectives regarding the intersection of music technology and education would be rich if they were privy to our times. Adorno (2001), who warned of the deleterious effect of the “culture industry,” might see music technology as an agent of commodification and standardization of music, potentially bringing students further into the cave while stifling creativity and genuine artistic expression. Similarly, Benjamin (1969) might have cautioned against the potential dangers of technologically mediated music production and consumption. However, since the first critical theories warning of the dangers of technology appeared in the mid-20th century, other voices within the field of education have seen its emancipatory potential. In his vision for “constructivism,” Seymour Papert argues that technology has the potential to “give learners a voice that they may not have had before. It can provide a bridge over barriers that exist in the classroom.” Foreshadowing the experiences of the participants we will meet in the coming chapters, Papert also writes that technology “can provide a connection to the world outside of school. And it can create opportunities for learning that students may not have had access to otherwise” (1993). Even with the daunting fury of its rapid development in the 21st Century, technology still promises to build bridges to the world outside the music classroom. As we will see in the literature reviewed in the next section, if the modes of music production and consumption are almost exclusively technologically mediated in today’s world, technology in the music classroom is vital if a connection is to be made.

The Emerging Role of Music Technology

Over the last two decades, the field of music technology has emerged as a new and significant presence in the discourse on music education and as a viable and integral component

of a student's musical exploration (Baur, 2014; Brown, 2013; Caravello, 2017). The technological revolution of the digital age has brought about the creation of new generations of musical instruments and related tools for music making, which are challenging traditional definitions of what a musical instrument is, and thereby transforming the aesthetics of music and, therefore, the demands and needs of music education itself (Brown, 2013; Cremata & Powell, 2017; Dean, 2009). Consequently, these new technologies have found their way into music education programs in schools, and their presence has been magnified and reinforced in the music classroom by the flowing tide of technology in the classroom and the influences of popular culture (Manzo, 2015).

It is in the special environment and learning ecosystem of the music technology classroom that students and teachers alike are invited to reach across disciplinary boundaries into what may be considered the seemingly unrelated domains of the Sciences, Technology, Engineering, and Mathematics (or STEM subjects, as they have become known). Hence, the emerging field of music technology may be considered a STEM-rich discipline. By definition, the name *music technology* necessarily includes the "T" in STEM for technology, but perhaps less obviously, the remaining letters in the acronym are equally essential to the study and practice of the field. The "S" is present for the requisite understanding of the physics of acoustics needed to gain full access to the new generation of instruments and tools, as well as the inclusion of biological and behavioral sciences' accounts of the perception of music as it relates to the tools and techniques of music production; the "E" stands for audio engineering including electronics, digital signal flow theory and the diverse traditional engineering skills required for new instrument design and creation; finally, the "M" that serves as the fundamental language of all the other above-mentioned sciences as well as the classical foundation and bedrock for harmonic

relationships in music. Considering the depth, extent, and possibility for such interdisciplinary connections and their considerable potential to enrich the process of music making, some music educators are recognizing the potential for bridging the gap between an approach to the arts and sciences through music technology curricula (Brown, 2013; Frankel, 2012; Gregorio et al., 2010).

As a nascent interdisciplinary area within music education and overlapping with the sciences and technology, there is much work to be done to understand the new ecologies of learning that arise from the music technology classroom. As Cremata (2010) states,

The use of technology for music instruction needs specific and pointed direction regarding its relevance to the music education community coupled with serious introspection to begin a free exchange of ideas among its educators as it continues to evolve from its current stage of early development.

The epistemological territory of music technology and, hence, technology-based music education is new, ever-shifting, and therefore ill-defined. As Boehm (2007) writes,

This term, “music technology” has perceptually different and shifting meanings, depending on the context in which it is used. The multiplicity of what exactly is understood by “music technology” is an indication of the fragmentation of communities at large and their emerging cultural boundaries, be it sound engineering, electro-acoustic music, music informatics, or music education technology. It also represents a fragmentation of our formerly holistically humanistic concept of knowledge and the delivery of knowledge. (p. 7)

In other words, the old “holistically humanistic” conception of knowledge content in music education has been split apart through what Bernard et al. (2021) identify as *diffraction* of a

phenomenon which means “to break apart in different directions” (Barad, 2014). Boehm argues that music technology has been diffracted into a multiplicity of variations on the theme, resulting in different concepts of knowledge, and hence the need for new delivery methods in the classroom. According to Braidotti (2019), the analysis (or taking apart of) disciplinary diffraction is not a step toward chaos, but rather a step toward justice as it opposes the injustices inflicted by humanism (p. 39). Such epistemological and environmental fragmentation and diffraction have created a critical issue within music education as a whole. Cremata and Powell (2017) assert that,

Change is on the horizon and through digital, de-territorialized e-collaboration, a whole new musical world is before us. The question then is how will the music education profession react? Will it embrace this new digital venue and shape it to maximize student-centered learning through constructivist learning models or will it resist and/or dismiss this new opportunity for music learning? Only time will tell. (p. 313)

Cremata and Powell’s dramatic statement that “a whole new musical world is before us” has become increasingly palpable as artificial intelligence has infiltrated the classroom and music education has needed to shift a hybrid instruction in the wake of the COVID-19 pandemic (Tobias & Miles, 2021). However, the question of whether music education will adapt to more of a student-centered, constructivist approach is still up for debate. Some scholars lament that progress has been slow, as it has been “hindered by institutional inertia, resistance to change, and competing priorities” (Elliott, 2015). A more dire observation is that despite the rhetoric of reform, music programs in schools “continue to resist meaningful change, clinging to outdated pedagogical practices that prioritize conformity, compliance, and performance outcomes over student-centered, constructivist learning” (Abril & Gault, 2010). More recently, however, scholars have observed a shift toward more student-centered models in which students more

actively engage with music through inquiry-based learning and creative expression through the increased use of technology in the music classroom (Bauer, 2014; Himondes, 2012).

Additionally, the digital tools of music production are “unprecedented opportunities for creativity, collaboration, and exploration in music making,” as Richard Colwell (2002) argues, predicting that “In the future, music education will be increasingly technology-oriented. The integration of technology into music education curricula is crucial for preparing students for a musical landscape that is continually evolving” (p. 15).

In this new musical landscape, and the diffracted and “de-territorialized” new world of music education described by Cremata and Powell, new methods of knowledge production and delivery are called for together, as are novel and transcendent disciplinary approaches.

Transdisciplinarity

The skunk is currently the main exhibit in the metaphorical menagerie of this dissertation, but we shall soon be adding elephants, lions, lambs, oxen, bears, tigers, and even a cyclops to the list. As we will see in this chapter, transdisciplinary thinking is metaphorical, allegorical, and poetic thinking. In this dissertation, I hope to convey its meaning and illustrate the power of language and reasoning by employing it. In the spirit of transdisciplinarity, I now return to the original elemental images of earth, air, water, and fire, beginning with earth.

Of Territory

On Planet Earth, relationships and territorial boundaries are often defined by power and politics. Likewise, relationships between disciplinary boundaries are also defined by power and politics when grounded in solid form. The old real-estate joke asks, “What three factors determine the price of land?” The answer is “1) location, 2) location, and 3) location.” The same

may be said for how knowledge is *situated*, especially in high-stakes neighborhoods such as the sciences. According to epiSTEAMologist Laura Colucci-Gray (2020),

new readings of science and technology are emphasizing the embodied and situated nature of knowledge, with great attention to disciplinary integration, multi-modal communication, and dialogue amongst different perspectives. (p. 105)

As disciplinary knowledge is increasingly understood through the relational ontology of how it is situated and embodied, new ways of knowing and thinking about knowledge are called for. As the complexity of Earth's "wicked problems" of poverty, equality, sustainability, and others (Barnett, 2012) defy conventional, reductionist approaches, the sciences and the arts increasingly find themselves "*at the intersection between mind and nature*, and thus integral to the ways in which as individuals we 'attend to' the world" (Colucci-Gray, 2020) [italics original]. Creating new earth, the arts and sciences rise together to find new and transcendent solutions to "wicked problems" and as Colucci-Gray posits, "[t]his position foregrounds 'aesthetic perception' - the 'A' in STEAM - as a prime form of knowing" (p. 105). As the sciences and arts change their physical state to become an amorphous vapor like STEAM, they may find ways to transcend the earthly boundaries that once contained them.

Rhizomatic Roots

In keeping with the approach of "grounding" the discourse on STEAM in environmental metaphors of epiSTEAMology, Deleuze and Guattari (1987) offer a transdisciplinary image: They theorize knowledge as a subterranean network of connected roots, specifically, roots of a tuber plant (or in biology, a "rhizome") such as ginger, which spread out in an unwieldy network of clusters and nodes. As Burnard et al. (2021) describe, "It throws us off onto another path, allowing us to break with old habits and form new ones, making the familiar unfamiliar, and

offering the space to make the unfamiliar familiar.” Burnard et al. argue that a rhizomatic conception of knowledge may be used to subvert and unearth conventional conceptions of epistemological territory. The invisible key to Kafka’s gate has always been under the mat and lying deep beneath it and in a different dimension, Kafka’s transdisciplinary allegory of the gate and the gatekeeper is itself a key to freedom for his readers.

Thinking Poetically

The poetic image of a rhizome serves as an example of *transdisciplinary* thinking and problem-solving. Russell et al. (2008) describe transdisciplinary as “a practice that transgresses and transcends disciplinary boundaries ... and seems to have the most potential to respond to new demands and imperatives.” As its primary method, the transdisciplinary approach seeks to decouple the specific and technical language of a discipline from its original context in order to open up new possibilities for *viewing and experiencing* the same phenomenon (Burnard et al., 2021). In their original vision, Deleuze and Guattari (1987) explain that untethering language from discipline allows “new points of conjunction to be found.” The act of relinquishing the power of a ‘sign’ (the crystallization of lived, experiential meaning into a given word) is equivalent to the act of de-territorialization (Burnard et al., 2021). Against this theoretical background, my own understanding of transdisciplinary (especially as it relates to STEAM) does involve the “appropriation” of language (although that word has taken on a negative, colonialist meaning). But more plainly, being transdisciplinary may simply require thinking poetically. It takes a radical and creative act of *poiesis* to loosen the tightly tethered meanings of technical words to signify shared transdisciplinary meaning.

Burnard et al. (2021) highlight the importance of transdisciplinary thinking and metaphorical meaning-making as a method of uprooting and deterritorializing disciplines. They

explain that disciplinary thinking is “characterized by specific core metaphors and concepts,” whereas transdisciplinary thinking “seeks to decouple the specific language of a discipline from its original context, in order to open up new possibilities...” As an example, I offer the metaphorical language of earth and atmosphere used in this paper to discuss the epiSTEAMological concerns of skunk-like music educators who occupy specialized ecoclines that lie between “fields.” Another illustration of the transdisciplinary leveraging of metaphorical language may be my undergraduate mathematics professor’s metaphorical description of my digital sampling synthesizer as a “Ptolemy machine.” Mr. Simpson’s poetic re-naming decouples the meaning of Ptolemy’s elegant phenomenological account of the heavens to reveal the fact that a digital sampler is also such a “machine” that can reliably reproduce the phenomena of musical sound in a way that is unconcerned and detached from the strings, mallets, and columns of air that usually cause them.

Polymaths

Aside from his knack for transdisciplinary thinking, Mr. Simpson was also a historian of mathematics and science who wrote on Maxwell’s Electromagnetic field theory (Simpson, 1966) and could also read Euclid (and Ptolemy) in the original Greek. By most definitions, Mr. Simpson would qualify as a *polymath*. The term derives from the Greek πολυμαθής (*polymaths*), meaning a person who knows a lot about many different subjects (dictionary.cambridge.org, 2024). A Creative polymath is defined as one who has “mastered multiple disciplines sufficiently to synthesize their broad learning so as to raise new problems and produce novel solutions” (Root-Bernstein & Root-Bernstein, 2019). In our own field, Peter Webster argues that scholarship in music teaching and learning is “almost inherently polymathic” as it requires expertise in multiple disciplinary areas. By *polymath*, Webster (2016) clarifies that he means “an

individual [who] feels deeply about understanding another field personally and works hard at achieving a deep and lasting level of understanding about it and actively considers this “other field” in relation to their own.” For Webster, depth and ownership are key defining factors of the term, pointing out that multi-disciplinary teaching, in which teachers from different disciplines “own” their share of the lesson. This is not the same as polymathic interdisciplinary teaching, in which teachers delve deeply and explore another field as a learner.

Transdisciplinary Tools

In Chapter I, I characterize STEAM as an ineffable and insubstantial cloud that is difficult to define or understand. Here, I build on Janet Barrett’s use of metaphors and Pamela Burnard’s call for transdisciplinary thinking in education to propose a thought experiment that might provide a more valuable and meaningful way of thinking about STEAM in this study. If we reimagine disciplinary *areas* and *fields* as disciplinary *spaces*, knowledge may be conceived as existing in multiple dimensions rather than merely in two. Clouds of STEAM form and intersect with more complexity and detail than a printed Venn diagram’s flat, two-dimensional ovoids. In the multidimensional space of a *Cloud Venn* (for lack of a better term), we might add a trivium of sciences of physics, biology, and chemistry around the “S” for science; the mathematical quadrivium of arithmetic, geometry, algebra, and calculus orbiting the “M” of mathematics; and dozens of hovering sub-specialties emanating from the “E” of engineering — including software engineering and audio engineering. In the metaphorical space of a *Cloud Venn*, amorphous clouds may signify a multitude of dimensions as they have an improved capacity to represent dynamic inter- and transdisciplinary understandings and practice. The color, shading, and texture of a cloud may signify differentiating aspects of understanding, including the magnitude and quality of knowledge. We may add a fourth dimension of time to

this conceptual model to account for the drifting changes of interest and focus as they ebb and flow; or to capture the burgeoning expansion of learning. Additional axes of meaning may include the electrical charges of affinity and repulsion as they might signify the implicit political charges of clouds of knowledge and interest as they interact and intersect with the world.

Boundary Objects

Borrowing from the field of organizational theory, a more powerful instance of a transdisciplinary tool (and one that I will return to and further explicate later in this dissertation) is the knowledge construct of a *Boundary Object*. Sociologists Griesemer and Star (1989) introduced the concept in the context of a study of collaboration between amateurs and professionals in a museum setting. They describe a *boundary object* as a knowledge-practice construct that is “both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain common identity across sites” (p. 387). Education researchers Akkerman and Baker add that boundary objects may be “interpreted differently by different communities, yet...maintain a shared meaning across these communities” (2011), and organizational psychologist Carlile notes that boundary objects are “information rich” and “enable efficient communication and coordination across domain boundaries” (p. 442). From the field of music, Duguid (2012) expands the definition to communities of practice, arguing that boundary objects can “mediate the relationships between different communities of practice, enabling collaboration and communication across disciplinary boundaries” (p. 241). Therefore, it might be argued that at the meta-level, boundary objects may be considered boundary objects in and of themselves, as they lie at disciplinary intersections where they serve as portals for navigating collaboration and knowledge sharing between disciplines. It has also been argued that as human constructs, boundary objects are conceived and established with bias.

Therefore, they cannot be viewed as politically neutral or consensual and are always, to some degree, an expression of hegemony (Huvila, 2011). Granted the possible snares of boundary objects and, for that matter, any form of representation or language, according to Foucault (1972), boundary objects are helpful tools for making sense of diffracted phenomena, such as STEAM (Burnard et al., 2021).

I will revisit and further explore the concept of the *boundary object* in Chapter VI, as it will be helpful as a way of making sense of STEAM. Considering the power of transdisciplinary thinking to bring disparate ways of knowing together, I will examine the literature on epistemological unity and division.

“Thinking the World Together, Thinking the World Apart”

The 13th-century Persian polymath and mystic Rumi teaches through his poetry that “knowledge is one” (Barks, 2004). American philosopher of education Parker Palmer (1988) echoes Rumi’s unifying insight when he asks what it means to “think the world together.” On the other side of the logical equation is the possibility that humans also “think the world apart.” While the *putting together* of synthesis and the *taking apart* of analysis are opposite processes, Palmer discusses the dialectical unity of the two complementary ways of thinking and how they work together to help elucidate complexities in the field of education. Thinking the world together may promote collaboration, empathy, and understanding in students, whereas thinking the world apart may invite critical reflection, reflection, and discernment.

In human intellectual history, the world has been *thought together* across traditions and multiple heritages (Frankopan, 2015). Among myriad examples of integrated systems of knowing is the Yogic tradition in India, which seeks to unify the individual soul with the universal spirit (Feuerstein, 2011). In addition, Indian educational philosophy has traditionally

sought a holistic, integrated approach to disciplines to foster a comprehensive understanding of the world (Dhawan, 2013). In Chinese philosophies of education, a holistic approach to knowledge is based on the Confucian, Daoist, and Buddhist values of harmony, balance, and interconnectedness (Ames & Rosemont, 1998; Ivanhoe & Van Norden, 2005; Katsura & Sidertis, 2013). Likewise, many African traditions have promoted holistic, integrated ways of knowing rooted in indigenous knowledge systems and grounded in experiential learning (Nsamang, 2013), and similarly, Indigenous educational traditions have emphasized the “interconnectedness of all knowledge” while fostering “interdisciplinary learning grounded in cultural traditions and values” (Battiste, 2013).

The Western tradition of education has also embraced the unity of knowledge, most notably, through the establishment of the *university*. The word implies the unity of knowledge as “it derives from the Latin word ‘universitas,’ meaning a community or corporations of scholars engaged in higher education and research” (Ruegg, 2004). However, five centuries before the first university was established in Bologna in 1088 (Newman, 1852), the Roman statesman and philosopher Boethius (c.524/2008) proposed a unity of subject areas in his book *The Consolation of Philosophy*, writing “The liberal arts are the foundation of all learning, providing the tools and methods necessary for intellectual inquiry and understanding.” As I alluded to in Chapter I, Boethius grouped the three areas of knowledge of grammar, logic, and rhetoric into a *trivium*, and the four disciplines of arithmetic, geometry, music, and astronomy into a *quadrivium* “which together provide a deeper understanding of mathematical principles and the order of the cosmos” (p. xx). The grouping of music together with arithmetic, geometry, and astronomy may come as a surprise to contemporary sensibilities as it is usually categorized as an *art*, but Boethius regarded music as a “science of harmonics” (p. xx), implying that its place in the quadrivium

complements the other disciplines by providing insights into the mathematical foundations of harmony and proportion, thus contributing to a deeper understanding of the order of the cosmos. Boethius's writings and his conception of the liberal arts provided a framework for education in medieval Europe and had a profound influence on the content of university curricula and the intellectual culture of the time (Ruegg, 2004).

Music as a Liberal Art

The music technology laboratory is arguably where we would find the likes of Pythagoras, DaVinci, Kepler, Wong Wei, and others if they could travel through time (and had to go to school). Bach would arguably make it his home as well. Before the schism of the sciences and the arts occurred in the 20th century, which the scholar C. P. Snow (1959) notably described as a growing divide between "two cultures," it was not unusual for thinkers and writers to freely traverse what we now may perceive as strict disciplinary boundaries. Among them were da Vinci, who famously embodied the integration of arts and sciences in his work; Goethe, who emphasized the unity of knowledge; and Islamic Golden Age scholars such as Ibn Sina (Avicenna) and al-Hytham (Alhazen), whose polymathic work wove together philosophy, medicine, mathematics, and the arts (Huff, 2003). Again, if these thinkers could travel through time, it might surprise them to find knowledge so divided.

When we return music to its place in Boethius's constellation of the seven liberal arts, we find it grouped with arithmetic, geometry, and astronomy. From our contemporary perspective, it may be difficult to understand the logic of this arcane grouping. Nonetheless, the rationale for including music as a necessarily *liberal* art (from the Latin *liber*, meaning "free") beckons us to consider the emancipatory power of music education. Can music education still be liberative in a real way in the world? Can we reasonably continue to consider it as a liberal art? The modern

answer may be a firm “no.” Some scholars in the field of music education argue that music’s place in the liberal arts has eroded in favor of an emphasis on STEM subject areas (Smith, 2019), marginalized because it is not seen as a form of critical education that encourages intellectual growth (Hatcher, 2017), and seen as an exclusionary field that requires specific expertise (Roberts, 2015). Classical (and arguably quainter) arguments for music as a liberal art argue that the elevated beauty of great music can convey essential aspects of the human experience beyond words and that it shares a profound connection with mathematics as an aural expression of arithmetic ratio and proportion and geometrical space. Music may also enrich students’ lives by cultivating good taste and have either noble or deleterious moral effects on the souls of citizens, as Plato and Aristotle theorized (Kalkavage, 2012). More contemporary arguments that position music as essential to critical, emancipatory education argue that music education promotes critical thinking, creativity, and social responsibility in students. As Allsup writes, “Music educators who embrace critical pedagogy see their task as one of liberation, creating conditions whereby students develop critical consciousness about the world, their social realities, and their capacity to participate in their own destinies” (2013, p. 61). Beyond these arguments, I would add that when music is studied as a *liberal art* (for which the *poiesis* and aesthetic criticality are in focus) rather than a *fine art* (which focuses on the *techne* of musicianship), music has the power to encourage and inspire abstract, relational, transdisciplinary thinking. In my experience, it is in the process of finding openings for poietic and philosophical musical thinking that music may be taught as a liberal or liberative art.

A strong link exists between interdisciplinary and liberal arts education, as a multidisciplinary approach to learning “challenges students to think critically by exposing them to diverse perspectives and encouraging them to question disciplinary boundaries” (Klein, 1990),

“promotes empathy by facilitating engagement with diverse perspectives” (Repko, 2014), and empowers learners to address “systemic inequalities and advocate for social change by providing them with the tools and knowledge to confront complex societal challenges” (Newell, 2002). Similarly, contemporary liberal education aims to “free minds.” According to the American Association of University Professors, “Free minds are flexible minds, trained to recognize that many areas of inquiry are interconnected, and many disciplinary boundaries are porous” (Scheuer, 2015). The free, educated mind is therefore not only flexible but also “trained to recognize” the interconnected nature of knowledge. Janet Barrett’s image of the human cell membrane comes to mind, signifying permeable exchange across boundaries. However, the horizontal, relational thinking that is the aim of interdisciplinary education (and the liberal arts) does not exclude arborescent or categorical and siloed ways of knowing. As Scheuer argues, “Categories are instrumental and practical: our tools, not our masters. Using them without obscuring the underlying connections is a hallmark of higher-level thinking” (2015). In Deleuzian terms, liberal education may promote a quasi-arborescent approach that shifts modality between categorical and relational, rhizomatic thinking as appropriate. The judgment required to know *how*, *when*, and *why* to shift between multiple modes of thinking and knowing is of the essence of higher-order thought.

I now turn away from the theme of unity in the original conception of a university to explore the literature on how the classical quadrivium was broken apart under the domination of the sciences, which, in turn, reformed as a new quadrivium of STEM in the cauldron of the 20th century.

The Seeds of STEM

On October 4th, 1957, the Soviet Union launched Sputnik 1, the first artificial satellite to orbit the earth—an event that would trigger the beginning of the “Space Race,” a component of the Cold War between the USSR and The United States. Two years later, in September of 1959, The National Academy of Sciences called for an exploratory conference (of mostly men) to investigate how science education might be improved in the United States. An array of educators and scholars from many disciplines, including chemists, physicists, engineers, mathematicians, psychologists, historians, and even experts in audio-visual production and filmmaking, convened in Woods Hole, Massachusetts to seek ways to “facilitate a closer relation between scientists in universities and those charged with teaching in schools” (Bruner, 1962, p. xix). The starting point of the investigation was the recognition of a stark discontinuity between what students were learning in schools and what professional scientists actually did and how they thought, formulated questions, and approached problems in their various fields. Across the nation, a desire was emerging within “various learned societies” to seek “ways of establishing contact between their leading scholars and educators in the schools” (Bruner, p. xx). The conference chairman was Jerome S. Bruner, a psychologist known for his foundational contributions to the field of cognitive psychology. Bruner produced a report of the findings of the conference, later published as a short book entitled *The Processes of Education*—a document that would eventually become thought of by many as part of the canon of American educational thought.

In the report, Bruner distinguishes between academic disciplines or “subjects” by their various ends and the methods of inquiry that lead them toward those ends as “fields of inquiry” and suggests that individual disciplines possess their own unique structural characteristics. Math and science, for example, are described structurally as “highly formalized” subject areas, in

contrast to the disciplinary structure of history, which Bruner characterizes as being a “more humanistic field” (p. xx). Borrowing from the work of Bärbel Inhelder and the Geneva School, Bruner espouses the idea that “basic notions in these fields are accessible to children seven to ten years of age, provided they are divorced from their mathematical expression and studied through materials the child can handle himself.” It is from this notion that Bruner proposes a “spiral” theory of curriculum in which fundamental concepts are presented simply in early stages and re-visited, developed and refined at later stages of cognitive development (p. 13).

Bruner describes a theory of learning that surmises two modes of transfer, the first involving the transfer of content knowledge and facts, and a second kind of “non-specific transfer,” involving the familiarization of the student with the structure and continuity of knowledge content of the subject. Bruner tells us that “To understand something as a specific instance of a more general case—which is what understanding a more fundamental principle or structure means—is to have learned not only a specific thing, but also a model for understanding other things like it that one may encounter” (Bruner, p. 25). Therefore, continuity of learning in the second form of transfer depends on mastery of the subject’s structure. It is from this second form of transfer that the most effective “episodes of learning” occur within contexts that cultivate a student’s interest in a subject by means of the excitement of discovery (p. 18). *Discovery learning* becomes possible when disciplinary content is perceived by the student as being “worth learning” because of its continuity with their understanding of the structure of a given discipline and “discovered” or “invented” by the student by making successful connections and inferences within that structure (p. 31). Bruner observed that at the time, “much has been written on the role of reward and punishment in learning, but very little indeed on the role of intellectual curiosity and the lure of discovery” (p. 19). Bruner adds that it is through “a sense of excitement about

discovery— discovery of regularities of previously unrecognized relations and similarities between ideas” that learning is reinforced when a learner may experience “a resulting sense of self-confidence in one’s abilities” (p. 20).

In keeping with the contrasts Bruner makes between the binaries of specific and non-specific transfer, the relative value of content knowledge and structure, passive and active learning, Bruner advances his argument with a contrast between two modes of cognition, which he describes as “analytic” and “intuitive” thinking. Bruner defines intuitive thinking as “the act of grasping the meaning, significance, or structure of a problem or situation without explicit reliance on the analytic apparatus” (p. 57). For Bruner, transfer via intuitive thinking is “at the heart of the educational process” (p. 17). Intuitive thinking and discovery learning make up the foundation for the more cognitively sophisticated form of thinking and learning practiced by professional scientists, and “in the judgment of many physicists, at least, there is too little attention given to the development of intuitive understanding [in schools]. Indeed, some have suggested that improving the use of intuitive thinking by teachers is as much a problem as improving its use by students” (p. 57).

Although Bruner enumerates the benefits for education that may have come from the Woods Hole Conference in 1959, the conference itself was spurred by war. Critical voices in the 20th and 21st centuries underscore the ways in which sustained, global military conflict serves the interests of corporations and wealthy elites, as it stimulates economic growth and technological innovation (Schumpeter, 1951). As a strange fruit of the horrors of war, education has collaterally benefitted from innovations and advancements as a “spillover effect” (Kaiser, 2004). With these causalities in mind, I will now explore a case in which a multinational

corporation benefitted from Bruner's insights as it formulated a new vision of STEAM to serve the purpose of innovation.

Factory STEAM

Nearly a generation after the Woods Hole Conference, a voice from the scientific and industrial world made a contribution to educational psychology that, as Breslow (2006) writes, "was in some ways, so simple and commonsensical that I wonder why it took so long to be articulated." Bruner's insights resonated equally in the corporate world: Bruner's critique of the sciences in education might be similarly applied to stimulate innovation in the technology sector. A noteworthy and decidedly interdisciplinary response to Bruner's critique came from the chief scientist at Xerox Corporation. From his position as a corporate stakeholder in education, John Seeley Brown advanced a "situated learning theory," which drew heavily from the constructivist theories of Bruner. As a starting point, Brown (2000) considers Bruner's distinction between the explicit and tacit knowledge of a profession. Brown posited that the "deep experience" that distinguishes professional scientists and students of science is best garnered through engagement in a scientific community of practice.

Being a physicist involves a lot more than getting all of the answers right at the end of the chapter. To be a physicist, we must also learn the practices of the field, the tacit knowledge of the community of physicists that has to do with things like what constitutes an "interesting" question, what proof might be "good enough" or even "elegant," the rich interplay between facts and theory-formation and so on... Learning to be a physicist (as opposed to learning about physics) requires... looking at the deep interplay between the tacit and the explicit. That's where deep expertise lies. (p. 15)

Brown (2000) argues that new and rapidly emerging technologies, along with their concomitant social and learning media, have brought about new learning environments with their own “learning ecologies” and resulting communities of practice. In order to understand and leverage the potential for such learning ecologies to bring about innovation, invention, and new ways of understanding and knowing, Brown offers four dimensions in which digital thinking and learning are shifting away from traditional modalities.

The first dimensional shift Brown describes concerns a movement beyond text- and even image-based literacies. Of more importance than literacies involving text and image, the ability to navigate through complex systems of information or “information navigation” becomes the essential literacy for the digital age. Hence, Brown predicts that “Navigation may well be the main form of literacy of the 21st century” (p. 14). The concept of information navigation as a literacy has since been expanded, refined, and elucidated in four sub-areas: internet searching, hypertext navigation, knowledge assembly, and content evaluation (Gilster, 2006).

The next dimension and shift that Brown describes has to do with learning. Non-linear, discovery-based learning has emerged as a viable alternative to “formal learning in an authority-based, lecture-oriented school” (Brown, p. 14). However, Brown argues that even the digitally infused version of what Bruner first described as Discovery-based learning combined with the new literacy of information navigation does not constitute a dramatic “shift” in cognition. A more subtle shift in yet a third dimension pertaining to forms of reasoning accounts for the most remarkable change Brown observed. “Classically, reasoning has been concerned with the deductive and abstract. But our observation of kids working with digital media suggests *bricolage* to us more than abstract logic” (p. 14).

I now revisit the concept of *bricolage* introduced by French anthropologist Claude Lévi-Strauss, who used the term to describe patterns in mythological thought, specifically, the skill of using whatever is at hand and repurposing materials to create something new. To recap, Lévi-Strauss (1966) contrasts the bricoleur with the engineer. The *bricoleur* is a “savage mind” and works with her hands in devious and innovative ways, in contrast and opposition to the “engineer,” who is a “scientific mind” who approaches problem-solving in a decidedly methodologic and rational fashion. Brown, who is nominally an “engineer” of the highest order, champions *bricolage* as problem-solving in the concrete, rather than the abstract. He defines *bricolage* as “having do to do with abilities to find something—an object, tool, document, a piece of code—and use it to build something you deem important.” Brown (2000) describes *bricolage* as a complex method of formulating judgment in the creative process. He asserts that “judgment is inherently critical to becoming an effective digital bricoleur.” In postmodern digital learning environments, Brown observes that “the sheer scope and variety of resources befuddles the non-digital adult. But [tech]-smart kids learn to become bricoleurs” (p. 14).

The fourth and final dimensional shift Brown describes is a movement toward playful and improvisatory action. In terms of myself, my own stubborn practice of not reading the manual or following the step-by-step tutorial, but rather mucking around instead until I figure it out. In this mode, “learning becomes situated in action; it is as much social as cognitive, it is concrete rather than abstract, and it becomes intertwined with judgment and exploration” (p. 14).

A generation before the digital revolution and the emergence of music technology as it now exists in music education, Jerome Bruner foresaw the implications of developing technologies and culture for education. He asserts that cognitive growth involves an interaction

between basic human capabilities and “culturally invented technologies that serve as amplifiers of these capabilities” (Bruner, 1962).

A First Puff of STEAM

A review of scholarly literature on STEAM would be incomplete without a historical account of STEAM and STEM. In Chapter I, I outlined key events and turning points that have shaped the cloud of STEAM as it has expanded and contracted. In this section, I will add to that story with a snapshot of one of the first educators to use the acronym. Although some accounts point to a graduate student named Georgette Yakman as the first to coin the acronym, the literature indicates that the portmanteau of STEAM had already been in use for some time in the educational community (Kimmel, Miller & Ratmansky, 2017). However, in a scholarly context, Yakman was among the first educators to advocate for the interdisciplinary concept of STEAM in a 2008 paper she wrote as a graduate student at Virginia Tech. Yakman introduced STEAM as an educational model for an integrated approach that transcends the boundaries of individual subjects and argues that STEAM aims to guide student inquiry, dialogue, and critical thinking (Yakman, 2008). In her paper, Yakman made playful use of alternative symbols to spell out the term as “ST Σ @M,” using the Greek letter sigma as the “E” for engineering. While it may not have been explicitly intended, sigma is used in mathematics to indicate a summation. In calculus, the summation symbol is written as an elongated “S,” where it denotes integration (adding up the areas of increasingly numerous and tiny rectangles to approximate the area underneath a curve). Yakman’s playful semiotic use of a mathematical sigma as a kind of synecdoche might be taken to imply integration in a larger curricular sense, and as we will see later in this dissertation, it is an example of transdisciplinary thinking that defines STEAM itself. Yakman’s light touch captures an inviting spirit of artful playfulness and freedom in the term, especially as it was

intended to challenge the more serious and severe face of STEM, as it had just marched out of the Cold War. However, what began in such a playful spirit has become more consequential and, therefore, complex as it has entered the educational zeitgeist (Aguilera & Ortiz-Revilla, 2021). In a private email exchange with Georgette Yakman in 2020, she expressed frustration at how controversial the STEAM had become since she created it and lamented how “territorial” STEAM had become in the following years (personal communication, November 2020). As it turned out, defining STEAM was then, and continues to be, a matter of territory.

Seeding the Cloud

In this chapter, I have only begun to expose the network of roots underlying the phenomenon of STEAM and music technology in education. Ground has been tilled around questions of the nature of disciplines and disciplinary configurations, critical perspectives of technology and the history of disciplinarity, emerging relational ways of knowing, and the forces in the world that brought about STEAM. As more literature is considered throughout this dissertation, our metaphorical cloud of STEAM should be adequately “seeded” to bring about “precipitation” in the early stages of synthesis of Chapter V. However, before rain can be made, I must first consider the natural phenomenon of STEAM as a cloud.

Rows and flows of angel hair
And ice cream castles in the air
And feather canyons everywhere
I've looked at clouds that way

But now they only block the sun
They rain and snow on everyone
So many things I would've done
But clouds got in my way

I've looked at clouds from both sides now
From up and down, and still somehow
It's cloud illusions, I recall
I really don't know clouds at all

– From “Both Sides Now” by Joni Mitchell

CHAPTER III: WAY OF KNOWING

Cloud Gazing

As we have seen in Chapter II, the cloud of STEAM education is elusive, and the search for groundings of earth, water, air, and fire in the form of tangible, measurable evidence or clear definitions has been inconclusive. If steam and STEAM are elementarily different from other phenomena in the garden of education, then so must be our way of thinking, seeing, and understanding in our method of inquiry. My hunch (as previously stated in Chapter I) is that the essence of STEAM education may not be so much a thing in-and-of itself, as much as it might lie more in the vapors of cognitive dispositions, interests, attitudes and lived social and political experiences of teachers and learners who inhabit disciplinary ecoclines. In other words, for us to know something about what STEAM is or might be, we might first look at the shared *lived experiences* (Creswell & Poth, 2018) of the people who claim to practice STEAM or its interdisciplinary equivalents. Beginning with these reasons, and for reasons which I will set out below, I believe an inquiry into how music teachers might understand and experience STEAM education is best served through a qualitative, phenomenological approach.

To achieve a holistic understanding of the phenomenon, we must first recall the purpose of this study, which was to explore a group of secondary music technology teachers' perceptions, practices, and attitudes toward STEAM education, their understanding of their own communities and ecologies of learning, their preparedness to teach in this emerging field, and their strategies for implementation of STEAM in the classroom. These phenomena were studied so that STEAM might be further enlarged and enriched within the discourse on music education, and in turn, be of potential value to a broader, more critical discourse concerning the influence of economic forces on knowledge, culture, and education. With the problem and purpose of this study in

mind, I will now set out the plan and method used to understand the phenomenon of STEAM education.

Sought Understandings

A single broad question emerged from a review of the related scholarly literature in the process of refining the goals of this study: I wanted to understand how technology-based music teachers understood, discovered, invented, practiced, and implemented a STEAM approach to music education. My objective was not so much to capture concrete instances of what a STEAM approach might be in different contexts as a case study would but was rather to understand something about why STEAM might be elusive, and what the common (yet often hidden) dispositions, understandings, assumptions, and biases are of music teachers who see themselves as practitioners of STEAM education.

Three additional research sub-questions branched out from the principal inquiry to address questions of *how* and *what*. They were:

1. How do the participants perceive their own community of practice (Lave & Wenger, 1991), and how do they make sense of their own ecology of learning specific to music technology as a discipline?
2. How and to what extent has their experience teaching, learning, and artistic practice led to engagement with STEM subjects? (In other words, just how “STEMMY” are they?) In what ways is their learning in STEM areas supported by their environment?
3. What are they doing? What do they consider the most STEAM-like elements or aspects of their teaching and learning practices to be, and how do they relate their praxis to the goals of music education? How do they relate to STEM education and STEM?

The research questions above call for accounts of *what* and *how* STEAM education is experienced and enacted by technology-based music educators. The product of phenomenological research is a composite description of the essence of *what* the participants experienced and *how* they experienced it (Moustakas, 1994). According to Yin (2003), *how* questions are essential to qualitative research because they can reveal the context of the studied phenomenon.

Why Qualitative?

As Yin (2015) explains, qualitative research is a useful tool for addressing *what* and *how* questions, as it “explicitly embraces” the social, institutional, cultural, and environmental contexts and conditions in which people’s lives take place (p. 9). In this study, establishing the cultural and environmental context of musical STEAM practitioners is essential to understanding how participants are situated in numerous ways: socially, culturally, institutionally, and epistemologically within and beyond the boundaries of the discipline of music education (*e.g.*, ecotones). Finally, Yin identifies a unique feature of qualitative research, in that it “permits and even encourages midstream adjustments” (p. 85) in the research design process. Qualitative research design is an iterative and recursive process in which it may not be advantageous for a researcher to make an early commitment to a fixed and particular research design form initially (p. 84). Therefore, in this study of music technology teachers who practice or experience the phenomenon of STEAM, I believe that a flexible qualitative methodology afforded the most open-ended and broadest net, from which I was able to continuously refine my research questions and methods as I proceeded with this inquiry.

Why Phenomenological?

Van Manen (1990) states that the purpose of a phenomenological study is to distill the individual experiences of the phenomenon into a description of a quasi-universal *essence* of the phenomenon in order to “grasp of the very nature of the thing” (p. 117). Accordingly, the proposed study will seek to find commonalities in the lived experiences of music educators who claim to practice STEAM, and subsequently weave those common threads into a description of the essence of STEAM as they experience it. Creswell and Poth (2018) assert that researchers proposing to use phenomenological methodology “would be remiss” not to first provide a discussion of its philosophical presuppositions. In addition, they enumerate a philosophical discussion of the basic ideas of phenomenology as a “defining feature” of all phenomenological studies (p. 75). But beyond the admonitions of methodologists, I read the story of phenomenology’s evolution to be a story about disciplinary ecotones and the politics of knowledge, and therefore, I find it to be resonant with both the STEAM movement and the situation of technology-based music teachers that I am studying. For these reasons, a brief discussion of the philosophical assumptions, underpinnings and context of phenomenology is in order.

What is Phenomenology?

Edmund Husserl (1859-1938), a German mathematician, formally introduced, founded, and pioneered phenomenology at the turn of the 20th century with the aim of turning philosophy into a rigorous science (Guignon, 2006; Moran, 2000). Later thinkers such as Heidegger (1927), Sartre (1956) and Merleau-Ponty (2012) would draw on and expand Husserl’s ideas (Spiegelburg, 1982). The thinkers who followed in Husserl’s footsteps offered contrasting philosophical arguments for the uses of phenomenology, but despite these disagreements, their

philosophical assumptions find some important common ground (Creswell & Poth, 2018). They agree that phenomenology involves the study of the lived experiences of people; that those experiences are conscious ones (van Manen, 2014); and the development of descriptions of essences from those experiences, as opposed to explanations or analyses (Moustakas, 1994). Surveying the similarities, van Manen (2014), describes phenomenology's capacity for methodical meaning-making as *phenomenology of practice*. Among the key philosophical qualities of phenomenology identified by Stuart and Mickunas (1990), is the rejection of *subject-object dichotomy*. In plainer terms, reality lies somewhere between the subjective experiences of an individual and the "objective" common to the lived experiences of a group of people who experience the same phenomenon. Furthermore, these lived experiences are taken as "conscious" ones which are directed toward an object (Creswell & Poth, p. 79). For the purpose of this proposed study, phenomenology would theoretically make it possible to derive an experienced reality about what STEAM education is from within the continuum between individual subjective experiences of STEAM, and a synthetic composite of shared and common experiences of STEAM of a group of music technology teachers.

Like the participants in this study, I also identify as a technology-based music educator who understands my practice as a form of my own understanding of STEAM education. For this reason, this phenomenological study was conducted as a form of *transcendental* phenomenology with the intention of understanding my own experience of STEAM through the experiences of similarly situated music educators. The transcendental phenomenological approach is contrasted with a *hermeneutic* or *interpretive* phenomenological study, in which the researcher is investigating an unfamiliar experience. Transcendental phenomenology employs a rigorous

method of bracketing or *epoché*, in which the researcher consciously attempts to suspend preconceptions and presuppositions (Moustakas, 1994).

My rationale for conducting a qualitative, transcendental phenomenological study is rooted in the recurring theme of the promise and potential of epistemological *in-betweens*. The theme appears consistently throughout the background and conceptual framework for the proposed study, beginning with the step of adding the A to STEM, (even if it is done so only in name). The metaphors of classical elements, of *ecotones* and of gradient *ecocline* ecologies of learning and knowing, are all in keeping with the theme of *epistemological in-betweens*. The theme appears yet again in my chosen methodology of phenomenology, which searches for truths in a continuum by resisting the dichotomy of subjective and objective realities (Creswell & Poth, 2018; Moustakas, 1994). Given that reason, Creswell and Poth extend the theme of epistemological ecotones even further when they claim that phenomenological research itself lies on a continuum between qualitative and quantitative research (p. 76).

Participant Selection

For this study, I interviewed four technology-based music educators who identified themselves as STEAM practitioners. The interviews with them were designed as semi-structured in order to leave the conversation open to collect participant responses and stories that may not fall within the expected framework (Kvale, 2008). However, the design featured a structured interview protocol to be used as a guide, rather than a script. Maxwell (2013) characterizes the qualitative research design process as an “interactive approach, whereby a qualitative study’s purpose, research questions, conceptual context, methods, and concern for validity all continuously interact” (pp. 3-7). Therefore, in this section, I will outline how I believe my

proposed research questions, my interview questions, and my conceptual framework currently relate to each other at the proposal stage of my research (Yin, 2015).

In keeping with Maxwell's description of qualitative research as a dynamic and interactive process (2013), my pilot study and initial participant selection process unearthed a number of unforeseen problems and issues that called for some modifications to be made to the research questions and the scope of the proposed study. On October 14, 2018, I posted a question in a closed Facebook group in which I am a member called *I Teach Music Technology!* in an effort to recruit possible participants for this study. I asked: "As a music technology teacher, do you identify as a STEAM educator?" Many of the respondents positively (and often enthusiastically) identified as a STEAM educator as I had anticipated, but a number of their responses surprised me. One respondent, whom I considered to be a pioneer in music technology education wrote,

STEM is an exclusive term; witnessed by the fact that we all try to add "A" to make it STEAM but we all know deep down that we're not included. I do not identify as a STEM teacher or as a STEAM teacher—I identify as a teacher (Retrieved on 10/27/18)

Another respondent echoed the same sentiment:

I'm not a fan of STEAM, although I only mention that to music people. To me, there is no need to include the "A" because music is already a STEM subject. I did just attend a conference session on music teacher partnering with other STEM teachers that has been very successful. I think including the A minimizes the necessity of Arts and how it generally improves studies in the rest of the subjects. (Retrieved on 10/27/18).

Although I initially considered both of these respondents to be solidly good examples of STEAMeducators, I was confronted with a problem: these respondents generally appeared to embrace the more idealized version of STEAM education I had originally conceived of as a researcher, but they rejected the term “STEAM” for the same reason, but in different ways. One respondent felt that STEAM characterized the Arts as being in a subservient position and as a mere utility to the sciences. Another felt that “music is already a STEM subject,” but is not a “fan of STEAM” because it “minimizes the necessity of the Arts” while it “generally improves studies in the rest of the subjects [STEAM].”

In order for my inquiry to address my research questions as I intended them, without losing the important, and potentially central critical perspectives of my potential participants, I realized that I would need to make some changes. I would need to provide my own definition of STEAM in which the letters in the acronym are taken to be of equal weight; or select some participants whom I believe to be practitioners of STEAM (as I understand it) based on my own criteria; or possibly modify my research questions. I ended up doing a little of each. I wanted participants to offer their own definitions of STEAM, but I also realized that I needed to recruit participants who have experienced the same phenomenon, regardless of how they labelled it, in order to effectively conduct phenomenological research (Creswell & Poth, 2018). To that end, I revised the interview questions to prompt participants who may embrace the ideals of STEAM, but object to the implications of the term, to be able to answer categorically. I also amended research question 1c to investigate how participants viewed their place in terms of both music and STEM disciplines.

Breaking Ground

A qualitative pilot study was conducted in August of 2015. In this study, I chose to investigate how college/university music technology professors perceived STEAM education. I selected a sample based on personal judgement (Babbie, 1995), the purpose of research (Grieg & Taylor, 1999), and the assumption that the chosen participants had significant experiences and perspectives on the phenomenon of STEAM education (Kruger, 1998). The study was comprised of two 60-minute semi-structured interviews conducted over Skype. Three were recruited, but only two were available to be interviewed at the time the study was conducted. After the interviews were conducted, the data were transcribed, shared with participants for verification, and coded for themes, analyzed, and reported (Kvale, 2008). The findings of the pilot study informed the proposed research in the following ways:

First, because the scope of the pilot study was limited to only two participants, it was difficult to make any well-founded theories, (dare I say generalizations) from the data collected. The participants were also both homogenous in that they were both practicing “experts” in the field of music technology, professors at large east-coast universities who held doctorates, white males, and self-identified as practitioners of STEAM education. Even with its small, homogeneous sample, the study did make me realize that even if enlarged and expanded, it would be study of “experts” rather than of every-day practitioners. While I believe the study of experts in this field would be valuable (as a point of comparison to other populations, as well as a study of *polymaths* in music education), I felt that a broader and more diverse population would yield more truths (with a small “T”) and make a stronger case for the possible quasi-universality of my findings. Moreover, from my own experience as a teacher at the secondary level as I mentioned in Chapter I, I strongly feel that the classroom is where “the rubber hits the road” in

terms of the utility and validity of educational theory as it applies to schools. For this reason, I decided to confine the scope of the proposed study to teachers in primary, middle or secondary classrooms.

Lastly, the pilot study, as well as mentor and peer feedback, helped me to revise my research and interview questions. The research questions were rewritten to focus my inquiry on the experiences of music technology educators, rather than to inquire about STEAM *per se*. I recognized an ambiguity in the questions as to whether I was investigating the STEAM movement in education at large, or how STEAM might be experienced by music educators. As I have described above, I am investigating the larger phenomenon of STEAM through the lens of the accounts of individual teacher experience. In addition, the experience of conducting interviews in the pilot study helped to recognize the need to engage participants with more prompts for open-ended discussions and fewer specific questions that elicited specific answers. Given what I have learned in the initial stages of participant selection and the pilot study, I have reworked my criteria for participant selection for this study. The final criteria that were used in my main study are listed in Table 1.

Instrumentation

The study was designed as a qualitative phenomenological case study of a diverse group of four music technology (or technology-based music) educators who were veteran, practicing teachers at primary, middle, or secondary level-schools in North America. Creswell and Poth (2018) state that a phenomenological study is the study of a phenomenon shared by a heterogeneous group, which may vary in size from three to five individuals. Polkinghorne (2004) recommends that the range is between five and 25 individuals. In this study, a total of seven participants were initially recruited, however three were unable to continue or opted out of the study after a preliminary

conversation. As a result of attrition, this study investigates the experiences of four key participants, and sought to explore their conscious experience and/or practice of STEAM education as both a teacher and learner. At least two 90-minute depth interviews were conducted with each participant until saturation (Creswell & Poth, 2018). Interviews were recorded, and notes were taken of non-aural phenomena during the interviews and observations. Each interview was guided by an interview protocol to ensure each research question was addressed to satisfaction and to accommodate participant responses that many not have fallen into the expected framework (Kvale, 2008). The two principal 90-minute interviews were conducted with open questions, through Teachers College, Columbia University Institutional Review Board approved study, protocol number 19-428 (Appendix A) using the questions in Table 1 as a guide. In addition, each of the participants were invited to choose an alias of their own preference in order to maintain anonymity guaranteed by the research protocol stipulated in the interview protocol.

Table 1

Participant Selection Criteria

| Table 1: Participant Selection Criteria | |
|---|--|
| Participant requirements: | <ul style="list-style-type: none"> • must be a practicing technology-based music educator at thesecondary level. • must confirm that they experience or practice ideas and ideal behind STEAM education, as I perceive them (in which all the letters of the acronym are equally weighted in terms of significance), e.g., they must identify as interdisciplinary teachersand learners. • must be active and vocal members of music educator professional community, either through professional organizationsor online communities. |
| Preferred qualities of participants: | <ul style="list-style-type: none"> • in the New York City metropolitan region. • represent diversity in race, gender, age, ethnicity and background. • have at least 5 years of teaching experience. |

Harvesting Data

The methods used to collect (or “harvest”) data in this study include unstructured interviews, document analysis, and memoing. A method, as Volpe (2000) describes it, is a tool that is used to generate or analyze data. In qualitative research, the use of multiple methods and sources of data is essential to gaining a more complete understanding of the phenomenon studied (Creswell, 2013) and provides various lenses through which myriad facets of the phenomenon may be revealed and understood (Baxter & Jack, 2008). I will now briefly describe the three methods of interviews, data collection, and memoing that I employed in the process of harvesting data for this study.

Method I: Interviews

This study’s principal means of collecting data was extended, detailed, open-ended, semi-structured interviews. A semi-structured interview uses a flexible interview protocol with open-ended questions designed to allow participants to freely share their opinions and perspectives to elicit rich, detailed descriptions of the participants’ experiences (Smith, 2015). The semi-structured approach offers flexibility to explore emergent themes and delve deeper into the participants’ responses (Creswell & Poth, 2018). In my extended conversations with the participants, I consciously strove to establish a reciprocal interview style in which free dialogue occurred between myself and the participant, allowing for subtopics and new perspectives to emerge during the interview (Bailey, 1996). The reciprocal approach contrasts with a structured interview, which strictly follows established research protocol questions (Kvale, 2008). In this study, semi-structured interviews were conducted until saturation was evident by the increased incidence of repeated stories, statements, or themes (Creswell & Poth, 2018).

Method II: Document Review

The study would not have been complete without the inclusion of documents that I collected from several participants as a supplementary data source. According to Braun and Clarke (2013), documents can provide additional context related to participants' lived experiences in phenomenological research. In this study, supplemental sources included published books and chapters the participants had authored, professional websites, and related, publicly available information on professional social media platforms. Documents reviewed and analyzed for this study included podcasts, curricula, syllabi, lesson plans, and examples of student work, which were used to support *triangulation*, as described below. Data for this study include public documents that existed before the study commenced and documents that were written and published during the collection phase. Both forms of extant documents are described by Merriam (2000) and Volpe (2000) as being stable and independent of the influence or potential bias of the researcher.

Method III: Memoing

While conducting and transcribing interviews, I used the "memoing" method described by Miles and Huberman (1984), in which I collected reflective thoughts, impressions, and hunches together with descriptive notes. My notes may be categorized as observational notes about what I perceived during the interview (p. 69), theoretical notes in which I attempted to make connections and "derive meaning" in the intersection of the interview data and theory supported by the literature (Bailey, 1996); and methodological notes defined by Bailey as "reminders, instructions, or critique" (p. 37), which were used to remind me of key talking points identified in the research protocol during interviews and to maintain standardization for the overall interview progress as it unfolded. Because such notes may be considered a form of

interpretation, as Morgan (1997) argues, they should be regarded as more a part of the analysis than the data collection process. However, they should also be identified as part of the data collection process as a safeguard against premature, foregone conclusions or judgments that the researcher may assume.

Procedure

I recorded each interview digitally to maintain focus on the conversation, rather than be distracted by the data collection process or note taking (Miles & Huberman, 1984). I stored the recordings on a secure cloud-based server. Afterward, I manually transcribed each interview without the aid of a transcription service or software to gain deep familiarity with the data and identify key themes. After the transcription process was completed, I harvested key phrases, quotations, and words as a reduction of each interview, which allowed for more explicit identification of emergent themes. This process is described in more detail in the following section. As an organizational tool to manage the collected data for this study, I created a secure spreadsheet with links to recordings, transcripts, reductions, portraits, notes, and digital artifacts color-coded for each participant in this study, as shown in Table 2.

Table 2

Study Data Organization

| Pseudonym | Transcript 1 | Transcript 2 | MP3 | Release | Supporting Materials | Reduction | Portraiture | color code |
|--------------------|---------------------------|--------------------------|--|----------------------------------|--|--------------------------------|----------------------------------|------------|
| Jasper | Jasper 1 | Jasper 2 | Jasper 2 Rev | Informed consent | bio | Jasper Quotes | Jasper Portrait | Orange |
| Andrea | Andrea 1 | Andrea 2 | Andrea 1 Andrea 2 | Informed consent | teachrock.com , book, podcast | Andrea Quotes | Andrea Portrait | Red |
| Ben / Benji | Ben 1 | Ben 2 | Ben 1 Rev Ben 2 | Informed consent | book chapter | Ben Quotes | Ben Portrait | Blue |
| Eun | Eun 1 | N/A | Eun Rev | Informed consent | N/A | Eun Quotes | Eun Portrait | Gold |
| Heather | Heather 1 | N/A | Heather Rev | Informed consent | N/A | Heather Quotes | Heather Portrait | Purple |
| Jim | Jim 1 | Jim 2 | Jim 1 | Informed consent | N/A | Jim Quotes | Jim Portrait | Green |
| Laronda / LaRhonda | Laronda 1 | N/A | Laronda | Informed consent | podcast, personal website | Laronda Quotes | Laronda Portrait | Maroon |

Taking Apart and Putting Together: Data Analysis and Synthesis

Plan for Analysis

The purpose of analysis in phenomenological research is to identify recurring patterns or themes from the data that characterize the phenomenon being studied (Merriam, 2016). There is a general consensus among methodologists about the procedure for analysis in phenomenological research (Moustakas, 1994; Polkinghorne, 2002). In keeping with that consensus, interviews with teachers were recorded, transcribed, and combined with field notes, interview notes, observation notes, and other collected data to be coded for themes. Significant statements from each interview that provide understanding of how each music technology teacher experiences the phenomenon of STEAM were identified and collected as part of a reduction of the interview, or what Moustakas (1994) labels as *horizontalization*. In the next analysis step, I arranged significant statements in the reductions into *clusters of meaning* to generate common themes (Creswell & Poth, 2018). In this step, I color-coded statements according to theme. The themes and significant statements were then grouped together in an intermediary stage, which I labeled as a *redux* of each theme, and ideas and quotations were color-coded by participants to track similarities and differences of perspective around each emergent theme.

Synthesis

I developed textural and structural descriptions of what and how each participant experienced STEAM. Textural descriptions describe what the participants experienced, and structural descriptions describe how the participants experienced the phenomenon in terms of the given conditions, situation, or context (Creswell & Poth, 2018). Finally, I synthesized the structural and textural descriptions of STEAM into a composite description of my participants’

experience of STEAM called an “essence” of the phenomenon, or what Creswell and Poth describe as “the essential invariant structure” (2018, p. 80). This richly described essence is considered the final product of phenomenological analysis (Creswell & Poth, 2018; Moustakas, 1994; van Manen, 2014). As a final step, the rich and textured descriptions, artifacts, and the “brushstrokes” (Lawrence-Lightfoot, 1997) of my own perspectives were combined to create extended portraiture of each participant, as described by Lawrence-Lightfoot as a qualitative research method that involves creating in-depth, textured, richly detailed portraits or narratives of individuals that capture the complexities, nuances, and lived experiences of participants. These portraiture are presented as findings in Chapter V.

The Role of the Gardener (Researcher)

Merriam (2014) describes the person of the researcher as the “primary instrument” of qualitative inquiries and argues that as such, human “instruments” can flexibly respond, clarify, and adapt to unexpected or unforeseen responses that may emerge in the data collection process. Human “instruments” are not without potential liabilities, however. In this study, my own preconceived notions about the phenomenon of STEAM may arise from the fact that I see the world from within my own cloud of STEAM.

The literature guiding and informing transcendental phenomenological research goes a long way to anticipate, predict, and avoid the introduction of bias or the inclusion of preconceived notions, yet my own experience as the researcher reminds me of how difficult it often is to see clearly in the fog, or *aporia* of a complex phenomenon. The real problem of researcher bias in this study may stem from the paradox that the way of knowing in this study is embedded in the paradigm it is attempting to study and understand; It may be a case of “disciplines on disciplines.” As a researcher, I must constantly remember that my perception of

the participants' shifting, multidimensional clouds of STEAM is refracted through my own. By way of an example, it took some time in this study for me to realize my lack of criticality with one participant's claim that STEAM was necessarily a form of Arts Integration. In this case, I needed to bracket away my inclination to organize and categorize curriculum like puzzle pieces. Since a structural perspective of curriculum is perhaps pervasive in my daily work as head of curriculum at an international school, it was admittedly difficult to consistently "suspend" this bias from the participant's perspective.

Pruning Assumptions

While trying to cultivate new understandings of STEAM, I took several measures to promote trustworthiness in my research. In phenomenological research, it is customary for the researcher to attempt to "bracket" his or her experiences out of the study through a full disclosure of personal experiences with the phenomenon (Creswell & Poth, 2018; Giorgi, 2009; Yin, 2014). The idea of bracketing originated with Husserl (1973), who used the ancient Greek word *epoché* (ἐποχή), meaning "suspension," to describe the desired disposition of the researcher in a phenomenological study. Moustakas (1994) refines Husserl's concepts in his *transcendental* or psychological *phenomenology*, in which researchers set aside their experiences as much as possible, to take a fresh perspective toward the phenomenon under examination" (Creswell & Poth, 2018, p. 78). Hence, Moustakas uses the term *transcendental* to mean a state "in which everything is" (1994, p. 34). The intended purpose of *epoché*, or bracketing is for the reader to "learn about the researcher's experience... [so they might] judge for themselves whether the researcher focused solely on the participants' experiences in the description without bringing himself or herself into the picture (Creswell & Poth, 2018, p. 77).

The concept of “Teacher as Stranger” is explored by Maxine Greene (1973), who emphasizes the importance of embracing otherness for educators as they experience it in their students and within themselves. In my attempt to practice *epoché* in this study, I remembered Greene’s call to recognize and embrace the Other as an essential way to recognize and value students’ diverse experiences, perspectives, and identities. My hope was to understand myself as a “stranger,” as much as a “familiar” through the process of bracketing, or *epoché*.

To that end, I have described several of my experiences in the preceding chapters and have disclosed my attitude and position regarding STEAM education, not only as a rationale for my investigation but also as a form of bracketing to promote reliability in my chosen methodology. In addition, I intended to reflexively (Bochner & Ellis, 2000) report on my own engagement in the practice of phenomenological research as part of the bracketing process (Marshall & Rossman, 2015) to account for what Creswell and Poth (2018) describe as the potential that phenomenological research has to transform the researcher himself or herself throughout the study. Max van Manen (1990) states that “[p]henomenology projects and their methods often have a transformative effect on the researcher himself or herself. Indeed, phenomenological research is often itself a form of deep learning, leading to a transformation of consciousness, heightened perceptiveness, increased thoughtfulness” (p. 163).

Ethical Considerations

Informed Consent

An informed consent document was prepared with approval from the Institutional Review Board to ensure that participants were aware of the research nature of conversations and interviews. Participants were informed that the interview was being recorded, that aliases would be used to protect their identities, and that they were free to leave the study at any time for any

reason. The terms of the informed consent were disseminated to participants in written form in digital PDF format and read aloud to them at the beginning of the first interview. Participants indicated their consent by signing the document and indicating on recorded record that they understood and agreed to the privacy terms of the research project. None of the participants were enrolled at the same university as mine, nor were they employed by the same institution or members of the same organizations I belong to. Therefore, I believe no conflicts of interest existed between the participants in this study and myself as the researcher.

Data Collection

Interview data were collected online using Voice Over Internet Protocol (VOIP) platforms, including Zoom and Skype, and recorded on a separate digital recorder. Multiple interviews took place with each participant for two semesters of an academic year and lasted between 45 and 90 minutes. The first in the series of interviews with each participant followed the reflexive, semi-structured interview protocol described earlier in this chapter. In contrast, subsequent interviews were open-ended and often provided opportunities to pose follow-up questions to fill any gaps of understanding or clarify meanings. All data were stored on a secure device and uploaded to a secure server accessible only to me via an encrypted password. Audio files were destroyed after the study was completed.

Trustworthiness of the Study

The overall trustworthiness of a qualitative inquiry is established by factors of the study's credibility, dependability, transferability, and an assessment of the study's limitations (Creswell, 2018; Merriam, 2018; Peoples, 2020). In the subsections below, I will account for each of these factors as they relate to this study.

Credibility

As a fundamental root of qualitative research, credibility refers to the validity, trustworthiness, accuracy, and believability of the findings that emerge from the research. Tools used in this study to establish credibility include triangulation, thick description, and reflexivity. Triangulation involves the corroboration and validation of findings through alternative research methods (Creswell, 2013). Through the process of comparing and contrasting data between different sources and methods, I was able to mitigate bias and strengthen the validity of my interpretations. My choice of using portraiture (Lawrence-Lightfoot, 1997) as a principal method for this study required the creation of thick descriptions that were intended to capture nuances, complexities, and subtleties of the phenomenon to enhance the credibility and authenticity of the findings (Geertz, 1973). Finally, a reflexive approach, as defined by Finley (2002) as it was applied to the process of memoing as described by Miles and Huberman (1984), invited my own critical reflection on my role, potential biases, and assumptions throughout the study to enhance the transparency and credibility of the findings.

Dependability

The dependability of a study refers to how stable the findings are if the study were to be replicated or repeated. Establishing dependability is challenging in social science research since human behavior is not static and varies across cultures and contexts (Merriam, 2016). While full replicability is not often possible in the social sciences because human behavior is constantly in flux, this fact does not invalidate qualitative studies with human subjects, such as this one. My use of tools such as audit trails or detailed notes on methodological dilemmas I faced and the decisions I made at various stages through the research process, allowed for increased transparency and accountability in the findings (Miles et al., 2014).

Transferability

The extent to which a study's findings may be generalized to other contexts or populations is referred to as its *transferability* (Patton, 2015). A factor in this study that may be thought to increase the transferability of its findings is the use of rich, thick descriptions as part of the portraiture method. Through rich descriptions, readers may understand how the findings might apply to similar contexts (Guba & Lincoln, 1985). The relative diversity of the participants in this study may have also increased the likelihood of transferability, as the sample reflected diverse backgrounds, contexts, and perspectives to the extent possible with a very small sample size (Patton, 2015).

Limitations of the Study

While qualitative phenomenological research can provide rich insights into lived experiences, it also has inherent limitations that should be considered. Even with a conscious effort to identify and bracket my own subjectivity and biases in the process, I understood the objective as an ideal that could never be fully realized. Many assumptions and possible biases were revealed during the study as I engaged in reflective memoing, as is typical in phenomenological research (Miles & Huberman, 1984). In addition, the small sample size in this study suggests considerable limitations and challenges for dependable replication and transferability. Bias within the sample population may also be a limiting factor, as all participants held advanced degrees in the field of inquiry. Most significantly, the ideal of achieving full data saturation in which no new themes emerged was difficult, as the open-ended nature of later interviews generated a limitless wellspring of new insights and perspectives. Bruce et al. (2008) acknowledge the challenge of achieving full saturation in the phenomenological study of complex phenomena.

A Final Thought Cloud

The best I could have hoped (and perhaps the best any researcher can hope for) in a qualitative research study is a freeze-frame: a frozen instance, in this case, of a cloud. In real life, Joni Mitchell's musical poem may hold true: it is clouds' illusions that we recall, and perhaps we really can't know them at all. The modest extent to which we can know clouds, such as STEAM, requires the intricate machinations of a philosophical construct that allows us to capture and study them. These tools are historically relatively new to us, with not even a century and a half since the ground was first broken by Edmund Husserl, whose work made it possible to study the drifting clouds of human experience in a way that counted. The methods of cloud-catching have been refined and improved to the extent that we may have hope that a study such as this one might hold some truth. The conceptual tools of transcendental phenomenological research, as they are described in this chapter, promise that it might.

All of this technology
Making modern music
Can still be open-hearted.
Not so coldly charted.
It's really just a question of your honesty
(Yeah, your honesty!)

One likes to believe in
The freedom of music
But glittering prizes
And endless compromises
Shatter the illusion of integrity

For the words of the prophets
Are written on the studio wall,
Concert hall
Echos with the sounds of salesmen
(Of Salesmen!)

– From “Spirit of the Radio” by Rush

CHAPTER IV: CLOUDSCAPE

Vision

In this chapter, I will explain my rationale for searching for STEAM in the lived experiences of music educators, and in particular, those who teach music through technology. I will set out a conceptual framework that relates the factors of environmental characteristics, ecologies of learning, attitudes, and habits of mind that might best cultivate and promote the kind of inter-, multi-, cross-, and trans-disciplinary teaching, learning, and thinking that may be taken to be STEAM education. Within that space, I will talk about location and power as I aim to hypothetically situate the technology-based music educator as an ideal inhabitant, practitioner, producer, a product of STEAM. In the next section, I will introduce the four volunteer participants who inform this study through brief biographical sketches.

Introducing the Participants

The purpose of the study was to explore the perceptions, practices, and attitudes of practicing school music educators toward STEAM education. The study sought to bring to light participants' understandings of their own conceptions and practices of STEAM, explore their communities and ecologies of learning, gain insight into their preparedness to teach under the various constructs of STEAM, and reveal their strategies for implementation of STEAM in the music classroom. Four practicing music educators in the United States volunteered to participate in this study. All participants identified themselves as "music educators who teach music through technology at either the primary or secondary level." Altogether, two male and two female teachers were interviewed multiple times throughout an interval of approximately one year. Interviews lasted between 45 and 92 minutes and were generally guided by the research questions detailed in this study's Interview Protocol (Appendix B). The following sketches

provide a brief portraiture of each participant, including their general demographic data; their educational background; the trajectory of their professional teaching experience, and a description of the social environments in which they currently teach or have taught. Each participant self-selected their choice of pseudonym, and all data, specifically identifying personal or professional biographical information, has been removed to protect their identities. Short biographical sketches of the participants are presented below in the alphabetical order of their pseudonyms.

“Andrea”

Andrea has taught music in public schools for two decades, and she is distinguished in this study as the only participant who has made STEAM a titular part of her professional repertoire. Andrea is a white woman who teaches in a suburban public school district on the outskirts of the New York City metro area, in which about a quarter of students receive free or discounted lunch. At the time of my interviews with Andrea, she described her professional roles as an early elementary general music teacher, STEAM Facilitator, and a K-12 Arts Integration Specialist, Andrea spends part of her day teaching general music to young learners, and the other part pushing into the classrooms of academic subject teachers to “bring [them] all of the arts areas...and connect them authentically with what the students are working on in their content areas.” Even under the constraints of COVID-19, Andrea has been busy online “consulting and having meetings and brainstorming sessions” to meet her district’s curriculum integration goals.

In addition to being a working STEAM educator by name, Andrea is also distinguished by the fact that she has worked both as a teacher and administrator over the course of her career. Equipped with an undergraduate degree in music education and a master’s degree in arts administration, Andrea started her teaching career as a chorus teacher in a suburban high school

and subsequently worked in other roles, including drama teacher, band director, and general music teacher in primary and secondary public schools. Early on in her career, at age 30, she decided to “go to the other side,” she says. After a few years of working as an administrator, Andrea decided to return to the classroom as a teacher. She says the experience dramatically changed her perspective on teaching. “It was like I was on the outside looking in and able to really observe like you can’t when you’re in charge of the whole classroom.”

It was upon her reentry into the classroom that Andrea discovered music technology for the first time. “The principal took me for a walk throughout the school, and all of a sudden, the last room he shows me is a brand-new Mac lab. He asked me ‘do you want to do this?’ and I didn’t even hesitate.” Andrea now admits that she didn’t have extensive knowledge about music technology at the time, but she did see its potential for engaging students. “I had taught music at the middle school level before,” she explains. “I knew what would and wouldn’t work, and I was like, ‘this is going to be a hook to get these kids—and it was a tough district—and get them excited to come to class.’”

Through her experience teaching general music through technology and a professional development workshop introducing GarageBand software, Andrea began seeing a multitude of connections between music and the sciences in particular. These connections interested her and prompted her to develop a “whole cross-curricular way of teaching technology” and pursue professional certifications as an Arts Integration Specialist and School Leader/Coach. “It’s really been kind of my passion and focal point over the years...finding concepts and topics that are similar between content areas.” When her district began making cross-curricular learning and arts integration a priority, Andrea says she “jumped [at the opportunity] right away, and was like:

‘listen, I have the administrative background. If I don’t get involved in this, they’re going to screw it up...because somebody in the arts has to help take the lead on this.’”

“Ben”

When Ben talks about his middle school general music curriculum to people outside the field, the response he says he usually gets is, “Wow, my music class wasn’t like *that*.” Ben is now in his seventh year as a music educator. He teaches general music at a suburban middle school in the New York City metro area, where students in the fifth to eighth grades rotate through music, visual art, technology, home and careers, and health classes on a quarterly basis. As part of the sequence, Ben’s music course features standard general music elements, such as songwriting for which Ben regularly invites hip-hop artists into his classroom as guest lecturers. But in other units, Ben admits that to the uninitiated, his classroom may not be immediately recognizable as a music classroom as his multi-disciplinary, project-based curriculum often intersects, overlaps with, and builds on what the students are learning in STEM courses at school. If one were to glimpse into Ben’s music classroom, one might see students using object-oriented computer coding languages such as Scratch and Python, digital audio workstations, MIDI controllers, and Makey-Makey electronic hardware kits to design and build their own digital musical instruments. With these in hand, Ben’s general music students are able to compose for and perform in school concerts with traditional band, chorus, and orchestral ensembles.

In his seven years building the music program at his school, Ben has had success finding funding in the form of grants, corporate sponsorships, and school budgetary support to acquire the technology he uses to teach. The school itself provides free or reduced lunches to about 19% of students. Ben’s general music course serves all the students in his middle school. It is

designed to fill the music education gap for students who do not participate in the more traditional band, chorus, or orchestra programs offered at the school, and provides a pathway to what Ben identifies as “different modes of musical expression.” Ben says he is “very aware that most of [his] students are not going to continue study music beyond middle school,” and contends that “those students still deserve a quality music education...that is meaningful to them as well. We owe it to them to show them the other possibilities of music making.”

Ben’s formal musical background began in the fourth grade, where he began studying percussion and playing in school ensembles. In college, he majored in music education, continued pursuing his studies in percussion, and minored in jazz studies. In his final undergraduate semester, Ben took a topics course in music technology. “It was during that class that I had a big realization,” he said. Ben was incredulous at what appeared to be a significant oversight in the curriculum of his college’s music education curriculum, but he was equally enthralled with what he was being exposed to in the course. He asked himself: “Why is this the first time I am learning any of this?” and “Why is this the first time that I am dealing extensively with notation software, audio software, video, web design...things that I thought were really important for music teachers to know, but were missing from the curriculum?” Ben’s newly-found interest led him to pursue a master’s degree in music technology at a large university in the Midwest, where his thesis project was about telematic performance, or live musical performance over the internet. “I was really interested in music technology for music education and learning about different ways that it could be used.” Ben returned to the New York City area to continue his research in music technology and education as a Ph.D. student where he currently researches music technology and music education. He is not affiliated with my university.

“Jasper”

Based in the Midwest, Jasper has taught music at nearly every grade level and in various contexts over the span of nearly three decades. Jasper holds a Ph.D. in music education and technology from a large research university in the Midwest. He also holds a master’s degree in educational technology and a bachelor’s degree in music education. Soon after he graduated from college, Jasper began his career as a school band director.

Then, after ten years in the job, Jasper decided to advance his career through graduate work in education. As a graduate student, Jasper taught music education and music technology courses at the university level. His choice of doctoral programs, he explained, was guided by his interest in pursuing the kind of teacher education that would support his career as a teaching practitioner in schools, rather than as an educator at a college or university.

For the past twenty years, Jasper has been teaching at a large public K-8 school in the Midwestern suburb of a mid-sized city. According to demographic data published on greatschools.com, the racial composition of the student population is reported to be 91% white, and most of the teachers, including Jasper, are also white. In this setting, Jasper teaches what he describes as “arts technology” to sixth through eighth graders. His curriculum includes units on computer-based music composition integrated with other “digital arts,” including filmmaking, coding, and graphic design. In addition to his teaching responsibilities, Jasper also provides support as a technology integration specialist, supporting other teachers in his building. Jasper’s school building is also its own self-contained public school district, serving approximately 900 students. As part of an isolated school district located in a wealthy suburban area that yields relatively high tax revenue, his school is a “very well-endowed school that supports the arts” with less than one percent of the school district receiving free or assisted lunch.

In the past, Jasper served as a technology chairman for national music education conferences and had been involved in a number of music technology organizations. However, in recent years, and in spite of the fact that he includes music composition in his “digital arts” courses, Jasper has drifted away from identifying exclusively as a music educator. “I took myself out of the music world...my job is now more technology...I was trying to be in both camps, but I couldn’t. And so, I moved more to tech.”

“Laronda”

Finding a music teaching job at the elementary school that you attended and then working alongside your old teachers is a dream that doesn’t come true for many music educators, but it did for Laronda. After four years studying vocal performance at a conservatory-style undergraduate music program, Laronda says she felt fortunate to find work as a choir and voice teacher her very own alma mater, located just outside of New York city. She stayed in the position for three years, but then, almost overnight, her position was eliminated. But Laronda was not deterred. She opted to continue her career as an elementary classroom teacher—a role in which she embraced and stayed in for the next six years. In this new role, Laronda continued her work as a music educator, but did so under the guise of a third-grade classroom teacher in the same district. “I was still doing programs, so I would write the plays and coordinate and direct it for Black History Month, Hispanic Heritage Month...graduation,” she said. “I would just say, ‘Listen, we can keep doing things.’” To sustain her presence in the classroom as a music educator, Laronda was able to find time and resources between the cracks,

As music teachers, you get into this to create music, and sometimes creating it is not from eight to three. Sometimes it’s after and sometimes it’s before school, and like, we’ve got to keep that that mindset because we are the ones who are the holders of making sure

people see how critical, and important, and how valuable it is. And if we get discouraged in that, we lose everything.

Laronda's commitment to music education in public schools eventually led her back to working music-and arts-specific job titles in her district. These roles have included serving as Assistant Principal for an urban gifted and talented academy school, and as the Supervisor of Visual and Performing Arts for her district for the past five years.

As a school administrator, Laronda stands out from other participants in this study. Laronda still very much considers herself a music educator; and moreover, as one who self-identifies as a "hip-hop music educator." As such, Laronda is currently exploring hip-hop music education as the subject of her own doctoral dissertation research at another institution than my own. Laronda sees technology as being essential to her work to design and implement musical learning, an essential ingredient for student engagement, and therefore, as an essential component for the future of music education. In one of her previous roles as school leader in her district, Laronda served as the Supervisor for Digital Performing Arts, a role which she says gave her insight into "viability" of music education and demonstrated her state's inclination to certify music programs under the rubric of Career and Technical Education programs well before they were approved as arts programs.

Toward Portraits

This study investigated the perceptions, practices and attitudes of and about STEAM education of four practicing music educators in the United States. The participant group consisted of two men and two women who currently teach in urban or suburban settings in the central and northeastern regions of the country. All participants are public school educators, with the exceptional participant working in an urban charter school that integrates and supports public

education at the administrative level. On average, the participants had been teaching for 15.3 years, with a minimum and maximum of 12 years and 36 years, respectively. The participants were evenly distributed according to the grade levels they teach: two teach at the elementary level, two at the middle-school level. Two of the participants work as school administrators or district leaders who specialize in the arts. All of the participants have earned master’s degrees in their fields, and two have earned a doctoral degree in their field. Three of the participants identified as White/Caucasian, and one participant identified as Black/African American. An overview of the participants’ age, level of education, race and ethnicity, teaching assignment, and years of experience as a teacher is provided in Table 3.

The brief sketches above introduce the participants before we hear from them at length in Chapter V of this dissertation.

Table 3

Participant Profiles

| Pseudonym | Reported Age | Reported Highest Degree Earned | Reported Race/Ethnicity | Reported Professional Role | Reported Number of Years Working in Education |
|------------------|---------------------|---------------------------------------|--------------------------------|--|--|
| Andrea | 42 | M.P.A. | White/caucasian | District Supervisor of Visual & Performing Arts and Consumer Education | 23 |
| Ben | 34 | M.A. | White/caucasian | Middle School General Music Teacher | 12 |
| Jasper | 52 | Ph.D. | White/caucasian | Arts Technology and Technology Coach | 36 |
| Laronda | 46 | Ed.D. | Black/ African American | Supervisor of Visual & Performing Arts | 20 |

Anyone can look in on schools. The trick is to see. Seeing requires an enlightened eye ... through which different genres of teaching can be appreciated.

– Elliot Eisner (1992).

CHAPTER V: PRECIPITATION

In this chapter, I present the findings of this study through narrative portraiture, a qualitative research method described as “a method of social science inquiry distinctive in its blending of art and science, capturing the complexity, dynamics, and subtlety of human experience and organizational life” (Lawrence-Lightfoot, 1997), as described in Chapter III. Multiple interviews were conducted with each participant over Skype and Zoom platforms at a mutually agreeable time. Two of the four participants had earned a doctorate in the field of music and education and all four were teacher educators who provided professional development to other teachers in their districts. In addition, all four participants either taught at the middle school level at the time of the interview or had previously taught middle school students in the context of public schools in the United States. Interviews were audio recorded and subsequently transcribed and coded manually by the researcher. Meaning units were grouped via a coding process from the transcripts to produce emergent themes. These themes were subsequently combined to produce the narrative portraiture of each participant in the sections below.

Andrea, the Technician

I first met Andrea via Skype just months after the COVID-19 pandemic struck. At the time, Andrea was splitting her time between teaching Early Childhood Music and working as a K-12 Arts Integration Specialist in a suburban school district outside of New York City. Over two long conversations separated by an interval of a year, Andrea and I discussed a broad range of issues and questions about STEAM education, including common misconceptions about what STEAM is, her “conversion” to becoming a STEAM practitioner, obstacles and challenges for both Arts Integration and STEAM, what it takes from teachers and schools to implement

STEAM, her own critical perspectives on STEAM, and how STEAM materialized during the pandemic.

Andrea began our conversation by making the claim that STEAM is a “hot-button topic” that is widely misunderstood. “There are many definitions out there,” she says. “[T]he majority of people don’t really understand what it really is... [and the term] just gets thrown around too easily.” Beyond the literal meaning of the letters of the acronym itself, she notes that definitions of STEAM are contested and that the lack of a clear definition of it can be problematic and even divisive. “Different people utilize the term in different ways, depending on what they need.” It is only when “you really start doing it and living it and breathing it and studying it” that it can be understood, she says. Considering the confusion, controversy, and misunderstanding that Andrea describes around the question of precisely what STEAM is, our conversation turned in the direction of seeking clarity.

Toward a Definition

To define what she means by the term, Andrea begins by talking about what STEAM is and what it is not. In Andrea’s view, STEAM is neither a stand-alone phenomenon nor a new one. Andrea explains that STEAM falls under the umbrella of the larger project of Arts Integration. In her district, STEAM evolved from the initial project of Arts Integration, which is now considered the umbrella term for the movement toward integrating the arts with all academic subject areas, including, but not limited to, STEM subjects. Secondly, Andrea points out that STEAM and Arts Integration are not curricula *per se* but rather an *approach* to teaching and learning. “It’s not a ‘You need to stop everything you’re doing for two weeks and do this massive project’ kind of interruption, or supplementary materials added to a curriculum. Instead, teachers are “teaching the same materials [they usually teach]. We’re just going to approach it

with students in a different way,” she says. Her third point is that STEAM only exists when students are engaged in problem-solving across disciplinary boundaries in a way that can be aligned with standards from each subject area. She gives an example of a science teacher who believed he had created a STEAM lesson when he invited the music teacher to speak to his class during a unit on sound waves. While Andrea admits that the teacher was well-intentioned, the music teacher’s “cameo” alone didn’t meet her definition. “That’s not really necessarily STEAM,” she says. “Where’s the music happening to really make that learning about sound waves come alive, and what are the kids problem-solving and what are they doing?” she asks. On this point, Andrea provides a second example from the other direction: a music technology teacher who believes her class meets the criteria for STEAM with a GarageBand composition project that explores sound waves. Andrea’s response is supportive but skeptical: “I’m like, well, not necessarily. Like, what are the two standards? How are you assessing it? What are the kids doing with it? What’s the problem they’re solving? What’s the inquiry? Where’s the critique? Where’s the dialogue? How are they utilizing it? And a lot of people go, ‘Oh.’”

In Andrea’s view, STEAM is much more complicated than adding arts to STEM in name only. For Andrea, there are right and wrong ways of understanding and practicing STEAM; in her view, most teachers are doing it the *wrong* way. In the first case of the science teacher, she explained to him that “you’ve got solid STEM going on...and you’ve got the “A” in parentheses, but it’s not really STEAM.” And I think that’s where a lot of people are coming from. They don’t really understand what [STEAM] means.” Yet Andrea still celebrates the science teacher’s efforts to integrate the arts into his lesson and gives him credit for identifying what she refers to as a “node” or “access point” that can bridge two subject areas. “As an access point, I don’t think

it's bad. I just think that as long as [he] continues to evolve the practice, then I, I think it's, it's great." Her encouragement reflects her overall tolerance for what she considers to be teachers' incomplete yet well-intentioned efforts to integrate the arts with traditional academic subject areas. "They might not be doing it right, but I don't think that's necessarily a bad thing," she says. "[A]t the end of the day, to me, it's 'What's your intent?'" Her only stipulation is that teachers take the interdisciplinary access points they identify and work to develop them into full-fledged integrated learning experiences for students. Andrea explains that her approach to STEAM requires teachers to explore unknown subject areas and make a sustained commitment to honing deep and sophisticated approaches to interdisciplinary teaching and learning. "People just need to understand and really own it. And I feel like if they're going to do the deep dive into it as that lifelong learner of figuring out, like, 'What is this really?'"

Discovery and Motivation

Andrea explains that her approach to supporting teachers as an Arts Integration Specialist is anchored in her own experience. After working ten years as a high school music teacher, Andrea decided to become a school administrator. She says the perspective she gained from this new role allowed her to understand teaching and curriculum through a new paradigm.

I was like on the outside looking in and able to really observe like you can't when you're in charge of the whole classroom. But when you can just go in there to observe, it's a completely different experience.

In the process of moving back to a teaching role, she says she was "converted" to a teacher who sought to approach STEAM through a new role of teaching music through technology. Andrea says she didn't see herself as a technology-based educator at the time.

I knew about technology, but I hadn't even touched GarageBand. I didn't own a Mac. I hadn't done much. I knew about microphones and stuff and that kind of thing, but I had never taught music technology *per se*.

Nonetheless, she immediately saw the potential for technology to excite and engage kids in music—especially at the middle school level. “I had taught middle school before, and I knew what would work and what would not work. And I was like, ‘This is going to be the hook to get these kids.’” A few weeks later, she attended what she describes as a GarageBand 101 workshop. “And from there, I developed a whole cross-curricular way to teach music technology. I wanted to tap into all the other content areas,” she explained. With her background as both teacher and administrator, Andrea considered “what [students] were learning? How were they learning?” in STEM areas and asked, “How could that be done through a production and music technology aspect?” One of her early thoughts was that the arts could help counteract what she perceived as the “drill and kill” approach of rote learning in STEM subject areas; the arts had the power to bring such content to life for kids.

Andrea saw the potential for integrating arts and STEM pragmatically as “a good way to tap into a community that was struggling desperately,” referring to dwindling funding and support for arts in public education at the time coupled with the dwindling enrollment she saw in her district. She says this crisis motivated her to “learn everything I could” and acquire professional certification to become a leader in what was then a new movement: Arts Integration. Andrea felt she needed to be involved, as her previous experience as an administrator made her skeptical about the efficacy of a top-down approach to the project of Arts Integration. “If you don't steer the ship,” she quips, “they're gonna screw it up, and it's gonna negatively impact you.” and adds, “Somebody in the arts has to help take the lead on this, or pardon French, they're

gonna really fxxx it up.” With this imperative, Andrea teamed up with another teaching colleague with a background as an administrator to “steer the ship.” Together, they “played a bigger role behind the scenes of trying to show [the arts] in the right light and help [the new “movement” of Arts Integration] to grow our programs in an advocacy effort.” As a cautionary epilogue to her story, Andrea told me that it was only the arts teachers who “jumped on board with the Arts Integration and helped lead it” who were able to hold on to their jobs that year. “All the other ones ended up getting cut.”

A more idealistic rationale for Andrea’s embrace of Arts Integration was what she saw as the intrinsic and already-existing presence of opportunities for critical, interdisciplinary teaching and learning through the arts. “I knew before I had the research that bringing the arts in and making more connections for kids... was important. I always did that in my own music classroom.” After concerts, Andrea would typically book the school computer lab to have students watch a video of the concert. “I wanted the kids to write a critique of each song and what they heard, and what do we need to do to prepare for Spring, and what should our focus be on what kinds of things?” One of Andrea’s core beliefs as a teacher is that “the more connections we can make for kids across contents, the deeper they’re learning, the more they’re gonna understand why they have to learn it and how it exists in our world.” Andrea adds that it is only in hindsight that she believes students can recognize the holistic value of interdisciplinary learning.

Obstacles

Andrea concedes that there is a long list of considerable hurdles for Arts Integration and STEAM in public schools, including a litany of structural and financial constraints, labor issues, and overall misunderstanding and disagreement over the purpose and objectives of Arts

Integration and STEAM. According to Andrea, one of the constraints for teachers and administrators in implementing STEAM is limited flexibility with programming and finding time for collaborative planning. In her role as an Arts Integration Specialist, Andrea is typically able to develop one new lesson per grade level per month, but planning time is scarce, and teachers' schedules are not necessarily conducive to collaborative planning. (These circumstances are also the case in my international school setting, and I can relate to this difficulty as an administrator.) To compound the problem of limited time, Andrea explains that there are many demands or "needs" on arts teachers throughout the school year, which tend to squelch out the "wants" of the kind of supportive, sustained professional development needed to fully support arts integration. Andrea explains that many of the arts teachers she works with (especially veteran teachers, she notes) have pushed back considerably for this reason, saying, "I have enough to do. It's not my job." In addition, she notes that, understandably, many teachers are not motivated to do the work required to make arts integration work effectively unless they are rewarded financially. While Andrea expresses sympathy for this position, she also expresses frustration with the possibility that teachers may lose touch with the greater intrinsic value of this approach and fail to understand what she views as the wisdom of engaging in collaborative teaching to enhance job security.

Another limiting factor that Andrea identifies is credibility. Andrea's arts teachers were initially resistant to investing time and energy in what they regarded as a short-lived trend. "They dug their heels in a little bit and were like this is just 'another thing,'" and failed to view Arts Integration as a sustained strategic initiative that could play to the interests of students and teachers alike. Perhaps the more serious and contentious issue around the credibility of the STEAM movement is that it might conceal a hidden agenda to minimize or eliminate the arts in

schools. Andrea insists that this claim is without merit. “We haven’t seen any of that anywhere or even rumblings of it,” she says.

Nonetheless, the notion was taken up by teachers’ unions who “tried to play that card,” Andrea says, by telling teachers that “they’re just doing this to cut all of you, so then they could teach your class.” Andrea’s retort to this accusation was that schools “can’t integrate the arts if the arts aren’t being learned first, in and of themselves, in the arts classrooms...That’s the definition [of Arts Integration].” She added the point that “the state’s not gonna let [schools] do that because [arts] are core to the curriculum, and they can’t cut us.” Even with these assurances, Andrea says that many teachers were unswayed. “There was no convincing them. They literally were like, with arms crossed, ‘Go ahead. You can do your thing, but we’re not touching this.’”

The challenges to the credibility and permanence of the effort to integrate arts with STEM subjects have cast a shadow on STEAM. Yet aside from what Andrea perceives as misguided resistance to Arts Integration, Andrea says that she is baffled as to why STEAM, in particular, has become a controversial “hot-button topic” and even a “bad word.” Andrea shares a story about an experience in which a large academic international publisher commissioned her to write a scholarly book on interdisciplinary teaching and learning through music technology. The book was originally pitched and funded as a title concerning STEAM, but after hearing from reviewers, the publisher backtracked and asked Andrea to remove the term STEAM from her title, as they now felt it may be “too controversial.” Andrea says she didn’t have much choice in the matter and ended up changing the name of her book. However, she argues that it is only a matter of semantics to talk about integrating STEM with the arts rather than calling it STEAM. Part of that controversy, Andrea explains, comes from the question of how the components of each letter of the STEAM acronym are balanced and the power relationship between them.

Despite the many challenges and misconceptions that have plagued the STEAM movement, there are still many teachers in Andrea's district who are open to Arts Integration, including STEAM, and come to appreciate it through collaborative work facilitated by Andrea. After a successful STEAM lesson with one teacher who had first been skeptical, Andrea says she "just smiled and looked at her, and I said, 'And that's Arts Integration. That's what should be happening, you know?' I was so proud of that moment of that understanding that this is real, this isn't fluff, this isn't extra. This is a real way." But even for such "converts" and teachers who are open to Arts Integration, there are considerable obstacles to implementing it. Andrea explains that one of the difficulties teachers face from both the arts and non-arts sides is learning to bridge the gap between disciplines. Andrea points out that it takes time and willingness for both sides to "build bridges."

Many STEM teachers may recognize the value of integrating the arts but feel they don't have time in their curriculum to include it, as they are driven by a mandate for student achievement on standardized tests. Andrea is adamant in her belief that increased Arts Integration and STEAM would unquestionably raise standardized test scores but finds the case difficult to make. She asserts that the soft associative skills associated with STEAM learning are "definitely hard to assess objectively in a standardized way. Because that doesn't leave room for creativity and outside-of-the-box thinking." Andrea also observes that standardized tests are product-driven, whereas STEAM and Arts Integration are more about "the process that leads you to that product." Andrea notes that while Arts Integration has been "wildly successful" in less privileged communities and districts, it is very much an unlikely success that has been against the odds. As she explains,

You know, these districts are under the microscope in terms of funding and more oversight from the state because they're not higher-achieving districts. That sometimes can be a barrier to be able to have...the time to experiment and play and train the teachers to understand that it's not something additional. It's just a different way of approaching the standards you're already teaching.

Andrea observes that the pressures of being “under the microscope” in less privileged communities decrease the likelihood of convincing parents and administrators of the viability of Arts Integration, especially when “their millions of dollars in funding is potentially on the line, or, you know, their district is being taken over by the state because it's so underperforming. They're not gonna put all their eggs in one basket.” Andrea admits that Arts Integration has been a hard sell in this context. “If it's not tried and true, and you know, ‘We have this data to tell us that it's one-hundred percent gonna work.’ It's [also] not a scripted curriculum they can buy that tells the teachers what to do, when to do it, and how to do it so the kids will quote ‘succeed.’” She notes that what teachers do in the classroom has never been as public as it is now, making it less likely for teachers to try new things for fear of public failure in front of vigilant parents. But Andrea points out that, ironically, it is only by losing the fear of failure and being willing to take risks that both teachers and students can sustain the most authentic and holistic interdisciplinary learning experiences. “As a teacher, you have to be willing to not know everything,” she says. They must be willing to say, “Hey, we're gonna try this together. I don't know where we're necessarily gonna go. Let's see what we come up with.” Andrea believes that both parents and administrators must be willing to support the kind of constructivist or “student centered” approach that can accommodate experimentation and failure. “Having that vulnerability with

your students really can sometimes work miracles and wonders in terms of getting them to be open to trying new things,” she says.

The obstacles Andrea describes all sound familiar to me as a curriculum coordinator and teacher. I experience many of the same frustrating constraints that Andrea describes, including the difficulties of solving the seemingly endless puzzle of scheduling time for teachers to collaborate, persuading teachers to buy into the promises of interdisciplinary education in the face of assessment-driven mandates, and taking the necessary, yet challenging risks required to cultivate and sustain a constructivist environment in which STEAM can be generated. That said, at least in my conversations with her, Andrea speaks at length about the garden of STEAM without ever mentioning the weather. I believe that a storm is brewing in the larger philosophical and political (yes, political) realm of interdisciplinary education and that ecotones, such as the music technology laboratory classroom, make for the perfect atmospheric conditions for a new kind of educational precipitation. I wonder how the forces of nature and the politics of knowledge are being played out in such spaces. I wonder to what extent music educators who occupy these spaces and are proponents of STEAM education might understand their situation as inherently political. Andrea has much to say about how she grapples with local politics of schools to implement STEAM, but when she enters the larger realm to talk about welding and forging academic disciplines together, I notice that her language changes.

Tech Talk

Andrea enumerates the practices and dispositions that she believes are needed to support Arts Integration and STEAM. As an Arts Integration Specialist, her definition of STEAM is a technical one strongly oriented around the alignment of standards between subject areas. In their current form, Andrea explains, state standards are often too subject-specific to “play well” with

each other across disciplines to enable interdisciplinary learning (as opposed to multi- or cross-disciplinary learning). However, she explains that they are being revised to incorporate more general language and common verbs in the interest of clearing the way for more robust alignment across subject areas. Andrea does credit the National Core Arts Standards (NCAS), which “do more to address creativities more broadly,” she says. Andrea holds the NCAS as an exemplar because “they became more generalized and more easily alignable to the other content areas because they used similar verbs that align with Bloom’s [Taxonomy]. [NCAS] used a lot of those verbs that make them friendlier to integrat[ing] lessons with other contents.” The key, Andrea explains, is to match cognitive demand levels between standards as verbs are aligned. However, one of the problems, she says, is that most teachers are not trained to read and understand the verbs defined by Bloom’s Taxonomy. “But who really taught people how to read those either and understand what they really mean?” she asks. “No one. Nobody’s done workshops on that.”

With this shortcoming in mind, Andrea makes the case for continued support and training for teachers to meet the demands of Arts Integration. Andrea is emphatic that coaching must come from qualified district leaders who have undergone a standardized Arts Integration certification process. Andrea’s “superpower,” she says, is to see the potential connections between disciplines that other teachers cannot see. She explains that this special ability comes from what she learned from her arts integration specialist certification, three years of coaching teachers on integrating arts, sixteen years as a secondary music teacher, and a deep familiarity with the standards in multiple subjects. Andrea says such training, coaching, and support must also be sustained. “I think that more sustained—you know—continually evolving our relationship and our collaboration in this together in more of a coaching model that’s sustained

over time, I think, is really the way to get this,” she says. For Andrea, one-off professional development sessions don’t come close to providing the continuous support and training needed to implement STEAM or Arts Integration. “All too often,” she says, “districts provide a workshop for an hour or two hours, and they’ll be like, ‘Go forth and do this! And at the end of the year, you’re gonna show us what you did.’ And it becomes a check-a-box where the teachers just check the box.”

What It Takes - Teacher Attributes

Andrea describes several teacher attributes and dispositions toward teaching and learning that she views as essential to the process of designing interdisciplinary learning experiences. At her foundation, Andrea describes herself as a lifelong learner and avid reader with a “thirst for learning new things.” For Andrea, the attribute of *sustained curiosity* has been the basis for her interest and knack for finding similar concepts across content areas. She extends this attribute as a requirement for teachers who must be curious enough to try to read and understand standards in subjects other than their own and “really sit down and study” the language (particularly the verbs) used in them. Secondly, Andrea identifies *community building* and *collaborative skills* as necessities for teachers who wish to develop integrated, interdisciplinary content. She explains that developing collaborative skills requires reaching across the divide and outside of herself: “As you probably figured out, I like to talk. I like to brainstorm. I like to have conversations. That’s how my practice evolves. I don’t like to have it just live in my own head.” From the beginning of her journey in Arts Integration, Andrea has networked to build a community of teachers around her who have been willing to collaborate.

I spent a lot of time wanting to become better versed and understand where the access points might lie between contents because, as a music teacher, I know music standards

pretty well, you know? So I've still got teacher friends. Like, I've got a science teacher, a math teacher, or I've got a language arts teacher, I've got a social studies teacher, I've got a world languages teacher that are my go-to people. So if I'm developing a lesson or I have a crazy idea, I know I can tap into them and say, 'Hey, here's what I'm thinking. Can you guide me in the right direction of the standards?'

Andrea adds that reaching across the divide to work with teachers in unfamiliar content areas can often be uncomfortable or at least take teachers out of their comfort zones. For this reason, teachers need to possess the attributes of courage and humility. Of her own experience, she says, "I wasn't that comfortable, and that's why I had to go to people to lean on. Because you can't expect to know everything about everything." By building trust with teaching colleagues in other disciplines, Andrea has started to learn their language. "And now I've learned to how to really read their standards and understand the language in them." However, the level of openness required to understand standards in unfamiliar disciplines means being open to being corrected and sometimes publicly corrected. Andrea gives an example of a recent STEAM presentation she delivered to a large group. "I was showcasing a lesson I had done, and a guy in the audience was like, 'I helped write the science standards. Did you know that that meant this?' And I went, 'Oh my gosh, I had no idea. Yes, if you read it that way, you're absolutely right.'"

Finally, Andrea identifies a positive approach to problem-solving as a key attribute for interdisciplinary teachers. In my first conversation with Andrea, she mentioned that she had previously held the title of STEAM coordinator for her district. Lack of funding and budget considerations led to the elimination of the position, but Andrea stayed on as a teaching and curriculum coach in her building, with split responsibilities. Despite the setback, Andrea persisted in her advocacy of STEAM and Arts Integration as a whole, set out to do consulting

work, and author a book on the topic. As a “technology person” in her school, Andrea reports that she was often frustrated by other teachers’ lack of initiative. By contrast, Andrea says she did her best to model resourcefulness and a fearless approach to confronting creative design challenges under constraints. I will discuss Andrea’s understanding of resourcefulness as a key attribute in the discussion below.

STEAM During the Pandemic

At the time of my second conversation with Andrea, the world was eight months into the COVID-19 pandemic, and the consequences were dire for public education. The doors of brick-and-mortar schools were closed around the world in favor of online virtual classes. The pandemic had disrupted education across the board, yet ironically, it had also necessitated the biggest push toward technologically mediated instruction in recent memory. Andrea shares several examples of how the constraints of the pandemic brought out her resourcefulness: When she was required to go back to the classroom again to teach hybrid classes, Andrea discovered a way to hack and repurpose her AirPods earbuds as an in-mask microphone for teaching live lessons.

In Andrea’s district, there was a sudden and urgent need for technology and curriculum support for teachers who needed to adapt their materials to the online format. “People weren’t prepared. If people weren’t up on technology, they were screwed,” Andrea observed. Tech skills quickly became a non-negotiable matter of survival for teachers as they were catapulted into situations where their understanding of technology became transparent. To illustrate this point, Andrea recounts an example of a music teacher who had planned a virtual concert for her students but wasn’t aware of the technical challenges involved in creating one, including the difficulties that digital latency would introduce for live, online music making.

Given her preexisting disposition toward creative problem-solving with limited resources and considerable constraints, Andrea suggests that the pandemic was as much an opportunity as it was a challenge for her. The game had suddenly changed in many ways: standardized tests “went by the wayside” earlier that year since “there were just such bigger fish to fry,” Andrea reports. The reduced focus on testing resulted in more openings and possibilities and called for increased flexibility and innovation in curriculum. Andrea reports that the pandemic also had similar effects on music education. With the elimination of the “product” of a final concert, music teachers had the opportunity to focus on foundations and musical “process.” Addressing her music teachers, Andrea says, “You guys have complained forever that we never have enough time to work on scales, to work on fundamentals, to analyze music, to do all that historical stuff. Well, guess what? You got time now.” She adds a hopeful vision of how things would be when the pandemic ended, promising, “You’ll blow their socks off...These kids will have such a solid and deep foundation of music that you haven’t been able to focus on because it’s all about product. Let’s focus on the process.”

Taking STEAM Apart

Even as a self-described advocate of Arts Integration and STEAM, Andrea has some critical perspectives on both movements. She observes that Arts Integration has been around for the past three decades and is “nothing new,” yet the STEAM movement has brought the integration of arts with STEM to the foreground and new funding along with it. Andrea asserts that funding dictates curriculum and argues that arts educators must “find a way to latch on for the ride.” While she expresses that she is aware of how funding might change the motivation or objectives of arts education, she embraces a pragmatic viewpoint in which she attempts to balance the opportunities of STEAM with more traditional objectives of arts education. In

Andrea's view, the opportunities for the arts in STEAM are explicit, in the sense that the arts are literally grouped with STEM subjects, but they are also implicit in what is happening in the power relationship between the components of STEM in this equation. An example of such an "implicit" opportunity is the unrealized roles of "E" for engineering and the "T" for technology in STEM. Aside from national programs such as Project Lead the Way, designed to attract girls and underserved students to the field of engineering, Andrea notes that both engineering and technology are not permanent, formalized fixtures in most K-12 curricula. She notes that to the extent they are, standards are often vague and "very generalized" and, therefore, can't readily align with standards in other subject areas.

Andrea says that she views the lack of specific standards for engineering as an opportunity for the arts—especially technology-inflected arts such as digital music— which can "fill the engineering design gap." She explains that "[w]here the arts come in is that design, that creativity, that habits of mind, that design process, which can help fill that gap in where those engineering standards are missing." Andrea also expresses less support and interest regarding the "T" of technology in schools and says that STEAM can be approached without technology. She expresses a desire to get beyond fetishizing technology and get back to the conceptual basics of what's being taught. Andrea believes that technology should be "kept in its proper place," that is, it should not drive instruction but rather support it.

Despite these critical perspectives, Andrea's assumption that STEAM is necessarily a category of Arts Integration might be challenged. Her highly articulated vision and version of STEAM is tethered to the static roots of earthly standards rather than freely forming and rising in the ether as it gathers powerful electrical charges needed for lightning, light bulbs, and enlightenment. While it may not be a major finding of this study, the possibility of decoupling

STEAM from Arts Integration promises new possibilities beyond what is permitted through the process of “grounding” or aligning STEAM to standards. After all, if STEAM is a transcendent phenomenon, it must transcend. It must be liberated from the rigid and systematically self-reinforcing structures of institutionalized education and float freely, as it did before the Cold War chilled the atmosphere. As I will discuss in Chapters VI and VII, an approach to untethering STEAM from hegemonic, educationalized conceptions of education may be transdisciplinary teaching and learning.

Document Analysis: Andrea’s Version of STEAM

Over the course of this study, Andrea co-authored a book on the subject of integrating STEM subjects with music education. Her emphasis on STEM, rather than STEAM in their titles, is perhaps more telling of the perspectives of her publisher rather than their own focus on STEM. As Andrea recounted, the well-known academic publisher she worked with directed her to remove STEAM from her book’s title for fear of what they perceived to be controversy around the acronym. Nonetheless, an examination of Andrea’s publication reflects a comprehensive approach to implementing STEM in the classroom. Her lesson plans take a project-based learning (PBL) approach and range from object-oriented programming and coding to compose and perform music to acoustic and digital instrument design and project-based explorations of musical acoustics. In each of her 15 lesson plans, Andrea categorically identifies which STEM subject area the lesson mostly pertains to and includes a standards alignment that matches all subject areas integrated into each lesson. Each lesson also includes checkboxes to indicate levels of cognitive demand using Bloom’s Taxonomy, multiple intelligences, 21st-century skills, and National Core Arts Standards. Table 4 shows how Andrea has reported the distribution of STEM subject areas in each of her 15 published lesson plans across three bands of grade levels.

Notable in Table 4 is a disproportionately low number of lesson plans directly related to engineering. The absence of engineering in Andrea's book on STEM may not reflect an actual absence of engineering in her lesson plans, but rather a blind spot caused by the limitations of her standards-based lens. By her own admission, the national standards for engineering are vague and "don't play well" with the other components of STEM. However, from my experience as an engineering educator, it is difficult to imagine that project-based lesson plans such as "Designing a Chromatic PVC Instrument" or "Invent an Instrument Using Recycled Materials" could be anything other than engineering. Since the "E" of engineering is often taught by "shop" teachers and grouped with the "T" of technology in the Career and Technical Education pathway, it lacks the same presence as the "M" and "S" of mathematics and science in the American curriculum.

Andrea and her co-author state, "We believe in play and the idea of free experimentation and exploration," but then argues that "Free experimentation, from a structural standpoint, needs to be more structured...when delivering education." Moreover, "Definitions, standards, alignment, assessment, language, and cognitive demand level need to be communicated, calibrated, and synchronized." In other words, in order for STEM + Arts Integration (dare they write "STEAM") to be able to fly, it must be securely fastened and grounded in rigor. It may be that the irony of this claim is not lost on Andrea and her co-author, as they may see a necessity for STEAM to take on a paradoxical intermediary stage as a concession that must be taken in a pragmatic approach to implementing STEAM. As we will see in the following portraits in this chapter, pragmatism looms large but is also balanced with, and ultimately driven by, idealism.

Table 4*STEM Subject Areas Identified in Andrea’s Lesson Plans*

| Name of Lesson | Grade Level | S | T | E | M |
|--|-------------|---|---|---|---|
| Shapes of Electric Guitars | 3-5 | | | | X |
| Sound Amplification and Speaker Building | 3-5 | X | | | |
| Measuring Length and Pitch | 3-5 | X | | | X |
| Invent an Instrument Using Recycled Materials | 3-5 | | | | X |
| Composing Music Using Light: Musical Automata | 3-5 | | X | | X |
| Performing Music Using Light: Theremins and Oscillators | 3-5 | X | X | | |
| Building a Fretboard | 6-8 | | | | X |
| Piezoelectricity Experiments | 6-8 | X | | | |
| Composing Music Using Coding | 6-8 | | X | | |
| Performing Music Using Coding | 6-8 | | X | | |
| Audio Engineering: Ratios and Recording | 9-12 | X | X | X | X |
| Designing A Chromatic PVC Instrument | 9-12 | X | | | X |
| Controlled Voltage: Composing, Performing, and Improvising with Subtractive Electronic Synthesis | 9-12 | X | X | | |
| Field Study: Sound Pollution and Its Effects on Bird Ecology | 9-12 | X | | | |

Ben, the Harmonious Blacksmith

My first conversation with Ben was in early 2020, a few months after the COVID-19 Pandemic had closed schools in the U.S. At that point, Ben was working from home, teaching middle school band online. Before the pandemic, Ben’s role included teaching general music in addition to band at his school, but the new “accommodation” that the school offered Ben once the epidemic struck limited his teaching to band. In response to the new challenges brought about

by the pandemic, his school district adopted a hybrid model in which Ben would teach small group classes in person at school a few days a week and then conduct “pullouts” to work with students individually during the regular school day online. Ben grew up musically as a band student, starting as a fourth-grade percussionist. “It turned out I was pretty good at it,” he says. With the support of school-based and private teachers, Ben played in various ensembles through high school, including concert, marching, and jazz bands, a symphony orchestra, and a pit orchestra for musicals.

Although Ben says he didn’t come from a very musical family, he decided to apply to a state conservatory for his undergraduate education, where he studied percussion and took a minor in jazz studies. His ambition was to become a school music teacher. It was only in his final semester at the conservatory that Ben took his first music technology course, leading him to have what he describes as a “big realization.” It was the first time he had been exposed to using notation software, working with audio software, and learning the ins and outs of video editing and web design. He asked himself, “Why is this the first time I’m learning any of this?” He was baffled as to why the conservatory had almost buried skills that he “felt were really important for music teachers to know but was almost entirely missing from the curriculum.”

Ben’s realization of this deficit in post-secondary music education (which, in his view, continues to persist) spurred his interest and made him want to learn as much as possible about what had seemingly been kept from him. After completing his undergraduate program, Ben pursued a master’s degree in music technology and education from a large university in the Midwest, where he wrote his master’s thesis on the topic of telematic performance (live performance over the internet) and explored ways in which new modes of composition might transform the usually pesky digital latency of online transmissions into an aesthetically desirable

musical effect. Ben was fascinated with what it meant to embrace and reimagine a problem as a solution. “So instead of figuring out, all right, how can we cope with it?” Ben found a way to “flip that around and figure out, all right, how can we use this to create music?” Now, years later, the strange coincidence that his experimental master’s thesis research project has become plainly applicable to his daily work with band students over Zoom was not at all lost on Ben, who chuckled at the irony of it all.

Ben’s creativity and resourcefulness continued to flourish since his days as a graduate student. While many people struggled with the isolation caused by the pandemic, Ben saw it as a chance to experiment and grow musically. In the weeks before our first conversation, Ben was busy developing a new appreciation for the Electronica and EDM genres by experimenting with technologies he originally intended to use in teaching. A grant from a music technology company allowed him to play with the technologies at home, where he now approaches music technology as a hobbyist. Ben’s newest musical interests have led him to learn to code and design new musical sounds using digital tools such as Max MSP and Ableton Live. Consequently, Ben reports that, as of late, he has noticed a significant shift in his own musical identity: “I’m spending more money on MIDI controllers and music tech things than I have on percussion instruments,” he says. Ben’s current spending habits are significant because “percussion instruments used to tend to pile up, but now the vast majority of my musicking is now tech-related as opposed to percussion related.”

Document Analysis: Making Music with Makey Makey

In addition to making music, Ben spent his time away from the classroom during the pandemic, contributing to a book about “aligning music to STEM.” In the book, Ben outlines a lesson plan he created for teaching instrument design in which sixth-grade students use an

invention kit called *Makey Makey* to create and then perform music on instruments of their own design. Along the way, students learn about the principles of electricity, apply the iterative engineering design cycle to their work as they design, test and troubleshoot prototypes, apply grade-level mathematics to design problems, encounter the work of contemporary composers who have created bespoke music for instruments of their own design (e.g., Theremin and the Theremin) and perform their own compositions and improvise as they present their instruments to the class. Ben's lesson spans ten class periods, making it appear more aligned with what is often described as a unit or mini-unit. Days one through nine of Ben's plan focuses on STEM subject areas as students design and build digital instruments and human interfaces using Play-Doh as a medium. On the tenth and final day, Ben proposes that teachers mount a "Makey Makey Fair," which I presume is a play on the *Maker Faire*, an annual promotional event for the Maker movement. On this final day, Ben advises that students should "perform," as "students and their teacher share their accomplishments through live presentations and/or asynchronous or synchronous online presentations."

On the one hand, a critical review of Ben's lesson plan might point out that the traditional components of music education are absent. Even during the cumulating event of the "Makey Makey Fair," Ben uses the word "perform" to indicate a presentation of the instrument through the lens of an engineer and doesn't ever seem to get to performance in the musical sense, as he promises in his learning goals and focusing question. On the other hand, in a book written for music educators, music educational components may be taken as implicit (although the day-to-day, step-by-step plan itself is explicit regarding STEM components). Although it may not have been written in his plan, it is impossible to imagine a living classroom following Ben's lesson that wouldn't be full of the same kind of joyful musical din one might hear in a band room. In his

lesson, students are invited to explore the connection between composition and the characteristics of musical instruments. They are also invited to expand their conceptions of musical possibilities as they research examples of new instruments and the new music they create. Of interest is the fact that Ben does not elaborate on these possible musical dimensions in his plan.

It may be the case that in his plan, Ben is making the case for instrument-making as a form of musical expression and, therefore, an aspect of music education. Beyond that possibility, I am also drawn to the possibility that the unscripted musicking that most certainly must be happening in a classroom following Ben's lesson plan might be left unaddressed or unscripted intentionally as a hallmark of a constructivist approach. Brooks and Brooks (1999) argue that traditional lesson planning may impede and limit a constructivist approach. The extent to which Ben's lesson plan explicitly addresses musical learning is limited but still central. The plan's principal learning objective aims for students to "construct meaning" as they "realize that there are ways to create and improvise music beyond traditional instruments and methods."

Given his grounding in constructivism, I expected to hear more talk of theory in my conversation with Ben. However, he explains that his approach to STEAM is not so much a theoretical one as it is a pragmatic one. "I think some of the more, like really heavy, lofty, theoretical, philosophical stuff all sounds well and good, but once you get into a classroom, it all kind of falls apart," he says. Nonetheless, Ben reflects on his teaching and relates it to a self-ascribed theoretical framework: Ben identifies his teaching approach as a hybrid of both *constructivist* and *constructionist* ideals, and he distinguishes between them: "Constructivism is about the social connection and building knowledge collaboratively, but in the abstract without something tangible. So it's building knowledge through concepts," he explains. Whereas he

defines *constructionism* as “the actual hands-on manipulation of materials, either physical or virtual, to gain understanding.” Ben believes that the two approaches overlap and share the same goal as they “both rely on the social aspect: sharing what it is that you’re doing with other people and getting feedback and going through some of those design process steps and those iterative processes in order to get further understanding,” he explains.

Ben’s Credo

Ben’s practice as a music educator is motivated and informed by progressive values and beliefs, as well as a vision for how music education might evolve as a proponent of democratic education. He observes that we live in a critical time for the arts, which he says are “more important now than they ever were” in education, for their humanistic, emancipatory potential, especially as they have sometimes been “pitted against” more instrumental versions STEM subject areas in school curricula. That said, Ben believes that a harmonious coexistence of the arts and the sciences is largely possible because it is nothing new. “It has been happening all along, whether people were aware or not,” he says. In Ben’s view, the idea that diverse subject areas have the potential to unite through creative applications has profound implications for education and society. Interdisciplinary education has the potential to teach students “that things are connected and that things don’t exist in a vacuum and that there are repercussions for events and actions,” he says. Moreover, Ben believes “those lessons can be extrapolated to personal relationships, business relationships, and political relationships.” Finding unexpected harmonies between diverse ways of knowing might also help ease the social and political tensions exacerbated by the isolation so many people experienced during the pandemic. Ben says, “I think that might be part of what led to some of the political division in the U.S. right now is that everything has been so isolated, and people don’t necessarily see how everything is kind of the

same.” Ben’s thought here brought to mind Parker Palmer’s (2010) challenge to teachers, “We think the world apart. What would it be like to think the world together?”

Ben’s understanding of interdisciplinary education as a way of building bridges, making connections, and seeking unity earns him the moniker of *The Harmonious Blacksmith* in this study. The idea of a *blacksmith* suggests the rugged *techne* of metalworking in the foundry of a school as new approaches to education are hammered and forged into new forms. *The Harmonious Blacksmith* is also the popular name for George Frederic Handel’s Suite No. 5 in E major, which according to an unfounded legend, was given to the piece when Handel found musical inspiration in a Smithy’s shop in the English countryside while seeking shelter from the rain (Sadie & Hicks, 1980). The name also recollects the well-known anecdote in which the Greek mathematician Pythagoras emitted one of the earliest known puffs of STEAM in the Western tradition, through which he forged a fundamental connection between mathematics and music. As the legend has it, Pythagoras was strolling past a blacksmith’s workshop when he first noticed the numerical ratios between differently sized and shaped anvils, the musical intervals that occur when they are struck by the blacksmith’s hammer, and the consonance or dissonance of the interval (Heath, 1921).

Given its deep historical roots, I wonder how and why the *techne* and *poiete* of music ever came to be smelted apart in the 20th century. From Ben’s perspective, the relatively recent re-forging of music and technology in the classroom through approaches such as STEAM reflects what he describes as a “tipping point” for music education as a whole. In his experience, the days of the strict traditionalist approach to the “B-C-O” (Band, Chorus, Orchestra) model of music education have given way to fresh ideas and new approaches, primarily through technology. “We’re starting to see some shifting as younger and more progressive teachers are

coming in. I'm seeing more of these kinds of ways of approaching music education," he says. With this shift, Ben feels that his expertise is not only welcomed and supported by his colleagues but also celebrated. "Even the traditionally trained classical music teachers who used to play in professional orchestras have been fully supportive. They see that the students become more engaged with [technology-based] activities," Ben observes. Part of the success of increased student engagement comes from a realization that many students will not take another music course after middle school, and most will not go on to participate in band, chorus, or orchestra. Ben argues that "students still deserve a quality music education. They deserve a music education that is meaningful to them as well. We owe it to them to show them the other possibilities of music making."

Ben believes that teaching music through technology not only has the potential to engage more students musically but can *release* (to use Maxine Greene's term) latent musical potential in students who would have otherwise been missed. He shares a story about how one such student was transformed:

I had an eighth-grade student who's now a junior in high school who was just kind of getting through every day. He hated school. He did not want to be there. But I knew he was into electronic music production. We did almost an independent study. He was in the chorus class, and he's a great guitar player, so he and I worked on an arrangement for the seventh and eighth-grade chorus to perform at the spring concert. And now he's in high school. He is very deeply involved in the music program and feels a sense of purpose and belonging, which he didn't really have before.

From my own perspective as a music teacher who teaches through technology, I can tell precisely the same story about several students who were "saved," as my principal at the time

used to describe it, through engagement with making music through technology. I recall the kids with histories of truancy, who I would find waiting outside my music technology classroom door first thing in the morning, eager to “make beats” as signed artists for the student-run record label that had become my music class. But like Ben, I also knew I wasn’t the only teacher in my school who had been given the privilege of helping to create the conditions for dramatic transformative experiences for students. Different students connect in myriad ways in different contexts and environments and with different personalities. Nonetheless, I share Ben’s sensibility that designing learning environments and experiences with all students in mind is one of the central missions of teaching.

Even with his compelling stories of student transformation as evidence of success, Ben maintains a keen critical perspective and actively reflects on his practice. Ben describes himself as being “Pro-STEAM,” but he is skeptical about how subject areas are integrated, if at all, in that configuration. “I like STEAM as an idea, and I agree with the push for STEAM instead of STEM as the acronym that we should be aiming for. But I do believe that they should be taught in a truly integrated fashion,” he says. I was surprised to find that, in Ben’s opinion, STEAM as a subset of Arts Integration does not meet that criterion.

We do not have [an Arts Integration specialist], and nor do I think I would want one. I’ve only had limited experience with Arts Integration, but I don’t like the idea of integrating arts. I have the idea of teaching arts for the sake of teaching arts. And yes, they do interrelate with the other subjects, but the idea of integration or that the term integration connotes that we’re using arts to teach something else, which I completely disagree with. Ben’s take on Arts Integration is not to suggest that he rejects the kind of shared spaces called for in most interdisciplinary approaches to education, but he does staunchly object to using the arts

solely to “sweeten” core academic subject areas. In a faculty meeting just a few months before our first conversation, Ben said that the arts teachers were asked to brainstorm ways to incorporate the arts into math lessons with the sole aim of raising scores on standardized exams. “This was repulsive to me,” he said. “Of course, I support the math teachers. I think the students should do well in math, and I want them to do well in all of their subject areas, but it denigrates the other subject areas when you talk about integrating like that.” However, Ben still wonders if his assessment of Arts Integration is fair and correct. He admits he may be wrong, but “I think that might not be what Arts Integration Specialists are trying to do. But that’s the idea that comes across to me.”

In addition to his skepticism about Arts Integration and, by extension, many conceptualizations of STEAM, Ben quickly points out that STEM is rarely integrated as practiced in schools. “I don’t like the way that I’ve seen STEM, in particular, being implemented. My thinking is that they should be more integrated,” he says. “The idea behind STEM, as I understand it, is that science, technology, engineering, and math are all interrelated, but you very rarely see them taught that way.” In addition to the lack of integration that Ben observes, he also points out that the STEM component subjects are not equally weighted. “There’s definitely an emphasis on math, at least from what I’ve seen in public schools in New York state.” Yet Ben is under the impression that the influence of STEM is dwindling to some extent, as he believes standardized testing has lost its footing because of a “backlash” resulting from “a recent wave of testing that is starting to subside.”

Another current and related initiative in education that Ben talks about is “21st-century skills,” which he notes is often seen as a rationale for STEAM. “That’s the knowledge that you need to have to be able to independently and fully participate in society,” he explains. When I

point out the similarity of his definition of 21st-century skills with the classical definition of liberal arts, Ben notes that the similarity is “ironic because now they’d now probably be thought of as progressive.” However, Ben notes that the emphasis on 21st-century skills might not be accessible to all students. “It’s problematic,” he admits. “I think because it is still exclusive. It doesn’t leave room for everybody to participate. For example, students with special needs, physical, cognitive, or otherwise.”

I share Ben’s skepticism about the so-called “21st-century skills,” but from a different perspective. In my view, they appear to be driven exclusively by economic utility rather than broader educational goals or simply learning for its own sake. As an educator, I hope my work involves more than developing the next generation of appropriately skilled workers. But Ben called me out on the narrow scope of my perspective: “Alright,” he said, “but so is the whole educational system as we know it. I think it’s a fair criticism, but it should be applied to the education system at large.” However, when I started talking about American education through the lens of a capitalist critique, it seemed to make Ben a bit uncomfortable. Ben brought up the historical influence of capitalism on education, beginning with Henry Ford. “He needed people to work in his factories and he needed them to have a certain whole of education in order to work on the machines,” Ben observed. Adding that “if [education] happens to be economically productive, that’s not necessarily a bad thing.” When I asked Ben if he saw any tension between ideas of education geared toward creating a design economy and others that might have a more open-ended or humanistic agenda, he said that he believes “both of those can be true at the same time. Who’s to say that more humanistic education can’t lead to a stronger design economy, and if it does, what, why is that necessarily a bad thing?” Ben’s apparent preference for harmony between competing ideas over taking up a more critical perspective about the influence of

capitalism on education seemed to alight squarely in the crosshairs of conservative educational critics from the late 20th century, who warned of an erosion of cultural, moral, and ethical values out of an imperative for “relativism” (Bloom, 1987). At this point, I notice Ben’s ideals take a sudden turn toward pragmatism as he makes the point that “economics, as a driver for progress, does not have to be taken so cynically. I think if the ends justify the means, and if it is a driving force for a stronger economy, I’m all for it.” With this statement, it became clear to me that underneath the strong social values he claims, Ben embraces a definition of arts education that primarily relates to economic utility. “Well, the arts is the marketing department,” he added.

Visions of STEAM

Given what appeared to be his bent toward an industrialist philosophy of education, I was surprised to learn about some of Ben’s visions of an ideal approach to STEAM and interdisciplinary arts in practice. I found one of his ideas particularly radical: that STEAM itself might be too restrictive. “Maybe we just need to do away with subject areas altogether,” he suggests. “Now that’s really pie-in-the-sky, but I think that if we really want a really comprehensive education, it’s essential to see how all the different subjects are connected because they are.” For this reason, Ben holds that approaches like STEAM are “coming from more of an ideal and theoretical perspective because the way that I think STEAM is meant to work is without separating classes by subject, by having it really being intercurricular. I don’t know if that’s happening anywhere.” If such a course could exist in the setting of public schools, Ben believes that it would need to abandon the traditional ideas of the subject-specific learning objectives and aims that are defined by standards in favor of more general ones that have more to do with approaches to learning. “I think it’s much more open-ended than what I’ve seen. It’s more of an open curriculum.”

Ben would also insist on having teachers from different subject areas co-teach in the same classroom to ensure more of an interdisciplinary rather than a multidisciplinary approach. “Instead of having a separate science class, a separate math class, a separate technology class, a separate art class, I think it would be best served and approached as a co-taught class with teachers in those different fields.” While he fully admits that such an arrangement would normally not be feasible in a public-school setting, Ben suggests that schools might experiment with alternate approaches to scheduling, noting that “within one school, you have a science, math, technology, and multiple arts teachers. So it is not difficult to get those four or five teachers in one room at the same time if you make a point to schedule it that way.” Ben notes that “The technology teachers are also often the engineering teachers” and suggests that engineering can serve as a natural access point for the arts. He points out that “there’s so much design inherent in engineering education that the arts have to play a role.”

Another possibility Ben suggests as a possible approach to interdisciplinary STEAM would be to have one person with multiple certification areas and broad interests teach across subject areas in a single course, although he admits that it would be “very difficult to find one person who could do that.” When I suggest that he might be an example of an ideal person for the job, Ben demurs by saying, “One of the things that I really love about STEAM and this approach is the collaboration element,” reinforcing his constructivist and constructionist disposition to “learn new things” in a learning community. Ben elaborates:

I love being in a situation where I need to learn something new. And it keeps things interesting for me as the curriculum can get very repetitive very quickly. So being pushed to the edge of my expertise is an opportunity to discover something new, to explore, and

then bring it into the classroom to rejuvenate myself, but also to bring a richer experience to the students.

Hence, one aspect of Ben's vision of how STEAM might exist in an ideal world involves scheduling that supports co-teaching and collaborative planning for teachers. It also suggests that teachers might regard "being pushed to the edge" of their expertise as an "opportunity to discover something new" that might benefit their students rather than see it as a threat.

At the same time, Ben can point to an example of what he considered a successful interdisciplinary class taught by a single teacher in his own experience as a student. "When I was in high school, there was an AP class offered that was a combination of European history, art history, and English literature. I think it was called 'Recurring Themes,' and I think it was taught by one social studies teacher." As a possible approach to STEAM, Ben envisions a "learning experience that encompasses all these different subject areas" that might include a multidisciplinary rotation of short subject-specific units throughout the year. "So then you have science and art and history and math. And I think that kind of mixing and matching would be a really interesting way to do this."

Ben suggests that a similarly interdisciplinary music course might investigate musical acoustics, incorporating science, engineering, mathematics, technology, and music into one course. "I mean, anything we do in music can be related back to science and acoustics," he says. "Studying sound waves can bring them into mathematics as well. And then [as a music teacher], my biggest focus is on creativity and creation and having students learn by making and learning through a constructivist methodology." Ben's current sixth-grade general music class already looks something like this, as students design and create digital musical instruments using Makey Makey kits and write music using Scratch (an online, object-oriented programming website

designed for kids). “Through working with Scratch, they’re able to explore elements of user interface, design, virtual instrument, design elements of sound design, and again, principles of programming and coding.”

Pushback

In recent years, as Ben has shared his approach to teaching sixth-grade general music at various music education conferences, he has felt some pushback from traditional perspectives that challenge the value or necessity of digital instrument creation as central to the goals and aims of music education. “I’ve presented at conferences about Scratch and Makey Makey, and I get the question every once in a while of, ‘Well, why are we having them make instruments when they can just as well learn how to play an instrument?’” Ben reflects that much of the pushback he has received has come from music teachers who are “uncomfortable with using music technology. They want to but are afraid. But that reminder is very powerful.” Through this perspective, Ben says he is usually able to remind them that national standards encourage the exploration and investigation of “multiple modes of musical expression. This is not replacing their band or orchestra instrument,” he says. He also explains, “In my view, the computer can be a musical instrument, and when treated that way, it doesn’t seem so foreign.” Ben says these arguments and approaches usually allay the fears of teachers who may object. “That’s enough to get them to at least agree with me in public. I don’t know what their internal thoughts are. They might still be very skeptical.”

Although bridging the “digital divide” between what Ahn and Jung (2016) and Metallo and Agrifoglio (2015) describe as younger “digital natives” and older “digital immigrants” can often present a challenge, Ben notes that it does not necessarily occur across generational lines in his experience. He observes that, on the one hand, many “older, more experienced teachers who

have found their rhythm and have taught the same exact curriculum for the last 10, 15, or 20 years” find it difficult to adapt to using new technologies, but not for lack of technological skills. “The younger teachers are able to adapt much more easily to change, and I think it’s more about that than it is about specific technology,” he notes. On the other hand, Ben says he is “always amazed at students at how bad students are with computers. They know how to use an app and touch an icon with a touch screen, but if they have to do anything with typing, or file management, or manipulating things with a mouse, they freeze.” Yet at the same time, there are students whose technical abilities surpass Ben’s, even as sixth graders. He had one student who was “dabbling in processing and C plus and Python, and he was complaining that this wasn’t real coding. It was a little frustrating because I didn’t have access to any of those higher-level coding languages that he would’ve loved to work with.” In the end, Ben says that access to the digital literacies required to support his understanding of STEAM is a matter of adaptability and how open and willing teachers and students are to explore emerging technologies.

The biggest challenge for STEAM, and why Ben ultimately believes “STEAM can’t happen,” are public school funding schemes tied to standardized testing results. “If students are not taking a standardized math exam,” he explains, “the school is not able to receive funding from the state.” For this reason, schools are reticent about taking any risks that might diminish their potential to achieve the highest possible ranking (and therefore funding). Ben sees the difficulty in his contention that teachers and administrators must embrace ideas and practices that may seem counterintuitive to that objective before they can show achievement at the highest levels. Open-ended approaches to learning (as Ben envisions for STEAM) are not feasible without first unlocking the constraints of standardized testing-dependent funding. “It takes a lot of courage from administration and faculty to embark on something like that. I think there’s a lot of

political courage. There's a lot of personal courage," he says. By "personal courage," Ben is referring to the "vulnerability" that teachers must possess in order for them to be the kind of authentic learners that are needed to support a constructivist approach. Ben acknowledges that "a lot of adults are very uncomfortable with that, but I think we're seeing in education now that there is more of a swing toward embracing that vulnerability." Although Ben says that he is unlikely to see these sweeping changes in the span of his public-school career, he has hope for the future. "I think there's the beginning of an opportunity to start moving in a direction like that or to start, at least, rethinking."

Saying What STEAM Is

With his critical perspectives on STEAM as a starting point, Ben is able to articulate several conditions that he believes are required to support his vision of STEAM teaching and learning in public schools. Several critical aspects of his school environment that he most appreciates include the forward-thinking nature of the administrative support he receives, which allows him to "go out on a limb" and experiment with new approaches. "I am lucky that I'm given a lot of freedom," he says. "I actually feel very supported." Ben's principal happens to be a former music teacher, which he finds to be helpful, especially when he sets out to try new approaches. "Even if I can't explain to him exactly what I'm trying to do, he's able to understand what the goal is. And he's able to help me focus my thinking a little bit more," Ben says. An example of that kind of familiar support is when Ben first proposed purchasing Makey Makey kits for a musical instrument design project. His principal asked, "Okay, so what's the music side of this? Why is this a music thing?" Ben says he had to stop and think about the question, but he felt supported in finding the best possible way of articulating a rationale for something he instinctively thought would be a powerful musical learning experience for his students. "...and I

knew that it was, and I'm still struggling with how to justify it verbally. I know inherently that what we're doing is important for the music education of my students. And I finally think the rationale is about different modes of musical expression," he explains.

Ben also appreciates his school's collegial and collaborative culture, where he feels comfortable working with colleagues in STEM areas to develop lesson plans. "I've actually gotten to be very good friends with them because our interests line up," he says. In particular, the technology department at Ben's school shares the Makey Makeys with him and uses Scratch to teach more advanced aspects of coding. As a result, Ben reports that the two curricula complement each other very well. "So the students that then have music after they've had technology have a little bit of that prior knowledge and that basis for creating some more advanced projects when they are doing that with me," he explains.

Scheduling is always a limiting factor for sustained collaboration between teachers. "We haven't had a lot of opportunity to work together because of the way the scheduling works out," Ben says. In addition, the fact that students are not programmed through elective arts and technology sequence of courses in any particular order "makes it challenging to co-plan a curriculum with another one of those rotating courses." Nonetheless, teachers still manage to co-plan and collaborate behind the scenes for asynchronous projects. One example is a ukulele that the students design in build in Ben's class and a ukulele pick that students design and 3-D print in a technology class at some other point in the school year.

As a *harmonious blacksmith* of sorts, Ben is attempting to construct an environment and approach that promotes free experimentation and autonomy through authentic learning both for himself and his students. He explicitly talks about his approach to the problem-solving needed to pursue his vision of STEAM as a multi-step, iterative "design process" and views his own

innovative practice as a teacher as a natural extension of the constructivist values he espouses as a teacher. Part of the educational design process for Ben is reflection and reassessment, and it has led him to learn about and adopt a constructivist approach, which has led him to a new and challenging terrain as a music educator. In the next section, we will meet an educator whose embrace of the ideas of constructivism took him even further.

Jasper, the Bricoleur

Jasper first became interested in music technology after attending a workshop for music educators on using MIDI in the music classroom. At the time, MIDI was a relatively new technology. “The Mac had just come out a few years earlier,” Jasper explains. The week-long workshop taught in-service teachers “how to connect synthesizers and computers together” and how to use the music software of the time to arrange and compose music. After nearly a decade of working as a school band director, Jasper admits he was keen to find easier and more efficient ways of arranging concert pieces for his ensembles. He recognized the potential that emerging music technology of the time had to serve as a practical and novel solution for the task of arranging multiple concert pieces and generating parts for band. For that reason, he says he was “very motivated and got on board right away and did all those things for arranging.” During the workshop, Jasper was struck by the ironic fact that because the large university that hosted the course “didn’t have any technology” at the time, the instructor needed to bring in gear from the middle school where he was teaching during the day to facilitate the workshop. This experience had an immediate impact; on the very first day after the workshop concluded, Jasper reports that he “bought a computer and synthesizer because I needed to rearrange band music for my small, little, elementary school band.” With what he learned from the workshop, Jasper was able to

address a problem that initially turned his interest to music technology: he was now able to tackle the complex process of creating school band arrangements with increased ease and efficiency.

In the following years, Jasper began finding more applications for technology in his music classroom and decided to enhance his practice by pursuing a master's degree in a program that specialized in music education and technology. He was attracted by the opportunity to study under a mentor who, he says, "wrote the book on music integration and music technology." This time around, in this particular university setting and only a few years after his first exposure to music technology, Jasper notes that he had access to state-of-the-art technology.

It was all very cutting-edge... And so, I wrote a coding program to get kids to compose music, but in HyperCard talking to a synthesizer." With the knowledge Jasper gleaned from his graduate work, he could "integrate the computer lab and integrate computers and get the kids to play music.

Jasper began exploring new applications in his own teaching and discovered an opportunity to support and advance interdisciplinary arts curricula on a broader level. As his career advanced and he moved to a large suburban school district, Jasper found that his skill set was regarded with interest and value. "And then," as he says with a sense of bemusement,

The schools started hiring me to do workshops to do music integration. Friends of mine said, "Hey, we are having this professional day, and us music teachers don't want to learn about Core Curriculum. Can we hire you?" So I got into the circuit of sorts.

With this, Jasper began to find that his skills and understanding as a music technologist and music educator opened new professional opportunities for him. In his job in a new district, Jasper began to split his teaching duties with a new role as a technology integration specialist. It was after three years of working in this context that Jasper entered a doctoral program in music

education and technology at a major university. He says the program was a good fit for him because he intended to remain a school-based practitioner rather than pursue an academic career. “Most people who go for the doctorate there don’t become professors. They have a big chart on the wall, and about half the people go back to the classroom.”

The Birth of a Constructivist

On his return to graduate school, Jasper noticed that some things were different: students seemed to have variable skill sets as they entered both the music conservatory and undergraduate music education programs. A notable blind spot for teacher educators in his program at the time was understanding the technological skill set of incoming students. Jasper’s doctoral advisor confessed “We have no idea of the skills of the students.” As Jasper considered the implications of this unknown, he recognized an important problem and quickly zeroed in on a key dissertation research question: “What technology skills do incoming freshman music students have?” Jasper also saw this research as a possible way of centering and scaffolding college-level curricula in music technology. In the ensuing research project in which Jasper analyzed “hundreds of surveys from Big Ten students,” he says he found that despite having some exposure to music technology in the classroom, more advanced students knew what they knew about it because it had become a hobby.

Like their music teacher showed it to them, but it wasn’t in school where they learned it.

It was those [students] who did things that were not shown [to them] by the music teacher in high school, but they did it on their own. They burned their own CDs, they composed their own music, they learned how to do drum tracks.

Jasper began to see a strong connection between the findings of his research, what he was learning about the theory of constructivism in his graduate coursework, and what he calls

“hobbification.” Jasper takes credit for coining the term, which he relates to the similar portmanteau of *gamification*. “Even in my current job today,” he says, “I try to create [hobbification] as an influence—that you try to make your class as hobby-like as possible.” Jasper’s concept of “hobbification” may be taken as a kind of what Bruner (1962) describes as *incidental learning*, in which knowledge and skills are acquired “without conscious effort or formal instruction” and occurs spontaneously as a product of environment, social interaction, and personal experience” (Mayer, 2019). The “holy grail” for Jasper is when students take what they’ve learned in the classroom and take it home as a hobby for enjoyment and further experimentation. “Hopefully, then, it becomes a hobby at home where the real learning happens. I mean, that’s really the goal,” he says. In his early years, both as a researcher and as a teacher, Jasper began to understand that the love of learning that motivated kids who “did it on their own” stood in contrast to what he saw as traditionalist approaches. He describes a graduate-level music technology methods course taught in the conservatory, where students were tasked with recreating the exact same score using music notation software. “That just sounds horrible to me,” he says. “When I teach it, the idea is, ‘What do you have in your life that you need an arrangement of? That’s what you should do, and I’ll give you an “A” for even getting it started.’”

For Jasper, a constructivist approach means embracing autonomous and student-directed learning as core values and, most importantly, motivating learning with necessity and knowing how to get out of the way of a student’s exploration process. He tries to avoid being the “sage on the stage” as much as possible.

I often say, “You are not learning if I am talking. If I’m giving instruction, you know, you want [my talking] to be [at] a minimum, so let me talk and then let me get out of the way because you don’t learn until you start talking to each other, and where you ask

questions out loud, like ‘How do I do that again?’” That’s when the learning takes place, not when I’m demonstrating it.

Jasper talks about a favorite assignment in which the student is given a video of a cartoon or animation stripped of sound as a starting point. The student is asked to create sound effects, dialogue, and music for the clip. He allows students to choose their own clip to work with and emphasizes the importance of giving students freedom and agency in this phase. He provides basic instructions on attaching audio to video and sets them free, saying, “Here’s how you compose for film and do foley. Go!” Again, de-emphasizing grades, Jasper says that he makes the activity as low-stakes as possible, explaining to students that “If you fail, that’s okay. At least I knew you tried.” And with even a minimum effort as a starting point, Jasper feels that he can scaffold student work to the next level with encouragement. “I mean, if you have ten sounds, you can have ten more.”

It is not difficult to imagine a potential misunderstanding of Jasper’s approach in which it might be thought that his curriculum lacks rigor. Yet Jasper reports that his approach routinely results in students working fervently on projects at higher levels that exceed his own expertise. “There are some crazy gifted children who are doing coding more than I ever will know, and I’m just trying to create an environment where they can be geeky with each other, and it’s okay.” Jasper aspires to a result in which students approach what they are learning in school with the passion, interest, and dedication of a hobbyist or an amateur (in the etymological sense of the word). “That’s where I feel like I can be a success,” he says, “when the kids come back and go ‘Hey, I did do what you said. Can I show you what I did at home?’ Like, that’s what I want.” Jasper offers this approach as an example of how he believes he is different as a teacher and, most significantly, as an example of what he means when he self-identifies as a constructivist.

When asked to provide a more exacting definition of what he means by this, he says that he views constructivism as being endemic to the arts and all other disciplines. It is a natural component of lifelong learning. “Whether it’s arts or not,” he states, “Your whole life ideally should be as constructivist as possible, in theory, because that’s how people learn.”

Jasper explains that he tries to strike a balance between instruction and exploration in his approach to curriculum to create the ideal conditions for a constructivist approach to learning. Bruner echoes Jasper’s sentiment when he writes that incidental learning “complements formal instruction by providing opportunities for serendipitous discoveries, unexpected insight, and spontaneous creativity” (Bruner, 1987). To accomplish a balance between intentional learning and incidental learning, Jasper front-loads his courses with more traditional, standardized content that emphasizes practical, creative skills and literacies and gradually releases responsibility to students throughout the course until they can work autonomously in the final weeks. He told me,

I think you do definitely need the standards and then some time to experiment later. So I think I honor that, if you squint at my curriculum, I do that, where I am trying to get them to all sort of do the same thing, or learn the same terms, or learn the same tools, and then set them free, and treat those last weeks of a nine-week class as a hobby.

While Jasper believes that students should be given copious amounts of free, unstructured time in class to experiment, he was not always comfortable with this practice. He struggled with earlier in his career when he worked as a kindergarten teacher. [It was] “just like when I taught kindergarten, like, ‘what all this hour-and-a-half of doing nothing in the afternoons?’ Like, it should be more structured, at least.” But now, Jasper prefers to allow students the option of entire unstructured class periods and accepts that such times won’t always be ostensibly productive and may, at times. As he explains it,

The kids just come in, and they're working on all different types of projects in a totally constructivist way. And I ask them, "Do you want it to be more structured? Do you want me to tell you what to do, or do you want it to just be open? And some days you don't do anything, and some days you do. What do you want?" And they said, "No, we love it open." I'm glad with their answer because that's what I wanted to hear.

Jasper also admits that often, his students just need to socialize and are not given adequate opportunities to do that during the school day. He shares that "Not every day is productive for every kid, but they have a good time, and it's very social and, you know, kids don't get enough social time like that, where they can just chat and hang out and so on."

A Question of Privilege

Jasper also seems to be aware that his understanding and experience of constructivism may not be universal and may not be accessible to everyone. Jasper points out (and almost brags) that his district is "well endowed" financially, which makes it possible for it to be exceptionally supportive of arts education and to continuously invest in technologies, thereby providing access to teachers and students to the latest and most current commercially available tools. Jasper says that the wealth that his school district enjoys supports an environment that makes his conception of a constructivist approach possible. He adds that "all kids have iPads or laptops," and his school technology lab website (considered in this study) lists an impressive catalog of state-of-the-art tools available to students and teachers in a specialized lab and across classrooms. "I have this production room... where I have state-of-the-art computers, cameras, microphones, a big green screen, lights..."

Jasper is aware of the school's economic privilege and points to his state's practice of funding school districts through local property taxes. "As unfair as it is—and there is a school

only five miles away that has no money—and, you know, we have all this money because we are on a piece of property with big houses with no apartments,” he says. “It’s like a dream come true that, you know, if you’re the superintendent or the business manager, you could say ‘yes’ to everybody.” The school said “yes” to Jasper’s request for a state-of-the-art digital production room. “Luck” was part of it, as he explains, “My superintendent finally said yes, just because of luck, you know. Finally, a room opened up, and he threw \$100,000 at it. And so, you know, there is some luck involved.”

In addition to the financial privileges afforded by a wealthy school district, Jasper explains that he also enjoys a special status in which he is given relatively full reign with the curriculum. “I’ve had a variety of jobs,” he says. “But the whole time, [administrators] just say, ‘What do you wanna do?’ and they give me a blank check, and I do what I want for half the day.” Jasper says he spends the second part of his workday as his district’s technology integration coordinator. In his current role, “I can decide what I want to teach,” he explains. “I’ve been there for 20 years. This freedom has resulted in a departure from strictly defined music courses towards more of a potpourri of digitally mediated arts, or “arts technology” classes, which sometimes (but not always) include a music component. Such a free mash-up of arts and technology may well be considered a form of *bricolage*, and Jasper, a *bricoleur*. As Jasper explains,

I currently teach three classes of art technology, sixth, seventh, and eighth-grade classes in various forms. So, I decided to teach an introduction to digital arts for sixth grade, where we do graphic design and coding a little bit, filmmaking, and green screen work. And then in seventh grade, they either can do programming or “multimedia,” I call it, where we do get into music composition. Then, in eighth grade, I teach filmmaking, and

now a music composition class, but there are other music teachers in the district [who fulfill music education requirements].

Other music teachers in his building (comprising its own district) approach music with a strong technology inflection. “All kids have iPads or laptops, and so these other great teachers are also incorporating music composition and analysis.

Jasper emphasizes the economic threshold to technology in public education and STEAM in particular. “The best description I read somewhere of what music technology is is that it’s a box of Crayons, except it’s a \$1000 box of Crayons instead of a dollar box of crayons. That’s what it is.” Jasper’s explicit and unabashed talk of blank checks, six-figure favors from superintendents, and thousand-dollar boxes of crayons signal a certain bravado about the economic privilege he enjoys in his school district. While I believe he expresses it as a point of pride and accomplishment, such statements taken out of context (or perhaps even in context) may fall flat on the ears of educators who are attuned to the challenges of working in less economically privileged settings, or perhaps indicate a problematic criticality. Nonetheless, it raises the question of whether a materialist perspective of accumulating “toys” might be part and parcel with Jasper’s vision of a constructivist classroom environment. I would argue that a materialistic ethos is not exclusive to advantaged districts such as Jasper’s. In my experience teaching music through technology in an underserved urban setting, I noticed that students were motivated by access to high-end technology and seemed to garner a sense of pride by learning how to use sophisticated technology that was, incidentally, often relatively expensive.

Divides, Gaps, and Identity

The rarified environment of a wealthy community tampers with the usual forces of nature that define technology and the arts in public schools. When the gravitational pull of economic

utility and material scarcity is removed from the equation, aspects of music education are turned on end and defy the norms that one would normally encounter in a public-school setting. An example of such a paradox is how the line of the digital divide falls between music teachers. One might expect such a divide to be age-related and exist between generations or perhaps between traditional “BCO” (band, chorus, orchestra) or general music teachers and technology-based teachers. But when I asked Jasper if such a divide existed among music teachers in his district, his answer surprised me. “That’s not a good question to ask me because all of us have tech backgrounds in our music department.” In fact, one of the general music teachers for fourth grade holds a master’s degree in music technology. Another music teacher holds a state certification in technology and is “very into technology.” The band director at his school used to teach composition and used computer-based compositional tools as a platform for his class. Jasper reports that there was never much resistance to technology as far back as he can remember in his decades-long career at the school. “Not in our neck of the woods,” he says, “because when I was hired, they were already teaching [technology-based] music composition to sixth, seventh, and eighth-graders. Jasper explains that the composition classes were thinned out as the population dropped. “Nobody ever said ‘don’t do it.’” Jasper sees technology as naturally integral to music education in his school, and teachers use technology fluently without any major obstacles. “There is no line between music and music technology. I think we all see it and use it every day.”

Despite the relative wealth of technological resources available at his school and his characterization of his school district as being unusually committed to the arts, Jasper reports that part of the limitations he has encountered in bridging the divide between performance and composition has stemmed at least partially from the challenges of dwindling populations and the

challenges of programming arts classes in a rotating schedule. But Jasper says that the main source of difficulty has been his colleagues' lingering commitment to traditionalist approaches and the challenges of "breaking" those patterns. He reflects that,

We're all friends, but like, it's hard to break that pattern. Like why doesn't the general music teacher, who's super tech savvy, why do they still play only recorders at the concert? Why don't they also get their iPads out and play some of their performances? So I can't break that yet. Give me ten more years.

Jasper also acknowledges that a generation gap does exist, but in an unexpected way: Even though next-generation teachers may be squarely on the literacy side of the digital divide, Jasper bemoans the traditionalist bent of most younger teachers, suggesting that older, more experienced teachers are better equipped to teach music through technology. He suggests that younger teachers tend to default to performance-oriented teaching using dated, traditional standard repertoire. "You know, sometimes it's hard," he says.

And we're older teachers, for sure, you know, when that band director retires, and someone comes in who's 20, or 22, or whatever, can I get them to not make it a John Phillips Sousa concert? Like, can I do it? So, it's just a little challenge for me.

Even though he considers the performance-oriented music teachers in his building/district to be "high tech," Jasper observes a pronounced gap between performance and composition that exists for his colleagues, which he has been trying to rectify over the course of his tenure, and which he identifies as area future growth at his school. Hence, the critical divide is not so much between music teachers who are equipped and facile with technologies but is rather between performance-focused teachers such as band directors and general music teachers (for which regular performance expectations exist) and the music technology teacher, for whom a student

performance may be regarded as an unexpected outcome. Considering the three National Core Arts Standards of Performing, Composition, and Improvisation, Jasper believes his job as a music tech teacher is primarily to engage students in music composition, performance, and improvisation, to a lesser degree. Reciprocally, Jasper feels that performance-based teachers should provide more emphasis on composition. “My job as the music tech person is that we do 95% music composition and a little bit of performing. But you, as the band director, should still be doing a percentage of all three,” he says. Regarding this frustration, Ben shares an anecdote illustrating the tensions he has felt with traditional educators.

For twenty years, I’ve been saying, “How are you gonna get music composition?” This gentleman’s like my age, and like, you know, he’s feeling a sense of burn-out. And I’m like, “I can help you! Like we can do all new things. No one cares if you play *Lincolnshire Posy* at the concert or whatever you want to do. Just no one cares but you. You know, your job is not to entertain the parents. That’s not your job. It’s tradition, but you could make it educational, and make it different, and make it—you know—get them off their phones and doing something really unique. Can I help you?”

Jasper asserts that his performance-based teaching colleagues in his school are beginning to include more progressive elements in their curriculum design but believes that they are still beholden to traditionalist values that are difficult to break away from.

Migration

Another kind of gap appears to be widening for Jasper as his commitment to his conception of constructivism increasingly draws him into a more interdisciplinary position that doesn’t always fit neatly within the domain of music and music education. He tells a story illustrating how his embrace of constructivism has managed to pull his identity and practice as a

teacher away from being a music teacher. Because he has a classroom full of computers, Jasper reluctantly took on the role of hosting his school's computer club, which he says, "I never wanted to do, but it just sort of fell into my lap." Initially, students saw this simply as an opportunity to play video games. Without disparaging the students' enjoyment and deep experiences of video games, Jasper leveraged student interest in gaming to transform the class into a social learning environment. "I said, 'We are here to teach each other. And if you want to game, go home, and I totally support you, but here, we're going to teach each other what we do best.'" Under these conditions, Jasper reports that students begin working at higher levels that exceed his own expertise. "There are some crazy gifted children who are doing coding more than I ever will know, and I'm just trying to create an environment where they can be geeky with each other. And it's OK." Jasper's initial success with the computer club led to further efforts to accommodate students' creative interests through technology, including an after-school filmmaking club, for which he received funding.

Jasper's multi-arts role also evolved from Jasper's previous years as a fifth-grade music teacher, although the curriculum has since drifted away from music *per se*. Now, despite his academic and professional background, Jasper no longer solely identifies as a music educator; his disciplinary palate has expanded to include other arts and subject areas that appear to be more about technology. Over the course of his career, Jasper says he has straddled both sides, but he now leans more toward technology as his native area.

I took myself out of the music world. Like, there are music tech music conferences sponsored by MENC..., and I used to be the tech chair of that. But now my job is more technology...I was trying to be in both camps, and I couldn't many years ago. And so, I

moved more to tech. I keep thinking about going back to the music conferences, and I just haven't done it. So, I find myself more on the tech side of the world.

With this unexpected turn, it now seems Jasper's identity as a teacher might now be more accurately characterized as being multidisciplinary or interdisciplinary rather than a dedicated classroom practitioner of music education. When I found Jasper's profile on a professional social media platform, I noticed that he describes himself as an "Arts Technology and Technology Coach."

I can relate to Jasper's positionality, as I am also an interdisciplinary teacher who primarily orbits around music but shares valences with other subject areas. Yet Jasper seems to have reached an escape velocity that resulted in leaving the orbit of music in favor of technology, at least professionally. Although I find that my own disciplinary roots are strong within the field of music, I recognize my own trajectory in Jasper's story. I can relate to how following student interests down the wormhole of new areas can lead to unexpected places that may or may not seem to fit within the common conception of disciplinary boundaries. I also have grappled with the question of whether those pathways are truly determined by pure student interest or are determined by the available technology itself. I wondered if education is guiding the use of technology in the classroom or if it was the other way around. Like Jasper, my pursuit of a constructivist and culturally responsive approach often meant constructing learning around what captivated student interest, which would most often relate to the entertainment they consumed. The interdisciplinary nature of these art forms often required coloring outside the lines of music education.

Of STEAM

When I asked Jasper about his views on STEAM as an Arts Technology Coach and former Music Technology teacher, Jasper immediately shared the story of his 14-year-old son, who attends public school in another district where he is currently enrolled in a “STEAM” course. “It just sounds painful,” Jasper said, to my surprise. Although Jasper describes his son as “sciencey,” he doesn’t show much enthusiasm for the kit-like projects assigned to him in the STEAM class. “How does that have payment later?” Jasper asks. “They do the project, but he never talks about it. He never was excited about it, although he’s very sciencey and tech-oriented. He knows how to play the game of school, so he does it.” Jasper blames this on a lack of authentic, responsive, and spontaneous constructivist approach from teachers, who lazily rely too much on programmed materials. Ben finds the “kit” approach to be anathema to constructivism and believes that teachers who adopt the commercial offerings of STEAM education “don’t really know what STEAM means.” Jasper says that he has watched STEAM education become increasingly commodified and has consequently begun to develop his own capitalist critique of STEAM. The phenomenon is most apparent to him when he attends national conventions for technology and education. “When you go into the room of all the vendors, that’s what it seems they’re pushing. It is just turn-key technology components, like for teachers to check it off. So it barely holds my interest.” With the increased commodification of STEAM education, Jasper’s “box of Crayons” has melted and devolved into prepackaged STEAM “kit” projects that come with step-by-step instructions to build (rather than create) a preconceived product. Jasper bemoans this fate, saying, “It was a box of Crayons before, and now these are just the kits. And when you’re done, you take it apart, and then the next student does the same thing.”

By contrast, STEAM takes on a much more organic and ingrained form at his school. Jasper believes that STEAM practices there are tacit yet practiced widely. To preserve that, he feels that he needs to “keep his mouth shut” lest these practices become codified and formalized due to the clumsy way he feels bureaucracies can often approach the finer points of curricula. It is STEAM in its vaporous form that naturally occurs in Jasper’s building. In fact, it is a point of pride for Jasper that students are not necessarily aware that they are engaged in STEAM learning, although as a teacher, Jasper “does it and sees it” and prefers unprompted, unscripted natural occurrences of STEAM where and when they happen. Jasper asserts that, like any creative workshop, STEAM is not necessarily neat and tidy in nature and, therefore, should be allowed to be “messy” from both a teaching and learning perspective.

Jasper also strongly asserts that learning must be driven by interest and curiosity. He contends that if something is not interesting to him, it won’t be possible for him to teach in a way that will be interesting to students because he would only be “making [his students] step through” something that he found monotonous and uninteresting. Take, for example, STEAM kits:

When I see those kits, there’s just no spark for me. And I don’t really like Maker Space myself. It doesn’t do much for me. So I have my own—it’s not demons—but my own thing that I like or not like to do. So therefore, I’m not going to teach it to my students because it doesn’t spark my interest, so how would they share that love? How would they feel that same joy of learning if it’s something that I’m sort of just making them step through?

For Jasper, passion and curiosity about a subject area are key factors in helping a teacher successfully connect with students. That spark is intensified when a learning community can be

established where the teacher can learn from students and find a way to honor their insights and perspectives. “When I’m teaching something kind of new to me, or something interesting, or it’s creative, or it’s artistic, then they feel my excitement for it,” Jasper says. “Or like when they try something new, and I’m like, ‘Wow, that’s so cool. I never even thought about it.’ That’s great.”

On Environment

Jasper contends that the panoply of digital literacies he offers students access to in his classroom helps create the special conditions necessary for students’ passions to ignite. In his view, a significant part of his mission as an educator is to create the kind of special environment where such sparks can be further kindled, and the key to creating that kind of environment lies in emphasizing intrinsic over extrinsic motivational factors. Jasper reflects that higher levels of learning are autonomous and driven by curiosity rather than motivated by grades or checklists of skills. Importantly, failure must always be an unthreatening possibility for students, which cannot happen unless the extrinsic motivations that can easily scare students away from failure can be removed from the environment. “And when they don’t have to worry about their grade or a real critical checklist of skills because failure is always an option, then that’s where the learning takes place.”

However, the special environmental conditions for “safe failure” are afforded not only by Jasper’s constructivist teaching philosophy but also by a perfect storm of a blind eye turned by his district supervisors, taken together with a lack of clearly defined standards for the “T” of STEAM. “I try to be a role model, yeah. So, I think that plays a role, and I take advantage of it. There are no state standards, really, for technology, or certainly ones that my boss cares about,” Jasper admits. He explains that administrators are too focused on core academic subjects to pay sufficient attention to technology and the arts curriculum. “They’re busy enough rewriting the

reading curriculum every other year, apparently, or what materials the math teachers are using. So I'm last on the list, and I'm happy that way." This administrative blind spot allows Jasper to be selective about what he presents to his supervisors. "I only share good news, like 'Here's some great things the kids are doing,' and then I don't mention their failures. Jasper's apparent contradiction about his own personal embrace of failure from his perspective as a constructivist teacher and his district's lack of understanding or tolerance for failure is noteworthy here. On one level, Jasper celebrates the fact that he enthusiastically models a "fail forward" mentality to his students, but when it comes to what might be visible to school leaders and parents, Jasper suggests that limited transparency is more beneficial for his purposes; he feels that he needs to sweep certain things under the rug. Moreover, he suggests that a certain amount of opacity is needed to create an ideal environment for innovative teaching and learning to take place.

Jasper suggests that the system he works within is purportedly progressive, and he is happy to celebrate and show off the fruits of innovation when they occur. But at the same time, the special quality of learning that can emerge from a project-based constructivist approach tends to happen in spite of administrative control. He also suggests that a pervasive traditionalist ethos is still very much present in the governing values of his district and American schools in general, but notwithstanding, Jasper and experienced teachers like him find ways to work around the typical constraints of traditionalist structures to create and sustain the special environment that he describes in his district, school, and classroom.

In addition to the environmental attributes discussed above, Jasper described several additional conditions that he felt would be the most conducive to STEAM. Firstly, he believes the school environment should support diverse cognitive teaching and learning styles defined by the teacher's strengths. "The teacher should teach where they feel comfortable," he says. "So, if I

was coming from computer programming and I was very left-brained, then the classes would look very different because that's where I would feel comfortable. And there's nothing wrong with that." This reflects a variable that Jasper refers to as "personality," by which I believe he means a combination of cognitive disposition, interests, and comfort with alternative approaches that may be productive while not necessarily understood and valued by an uninitiated outside observer. "So, I mean, we all have our comfort levels, so I think personality matters as long as there's a very supporting environment," he adds.

Secondly, Jasper talks about the importance of a like-minded community to support the environment. In recent years, he has found an online community of fellow middle-school STEAM educators that has been a valuable resource. In this group, teachers help each other by making suggestions for lesson plans and discussing the latest trends in technology. For Jasper, it doesn't matter that the focus of such lessons doesn't always include music as a disciplinary element. His bailiwick now includes a broader base of creative digital practices; therefore, the net is wider. However, despite the wider net, Jasper's community is relatively small, consisting of two other teachers he describes as creating "similar open-ended projects" to his. Nonetheless, the harvest is a good one for Jasper. "We're sharing projects as fast as we can," he says. "I got years of material from two ladies from around the world, who shared their projects with [the group]." One of the outcomes of Jasper's engagement with this group has been multidisciplinary lesson ideas that have helped him forge partnerships with teachers from other disciplines in his building. In his own building, Jasper has identified a small group of elite teachers who also enjoy the kind of special privileges and freedoms that Jasper claims provide the needed environment for STEAM education. "I don't want to say, 'cream to the crop,'" he says, "but there is a group of us that is given that freedom." The small size of his self-contained district, which only has 900

students and in which the superintendent does daily bus duty, allows for such freedoms. Yet he speculates that if he worked in a more standard context or had to work closely with another music teacher in another district, he would be held to different standards and wouldn't have the room to experiment. "Then I'd have to be really responsible. I mean, I couldn't make mistakes because I'd have to be accountable to somebody else." But because "nobody cares what I'm doing—in a good way—then I can experiment and fail."

Finally, Jasper supports a much more liberal approach to making high-end technologies accessible to students. He rejects the idea that teachers should be models of frugality, always trying to do more with less. He argues that in a financially privileged district like his own, the potential benefits of building student autonomy, pride, ownership, and trust outweigh a more financially conservative approach.

So I could say, "Do the best you can with what you have," but why say that when we can do cutting-edge stuff, and the kids have taken care of it and take pride in it, and, you know, have ownership of this equipment. And so, there's also that ownership and independence and trust.

For Jasper, this means unlocking doors and taking risks to make equipment more accessible. "When the kids come in and just start working, or pulling out \$3000 cameras or mics off the shelf and saying, 'Can we go outside now?' I always say 'yes,'" he says. In this regard, Jasper sees himself as exceptional because "that would freak other people out. It wouldn't fit their idea of taxpayer-funded public education." Jasper's rationalization for acquiring more expensive prosumer (another portmanteau blending the words *professional* and *consumer*) -grade equipment includes an argument for "authenticity" insofar as students would be using more technologically sophisticated equipment that would presumably bridge more effectively to future technologies.

When students ask if such expensive equipment is necessary, Jasper responds by saying, “You’re right, I could. But we can learn so much more with this better equipment because it’s more authentic to what you will do in your future life.” In Jasper’s view, authentic learning necessitates materials and an environment where students can create media that resembles the media they consume.

Jasper’s efforts to create deeply authentic learning experiences for his students speak of his commitment to constructivism and raise a larger question of whether there might be a strong correlation between the principles of constructivism and the domain of STEAM. The music technology lab can be a site of traditionalist approaches, such as the “methods” course that propelled Jasper into constructivism, or it can also be more like Jasper’s “box of crayons,” a creative sandbox where students are granted autonomy and freedom from the traditional pressures of assessment. As we will see in the next section, the experience of the fourth and final participant paints a pragmatic yet somewhat paradoxical possibility for STEAM: a traditionalist, disciplinary pedagogy contained within a larger progressive, constructivist, interdisciplinary agenda.

Laronda, the Pragmatist

Music in the House

Laronda enjoyed a relatively diverse musical background as a child, as she started with the violin in third grade. In fourth grade, it was possible to join concert band, so she signed up and took up the clarinet, which she continued to play and study throughout high school. Later, in middle school, Laronda discovered her voice and joined her school’s choir. Her passion for singing eventually led her to pursue an undergraduate degree in vocal performance in a music conservatory program. In college, Laronda also developed an interest in teaching and started

conducting vocal ensembles. “I used to direct choirs, both church choirs and local choirs, things of that nature. But, as I shifted into the classroom music realm, I didn’t do as much of that,” she says. In her first few jobs in education, Laronda taught general music, “but vocal is my gig,” she says. When I shared my own similar beginnings in vocal performance, I was surprised by the sudden burst of emotion I detected in her response. “It’s a dying art, let me tell you,” she said with a slight tremolo in her voice. “It’s really rough trying to keep it alive.”

Laronda also enjoyed a significant and parallel musical pathway in her life, but it stayed separate, and she never managed to mingle with her musical experiences in school and her teaching career. When Laronda first met her husband, he was captivated by *house music*, which had evolved as a sub-genre of electronic dance music (EDM) created by DJs and music producers from the Chicago underground club culture during the 1980s (Fikentscher, 2000). Now, decades later, her husband continues to produce House music, and the genre has since grown into a shared musical passion and interest for both of them. As much as she appreciates and celebrates the genre, Laronda notices with a sense of injustice that house music is often neglected, underappreciated, and often invisible in the music world. “It really doesn’t have a place in music. It’s kinda like the stepchild, right? Um, that nobody wants to kind of talk about,” she says. Laronda contends that the invisibility of the house music genre is even apparent in the music industry, as House music awards are not publicly shown on the Grammy Awards broadcast. “And that’s even if people call it music,” she adds, “because [DJs and house music producers] don’t often play instruments in the traditional sense, and most of the music is electronic.” Yet Laronda observes that despite the genre’s lack of notoriety, “amazingly, it’s one of the most income-producing genres of music that people don’t talk about.” Her husband has “got a lot of friends who are in the [house music] industry who are Grammy award-winning

artists, and many of whom are millionaires who own two houses. However, you've never seen them acknowledged," she says. "And I got to tell you this — a lot of these guys don't have college degrees. They're just high school graduates but passionate. And it's amazing to me that they're making eight to ten million dollars a year doing this. But they're looked down on by the community."

The disconnect between fortune and fame she observed in her community of House music producers was fascinating to Laronda. "That was where my curiosity came in. Cause it's like, yeah, but you're making all this money, and people aren't even getting it!" However, the disconnect she perceived between the opportunities afforded by popular music genres and what she saw taught in music classrooms was even more striking. House music, hip-hop, and other popular urban genres have "no presence in school, and the perceptions about what people think it is is what's kind of keeping it from coming in," Laronda observes. In her view, there was no question about the artistic merit of DJing and house music as an elevated musical art form. "We all know that magic when you go to a wedding or an event. And that music is just right where it needs to be," she says, but also notes that "there's a lot of kids who are already doing this without our knowledge, without our training, without us helping them." Laronda realized that music education was not only failing to reach students where their interests lay but was also failing to help students take advantage of the vast potential advantages within those interests. At the same, she was surrounded by a creative community that had the potential to build bridges for such students. "And these are guys who are out there producing stuff for Madonna and Sierra and Beyonce, like really big-time people in the music world and saying, well, 'What do we need to build? If we wanted to build this, what would it look like?'"

The solution for this particular puzzle, thought Laronda, was to extract music education from its usual position in the constellation of arts education and reimagine it as a component of Career and Technical Education (CTE), which had evolved from the “shop” courses of vocational or education in the 1990s. “Do you know the only [state] approved music program [for CTE] is in our district?” she asks. “It’s not vocal, it’s not instrumental. The music program is music technology.” When she says her district was “going through a huge push” to apply for funding for CTE programs, Laronda felt compelled to find a place for DJing and popular music production under the CTE umbrella. It was also a matter of survival. “So I’m like, I gotta get on the bandwagon too. So, you know, my courses don’t get eliminated. And when I did it, I said, isn’t this something?” Now, with her music technology program as the first and only CTE-approved music program in her state, Laronda was able to untether her version of music education from the traditional academic and conservatory-like aims of music education as it usually exists in schools. She found that under the rubric of CTE, music education was driven more by pragmatic vocational concerns and less by the academic skills required for college prep. “So I decided that there’s a lot of kids who may or may not want to go to college for a thousand reasons, and now with COVID, like a lot more reasons,” she observed. Yet freedom from the mindset that all students should necessarily be on a pathway to college allowed for the possibility that students could find viable career paths while still following their passions. “I also knew how much money these [music producers] were making, and I was just like, ‘If I got a kid who’s passionate about something, listen, an honest living is an honest living. I don’t care what you do.’”

Defining the Problem

In her current role as an administrator in a suburban school district outside of New York City, Laronda concedes that most instances of music education in her purview cannot be repurposed as an element of CTE. The state is still bound by arts standards and keeps an army of thousands of arts teachers, all of whom have earned specialized teaching certifications in their art form. When it comes to new initiatives and inviting change to the existing system that her district operates under, Laronda says that she experiences the expected difficulties of trying to change a structure from within. She also expresses frustration with the extent to which she feels teachers are prepared to handle the changes required to support students in the 21st century. In her view, these conditions impede the possibilities for “Arts Integration.”

As far as music educators in her district are concerned, Laronda believes that the majority of them are particularly ill-equipped to implement interdisciplinary approaches for initiatives such as STEAM for several reasons. From a philosophical perspective, Laronda holds that “the arts, in its really unique way, is a reflection of life. And equally, life is a reflection of art.” For this reason, arts teachers should take a holistic approach to the creative process that takes into account multiple ways of seeing and thinking, but such an ideal is not the case. Laronda says she generally finds visual arts, theatre, dance, and film arts teachers to be more open to Arts Integration than their counterparts in music. “Some of them are totally into that philosophy,” she says, “and I find they are way more aware and embracive of the concept. Music teachers are not.”

The culprit, Laronda believes, is what she describes as a “crisis in the postsecondary world,” specifically in the field of music. “We have a crisis because students are taught the way that teachers were taught. Post-secondary educators do not fully understand the world that their

current students are walking into.” Many young teacher candidates who have graduated from conservatory-style music programs have the “wrong idea” of what it means to be a music educator in a public-school setting. “I really think there needs to be a serious revisit of post-secondary education as it comes to music education. I really am very passionate about that,” she attests. “I really put it back on the postsecondary folks,” she says.

You prepare them to be a musician, but you do not prepare them to be a teacher within an organization. I want to say, “You are beautiful as a performer. Amazing. But can you translate that knowledge for the next generation? Cause if you can’t, it will die on that hill with you.”

With many new music teachers, Laronda says that she often has to sternly explain that “it’s really important to know what your role is in an organization. You are not the entree. Because in a post-secondary music program, you are the entree.” With this potential misunderstanding in mind, Laronda says she will give new teachers a pep talk:

I say, listen: We are the appetizer. We are dessert, right? [Students] look forward to it, so whet their appetite. We get them ready for the main course, and we know that the main course is the testing grades, right? But once that’s done, we are the sweet treat at the end. So we kind of wrap the meal together. So don’t be upset that you’re not the entree.

Some readers may bristle at Laronda’s description of arts education as a side dish or as a kind of reward for students, especially as the metaphor of “arts as the dessert” echoes widely across policies such as “Race to the Top” (2009) that marginalize arts education in schools as “add-ons” (Garcia & McCarthy, 2020). Nonetheless, I believe Laronda’s observation needs to be put in context, as it is rooted in her own considerable experience and hard-earned, pragmatic wisdom. I see it as an apt response to the solipsism I have sometimes encountered in conservatory students

and a tough reminder that in many public schools, the arts are underfunded and undervalued. In any ensemble, players must learn how to blend and collaborate; interdisciplinary teaching shares the same demands of a musical ensemble in this regard. “*Not everyone can be the entree.*”

Laronda says that a similar ideal often attracts post-secondary music students to careers as music educators. “Everyone wants to be a high school band director,” she says. But many are bound to feel disillusioned once they are hired to teach elementary school general music and “realize that you’ve got to teach all six grades and it’s art on a cart. And like, and not embracing that because it feels like it’s, ‘I just gotta get through this until I can get out of this.’” Laronda takes a beat to reflect. “Yeah. Okay,” she says wryly. She shares an alternative scenario, “Now you’re teaching in a basement in a hall, right? And there’s this emotional impact of ‘Now I’m just tossed aside’ and really not understanding how you have to work to integrate and create a place for yourself.” Laronda explains that this, too, results from misguided expectations germinating in the conservatory.

Music teachers in Laronda’s district face another genuine concern: student enrollment in band programs is dwindling. According to Laronda, many music teachers don’t think of their programs as something they have to sell to students and colleagues. She argues that finding viable ways to connect across the curriculum and be instrumental to the school’s mission is essential for survival. “A lot of people don’t get that because they get caught up in the musicality, which is not a bad thing. It’s a great thing. But you have to know how to package yourself,” she says.

Selling music education to students is another matter. “You know, students have a lot of beautiful choices these days. There’s a lot of free options out there, more than when I was a kid, and music used to be that one option,” but that isn’t the case anymore, she says. Laronda cites

the example of her three school-aged children who, even in a household with musical parents, are not interested in picking up a musical instrument. “They’d much rather be on their phones,” she says. Laronda argues that 19th- and 20th-century pedagogical practices have no place in the 21st-century classroom. “Our students are a different type of customer today, and they’re looking for quality assurance. If you were a kid in the eighties and the nineties, you’re just happy to be sitting here. That attitude difference is killing us, and post-secondary people aren’t understanding. Those days are over.”

Another considerable obstacle for music teachers that Laronda points to is a steep digital divide. “We have a bunch of educators that are out here who are not well-versed in technology because technology means whatever you mean when you say the word technology.” She points out that many teachers may have thought that they were proficient with technology because they owned a phone or computer, but when the pandemic struck, it quickly became clear to Laronda that many teachers lacked the requisite skills to use technology to teach effectively online, let alone integrate it into their curriculum. In the meantime, Laronda claims the difference between teachers’ and students’ technological literacy levels has widened dramatically. “Now you have a population of students whose skill base surpasses the teacher... and not by a little bit-- by light years.” When it comes to music educators, Laronda ties their technological shortcomings back to inadequate post-secondary teacher preparation: “I think back to when I was a music major, when did I use a computer? never.” Yet the problem that Laronda describes is not merely a matter of teachers who were revealed as technological troglodytes during the pandemic but rather a more complex problem of integrating technology when teachers and students have a broad and scattered range of abilities. “We’ve realized in this situation how deficient our educators are, or for some of them, how advanced they are in the tech. So we are really in this weird place where

curriculum standards are increasing, but you have teachers who don't know how to integrate technology.”

If we are to take them at face value, the sum of the factors Laronda describes adds up to a fundamental difficulty for teachers to connect to students, let alone connect collaboratively with teachers of other disciplines. “As a person who hires teachers, I have to break that news all the time because they're not ready,” she says. The problem, Laronda says, is not only that many music teachers have difficulty connecting with students and colleagues but that they are often so isolated that they don't see the benefit of connecting in the first place. “So then you hear about collaboration in curriculum, it honestly feels completely overwhelming, like a wave that's eight feet over for you because you're not prepared for that,” she says. “And if you're saying, okay, we got to create a curriculum that connects with students and connects with STEAM and so on, it's too much. You're really talking about a community of educators who are actually uneducated in how to connect.”

In Search of the Substance of STEAM

Toward the end of our first conversation, I was surprised to learn that Laronda had attained a professional teacher certification in Arts Integration through the same program Andrea had attended. Although I suspected that their paths had crossed at some point, I did not ask if they knew each other in the interest of maintaining confidentiality and following IRB guidelines. I was also interested to hear that Laronda found that when asked, most of her colleagues in the Arts Integration certification program struggled to offer a clear definition of STEAM or even describe examples of what it might look like. Other than the literal meaning of STEAM as the sum of the constituent subject areas, taken with the implication that these areas should somehow be working together in an interdisciplinary way, “there's not a really solid, strong, tangible

example of what it is that's aligned to a singular definition," she says. This lack of clarity compromises the potential of more refined embodiments of STEAM as they might exist and leads to common misunderstanding and confusion. Laronda points out, "People hear STEAM, and honestly, I think they think science and engineering, period."

However, to Laronda (and Andrea), STEAM is something defined and specific: It is an instance of Arts Integration, "which is, I guess, like the directional map of STEAM education. That's what I think," she says, adding authoritatively, "in order for it to be done well and authentically, the true definition of Arts Integration must be upheld." As we previously heard from Andrea, "Arts Integration" is defined by a technical criterion of aligning standards across content areas. These must be "two or more contents that have an equal footing of elements, skills, and assessment," Laronda explains. Andrea and Laronda point out that many teachers falsely believe they are "doing STEAM" by merely including something they consider "artistic" in a science or math lesson or, conversely, something "sciencey" in an arts class. "People say, 'Oh, we're doing science! Color the map. Color the... We did it!' And you're like, 'um, no.'"

Without the careful, explicit alignment of standards across content areas that share an "equal footing" of elements, skills, assessment (and "cognitive demand," as Andrea would add), "it's just *arts enhancement*," Laronda states. "And I gotta be honest with you," she adds, "I think that's why you don't see it, and if you do see it, it's not long-lasting because it's not done systematically."

Laronda's rigid definition of STEAM surprises me, just as Andrea's did. As a technology-based music teacher who strives to make deep interdisciplinary connections, I am not following Laronda and Andrea's exclusive formula, but I wouldn't consider my practices anything less than pure STEAM in its best moments. If I were to analyze what happens in my

classroom after the fact, I might be able to dig out some of the rigid roots they both demand, but I would argue that doing such rootwork in retrospect is quite different from planning it in advance. I feel more at home with Janet Barrett's assertion that an "interdisciplinary perspective resists classification and ridged definitions" (2023, p. 216), and I wonder if Laronda is perhaps burrowing her way to freedom by embracing the rootwork of standards as the way forward as Andrea does.

Regardless of whether Laronda's tactics to implement STEAM are subterranean or airborne, her aim is structural change. She argues that institutional values and the organizational structures that contain STEAM must be reimagined if interdisciplinary initiatives are to be viable and sustainable. In Laronda's view, nothing less than a complete structural overhaul would be needed to break through (or perhaps to completely dissolve) the reinforced walls of disciplinary silos for a STEAM approach to education to thrive on a large scale in schools, "but to do that takes so much time, structure, energy, systems," Laronda explains. "Schools aren't organized that way. Schools are organized in silos, and contents are organized in silos." Another constraint is finding the needed time and space within such rigid, vertical structures driven by the imperative of standardized testing. Laronda points out the problem:

If you're after fifth grade, even fourth grade, the space for STEAM gets real challenging because the standards are so rigorous and time-consuming. To master the standard of one content, how will we bridge it for two? And I don't think that it's that people don't want to. There's not enough time in the typical American school day to fulfill both objectives. Once again, the old theme of *standards as education* grounds the imagination and dries out the air needed for STEAM. The narrow dead end that Laronda describes reminds me that institutional structures are always a reflection of underlying values, and if structures are to

change, values must change first (Scott, 2014). For STEAM to exist in public school systems, Laronda believes that it must first be a core value before it can receive the programming support and resources it requires, but she is cautious and realistic about the possibility. “I won’t say that it’s not attainable, right? I would say that it has to be of value within an organization. The challenge is that value has to be at the core for it to work.” The hard reality is that STEAM often fails due to competition with what is almost universally the higher priority of standardized testing.

If you are in a district where test scores are challenging, it’s really typical to fail because there needs to be so much planning, and planning takes time, and planning cannot be in isolation. Like I, the music teacher can’t do it. I have to have an English teacher and a science teacher. Like we have to be sitting at a table to create this and then implement it. So I don’t think that it’s just hard. It’s just hard because when is there a time for us to collaborate?

Hence, interdisciplinary teacher collaboration and planning must happen in person, with teachers from all the relevant disciplines at the same table. Laronda describes her experience of the rapid back-and-forth process as a ping pong game in which “you do something, and then I do something,” in a dialectical process of building a curriculum as a community. In this conception, STEAM changes its state from the cloud-like “approach to learning” that Andrea describes to the solid form of printed lesson plans that a teacher needs in hand. In this regard, Laronda differs from Andrea in her insistence that STEAM must be considered as a kind of curriculum (and not just an approach to one) if it is to survive. In Laronda’s view, if an idea is not in a concrete form and on paper, it remains elusive and vaporous; it will evaporate. The “magic bullet” missing for STEAM, says Laronda, is a “good, viable, solid curriculum that is carefully mapped out with

standards.” Laronda is aware of the trade-off; in its temporally frozen form, an instance of STEAM might appear to lose its more elusive dynamic qualities, yet she also asserts that at least in its early stages, a pragmatic compromise must be made if STEAM is to stick and be sustained. As Laronda explains, the reason is simple: “School leaders think materially and in terms of the almighty standards.”

Facing the challenges of the monumental institutional changes that would be required to implement a STEAM curriculum leaves schools in “uncharted territory,” Laronda says. But she also expresses a heightened sense of urgency attached to pursuing this ambition, especially in the wake of COVID-19, which managed to loosen the soil for new curricular possibilities and technologies. “Schools have got to reframe and restructure right now and strike while the iron is still hot,” she says. But this is no small undertaking, she admits. “you’re trying to break and completely restructure the silos,” The work ahead requires disruption, she says, and she closed our conversation with a personal and passionate call to action: “We ourselves are disruptors in this field of music education, so it’s necessary. Because if we don’t disrupt, I believe there won’t be a field left.”

The Tales (or Tails) of Four Skunks

The portraiture of the four music educators described in this chapter reveal both commonalities and differences in their dispositions toward, practices, and understandings of STEAM education, but their habitat on the epiSTEAMological ecotone comes into sharper focus as a dynamic and complex interdisciplinary borderland. To the extent that generalizations may be possible, the interdisciplinary “skunks” portrayed in this chapter are characterized as a *technician*, a *harmonious blacksmith*, an exiled *bricoleur*, and a savvy *pragmatist*. In the following chapter, I will argue that they all share the same striped tail (and perhaps scent glands)

of a constructivist and explore critical questions that lay outside the frame, including the extent of their reflective criticality about how they are situated in the political scheme of knowledge in schools, their acquiescence to the authority of standards, and the question of whether many of their efforts to work to affect change within the system might reify and reinforce the old, restrictive epistemological silos of academic disciplines at the expense of a more transcendent conceptualization of STEAM.

“The best way to ‘know’ a thing is in the context of another discipline.”

– Leonard Bernstein

CHAPTER VI: REGROUNDINGS

A Return to Eden

In this chapter, I return to the metaphorical garden where this study began, but now, with the fruit of the new understandings and theoretical insights that emerge from this study in hand. It may be helpful to start a discussion and analysis of the data presented in this chapter with a reminder of my original purpose. In this dissertation, I wanted to explore a group of secondary music technology teachers' perceptions, practices, and attitudes toward STEAM education, their understanding of their communities and ecologies of learning, their preparedness to teach in this emerging field, and their strategies for implementation of STEAM in the classroom. These phenomena were studied so that STEAM might be further enlarged and enriched within the discourse on music education and, in turn, be of potential value to a broader, more critical discourse concerning the influence of economic forces on knowledge, culture, and education.

My aim in this chapter is to examine the views and experiences of the participants to understand how they may interact with and relate to existing scholarship on STEAM and music education I described in Chapter II, the evolving research questions guiding this study, and my own experiences throughout my career as a teacher. In the metaphorical language of this dissertation, I will examine the paw tracks of the skunk-like participants to see how they overlap, diverge, and intersect with the literature and my own experience.

An Arborescent Analysis of STEAM

In the spirit of transdisciplinary, I extend an ecological metaphor that stems from the related literature to be applied to the research questions, which now take the form of the parts of a tree: the trunk, rings, branches, twigs, leaves, and crown. The image of a tree is advanced by Deleuze and Guattari (1987) to represent hierarchical, binary, linear, and centralized structures of

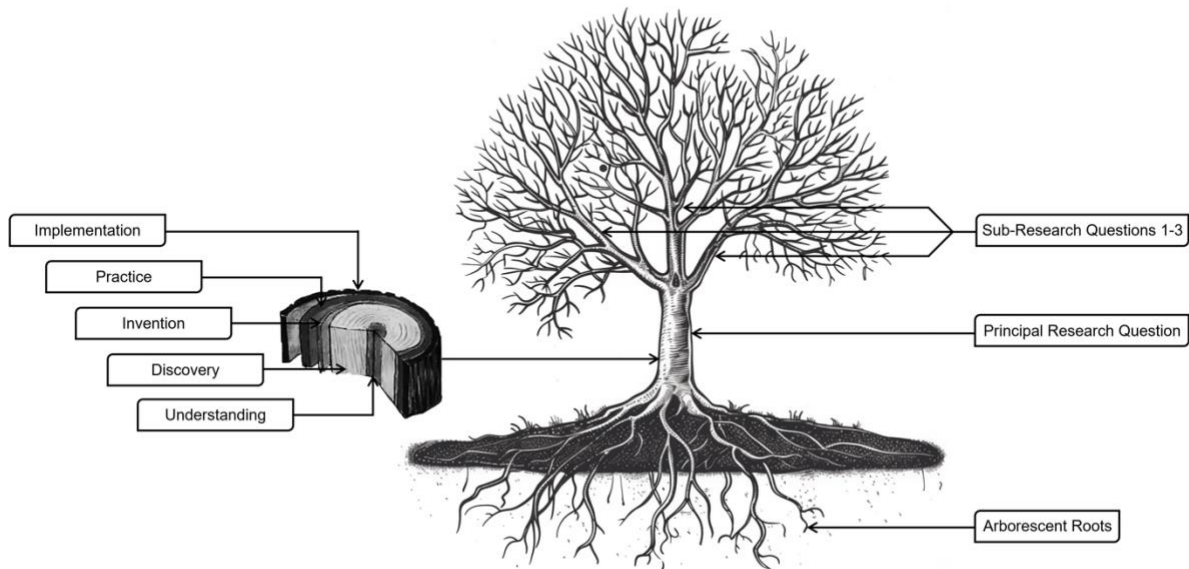
knowledge, such as those found in scientific paradigms and arguably in academic disciplines as they exist in their usual silos. Deleuze and Guattari contrast the tree-like or “arborescent” knowledge structures with non-hierarchical, non-binary, nonlinear, and de-territorialized ways of knowing represented by a rhizome, such as the ginger root. This study began with an arborescent and structured approach to research questions, however, as I discussed in Chapter III, research questions may change and adapt in phenomenological inquiries (Creswell & Poth, 2018). The tree of inquiry may change its form as the phenomenon is revealed and understood, either into new tropes of the original branches and twigs or perhaps into subterranean networks of rhizomes that subvert and upheave the old tree. This chapter begins with an analysis of the data based on the fixed, initial arborescent structure of the research questions. In the second part of this chapter, I will look outside the frame of the research questions to investigate phenomena that may not have been caught in their branches and twigs.

Research Questions

The principal research question, or trunk of the tree, seeks to understand how a group of four technology-based music educators “*understand, discover, invent, practice, and implement STEAM education,*” suggesting five categorical rings within the trunk of the primary research question, which seek to understand the phenomenon of their lived experiences of STEAM as teachers and learners depicted in Figure 1. Therefore, in this section, I will discuss how the participants in this study described their experience of understanding, discovering, inventing, practicing, and implementing STEAM in their classrooms.

Figure 1

Conceptual Framework of Analysis



Afterwards, I will return to the trunk to find three branches of sub-questions reaching skyward, which asked:

1. How do the participants perceive their community of practice, and how do they make sense of their own learning ecology specific to music technology as a discipline?
2. How and to what extent has their experience teaching, learning, and artistic practice led to engagement with STEM subjects? (In other words, just how “STEMy” are they?) In what ways is their learning in STEM areas supported by their environments?
3. What are they doing? What do they consider the most STEAM-like elements or aspects of their teaching and learning practices to be, and how do they relate their praxis to the goals of music education? How do they relate to STEM education and STEM?

Continuing with bifurcation, I will discuss and evaluate the data as they relate to each twig of the research sub-questions.

Living Rings Within the Trunk

Ring 1: Understanding

The trunk of the primary research question seeks to understand how the music teachers in this study *understand, discover, invent, practice, and implement* STEAM education. As we look at a cross-section of the trunk, we find the large, innermost ring of *understanding*, which contains many of the tree's xylem and phloem. In this first ring, I will explore how STEAM is defined by participants and the literature, followed by a more extended discussion of how the participants view and experience the power relationships between the arts and the sciences implicit in the acronym.

In contrast to evidence in the literature that STEAM might be an ineffable and fleeting phenomenon, Andrea and Laronda shared a conception of STEAM in crisp, solid form and in high resolution: They offered a detailed and technical definition of the term in which STEAM is seen as part of Arts Integration and, as such, must be purposefully grounded through the alignment of standards across two content areas with similar cognitive demands. The taxonomic precision of Andrea's (and, to some extent, Laronda's) vision of STEAM is reflected in the insistence that STEAM could only formally exist in the context of a school curriculum if it met rigid criteria. Andrea's orthodoxy is most likely a product of the training she and Laronda underwent as state-certified Arts Integration specialists, especially as they both appear to have been trained by the same outfit. Paradoxically, they dug deep into decisively disciplinary earth to find solid foundational grounding and rooting to define, capture, and perhaps even bottle a phenomenon that is neither solid nor static. In addition to her intricate rootwork, Andrea insisted

that STEAM should necessarily be categorized as a branch of Arts Integration, following her training and practice as an Arts Integration Specialist.

Andrea's definition came as a surprise to me, especially as someone who thought they were already an avid practitioner of STEAM – perhaps I wasn't all along. On the one hand, the notion that STEAM might be defined separately from other possible interdisciplinary configurations beyond the STEM subjects made sense. On the other hand, Andrea's understanding of STEAM strikes me as having a chilling effect, as it removes the warmth and inviting comfort of my first experiences of STEAM to freeze it into *ice cubes*, with the hope that doing so would allow neat cubes of frozen STEAM to fit into a rectilinear, institutionalized vision of education. The poetic eye of transdisciplinary thinking and relational understanding might see STEAM as a richer and more complex phenomenon. I remember my college tutor, Thomas Simpson, who could see mathematics (and arguably, STEAM) deeply and metaphorically. The way Ptolemy's phenomenological system of the planets might be understood as a "cosmic dance" and how the significance of Ptolemy's mission to "save the appearances" might also be expressed in the circuitry of a digital sampling synthesizer are exemplars of the kind of transdisciplinary, relational understandings that Deleuze and Guattari (1987) describe as "lines of flight." I wonder how Mr. Simpson might have reacted to Andrea's conception of STEAM and how he might have tried to emancipate her understanding from its well-intentioned but limiting moorings.

Ben struggled to find a definition of STEAM that would help him justify and bring legitimacy to his teaching practice when he found himself drawn into the misty fog of a STEAM ecocline between music education and the technical aspects of digital instrument design and construction. At least initially, he was unable to fully articulate how his vision for such a high-

tech curriculum might relate back to the traditional goals of music education. “I knew that it was — and still am — struggling with how to justify it verbally. I know inherently that what we’re doing is important for the music education of my students. And I finally think the rationale is about different modes of musical expression,” he explains. The STEAMy fog that Ben experienced may also be the kind of philosophically generative confusion that Socrates describes as *aporia* (ἄπορίᾱ) in Plato’s *Meno* (2006). More currently, Maxine Greene describes the benefits for teachers when they are open to being surrounded by the kind of clouds of confusion that one often encounters in borderlands. As Allsup (2016) paraphrases her, Greene argues for “the idea that teachers are at their best when they are on the edge between knowing and unknowing, learning and unlearning.”

Jasper and, to some extent, Laronda were less exacting in their definitions of STEAM and offered more anecdotal accounts and metaphorical representations of their understanding, (e.g., Jasper’s recurring image of a “box of crayons”). A significant difference between *understanding* and *definition* is highlighted when we consider the implications of Janet Barrett’s assertion that “an interdisciplinary perspective resists classification and rigid definition while opening space for catalytic turns and openings” (2023). The participants who sought to pin down a definition of STEAM shared contrasting understandings of the phenomenon with those who resisted offering a rigid definition and classification beyond the literal meaning of the acronym. Except for Jasper, who took more of a non-essentialist approach to the question, the participants share the frustration that the blurred lines that define STEAM are an obstacle for the concept and for the teachers who seek to practice it.

The same sense of frustration around the problem of defining and legitimizing STEAM led me to explore this topic and investigate it further through the process of this dissertation. I

once had the opportunity to teach on a campus that was home to two schools; one was a half-day program for gifted students in the arts, and the other was a program for similarly gifted students in STEM subjects. I taught music at the School for the Arts and taught courses in engineering design and foundational principles at the STEM Institute. My district superintendent enthusiastically supported both schools on the campus and recognized my potential to bridge both learning communities as an interdisciplinary teacher. On the arts side of campus, I enjoyed an open-ended environment similar to the one Jasper created. I taught in a well-resourced digital lab and, with some success, maintained an open-ended constructivist approach with learners in the room for some classes. I enjoyed similar freedom on the engineering side, as the curriculum was project-based, and our programming allowed students to explore and experiment. Both schools served socioeconomically and racially diverse populations as a magnet public school program, and consequently, our campus seemed to be an ideal ecotone for a STEAM approach to flourish as the environment seemed to foster creativity, innovation, and critical thinking skills by integrating Arts with STEM disciplines (Johnson, 2018). However, when I proposed that the campus might be imagined as a laboratory for STEAM education, my superintendent showed a sudden reluctance. The problem, he explained, was the same lack of consensus about the term's meaning and purpose that echoes throughout the literature and is described by the participants in this study. That lack of consensus had made STEAM into what Andrea describes as a "hot topic" and possibly even a "bad word," especially after her publisher asked her to remove it from the title of her book on the subject.

Andrea and Ben point to perceived imbalances and a presumed hierarchy between the STEM and STEAM acronyms' component subjects as the underlying issue. The literature suggests that approaches to STEAM should be collaborative and exercise a balanced weighting

of disciplines in order to take full advantage of the unique strengths and perspectives that each discipline brings to the table (Honey et al., 2014). In addition, equitable power dynamics among STEAM components are essential for promoting interdisciplinary learning experiences that engage students in authentic problem-solving and inquiry-based activities (Bernard, 2014). But as Andrea points out, both the “E” and “T” of engineering and technology are not standard fixtures of the American K-12 curriculum, and consequently, both subject areas currently have standards written using generalized language, making the alignment needed for formal arts integration challenging. Ben latches on to Andrea’s observation and argues that the relatively weak presence of “E” and “T” in STEAM is an opening for the “A” of the arts. “There’s so much design inherent in engineering education that the arts have to play a role,” he says.

I can relate back to Ben’s point, as I once took advantage of introducing musical design into my engineering classes. A student who played the trumpet was curious about how trumpet mouthpieces worked. As a project-based learning activity, he designed his own inquiry in which he researched the geometry and physics of trumpet mouthpieces and then 3-D printed a (somewhat) functional mouthpiece of his own design. One might ask what was being taught and what was being learned in that instance; was it music or engineering, and how should it be counted? From the perspective of the engineering design curriculum I was teaching, this was a pure engineering problem, and at least in my view, it was also just a purely a musical problem, but would such an activity be as readily and universally accepted as part of a music curriculum? I am reminded of Ben, who finds himself politely defending the idea that instrument design is part of music education at music education conferences while sometimes feeling an unspoken, angry resistance from the strict traditionalists in his audience.

In my story, there was no resistance. No toes had been stepped on, and there was no fear of possible consequences for crossing disciplinary boundaries. Nor was there any need to maintain a perfect balance between letters in an acronym. There was just the simple joy of a small, spontaneous project that seemed to lie perfectly across subject areas. I couldn't have planned for it, and the last thing on my mind at the time was how I might need to justify or account for it by aligning standards. That is, of course, because it was only me operating in what amounted to a one-person schoolhouse. As an individual teacher in a vacuum, the balance between disciplines becomes less consequential. When the "normal" forces (a physics term that usually describes gravity) of human, social, economic, and political dynamics that are typically found in a school community are reintroduced, the question of balance between disciplines becomes a political and territorial one that is ultimately a matter of epistemic justice (Fricker, 2007). What began as a question about the internal balance between the letters of a "buzzword" acronym reveals itself as a more profound question of justice within a learning community and the politics of knowledge within the academy (Foucault, 1972).

The biggest question about power dynamics that echoes throughout the literature and is discussed by all the participants in this study is how the "A" for Arts is seen in relation to STEM. The prevailing fear is that STEAM education will not take the form of a democracy of disciplines in which constituent parts are on "equal footing," as Laronda describes it. It would rather be more likely to operate like a republic in which the "S" and "M" components dominate. In the context of a discussion about the implications of a "postmodern" approach to arts education, Elliot Eisner (1992) expressed his concern that "arts education may become little more than a handmaiden to the social studies" (Stinespring, 2001). Eisner's cautionary turn of phrase might now be morphed and repurposed as "the arts as a handmaiden to the sciences"

(Burnard, Colucci-Gray, Sinha, 2021) or perhaps now, more appropriately, “the arts as a *servant* to the sciences” to reflect a critical perspective of the power relationship that many fear might be implicit in STEAM.

Andrea might contend that STEAM in its current form is not necessarily a handmaid’s tale, especially as she claims there is no basis for concerns that the sciences will consume and eliminate the arts. She assures us that “The state’s not gonna let [schools] do that because the [arts] are core to the curriculum, and they can’t cut us.” While such protections may currently be in place in some states, both Ben and Laronda point out that a bigger problem is a common misconception of STEAM in which the arts are nominally and superficially “added on” to a science lesson plan without meaningful and purposeful intent or impact. This is what Laronda classifies merely as “arts enhancement.” As Arts Integration specialists, Andrea and Laronda provide examples of well-intended yet failed attempts at STEAM that fall short of the criteria as they lack alignment of standards and critical problem-solving.

Understanding the arts as serving as a “bridge” to the sciences is just as problematic. In this conception, the arts are again seen as a utility for the aims of STEM, rather than existing independently as distinct ways of seeing and knowing that are essential to a well-rounded education and a “complete mind,” as Eisner writes (2002). Ben voices his strong objection to his administrator’s request for the arts teachers in his school to brainstorm ways of “sweetening” STEM lessons for the purpose of attaining higher test scores. “This was repulsive to me,” he says. “Of course, I support the math teachers. I think the students should do well in math, and I want them to do well in all of their subject areas, but it denigrates the other subject areas when you talk about integrating like that.” By contrast, Laronda embraces the idea that in her experience, the arts are “the dessert” or the “appetizer” to core academic areas. “The main course

is the testing grades [which I take to mean subject areas in which there are high stakes standardized tests].” While the metaphors may be similar, an important distinction should be made between Ben’s strong objection to using the arts to “sweeten” the sciences and Laronda’s embrace of the idea that the arts can be used as an incentive or “dessert.” Both approaches use the arts as an incentive, but instances of Laronda’s “dessert” could stand alone as complete and holistic arts learning experiences, whereas Ben’s “sweetening” implies a cursory inclusion of the arts that do not necessarily have the goals of arts education as its aim.

Another source of contention and confusion that arises in the effort to define STEAM is the question of whether it is essentially a *curriculum*, as Laronda states, or merely an *approach to learning*, as Andrea stipulates. Jasper holds a different view, in which STEAM is a natural byproduct of a constructivist (and constructionist) interdisciplinary praxis. His example of his son’s experience of a so-called STEAM class serves as a strong argument against non-constructivist predetermined approaches or definitions. Jasper’s environmental approach to inducing STEAM, rather than trying to plan for it, might lie closer to my own fleeting and often spontaneous experiences of the phenomenon. In this view, STEAM might be thought of conceptually as an attribute that may describe a meaningful instance of interdisciplinary learning that unites artistic and scientific problem-solving rather than a concrete and well-defined procedure.

Ring 2: Discovery

The second and third rings of *Discovery* and *Invention* are entwined. In his seminal treatise on *The Structure of Scientific Revolutions* (2012), Thomas Kuhn writes that “discovery drives scientific progress by uncovering new phenomena or insights,” whereas “invention plays a crucial role in translating discoveries into practical applications and innovations.” In this study,

the ring of *discovery* was illuminated in the personal histories of each participant as they first came to understand the value of STEAM in their lives and in their teaching practices. Each of the participants' rhizomatic and nonlinear journeys as music educators led them to unexpected junctions in their careers, leading them to embrace technology as their primary means of teaching music. With the exception of Laronda, who did not emphasize technology in her musical history, the other three music teachers in this study spoke of moments of discovery in their own histories that led them to diverge from traditional teaching pathways. Andrea described her "conversion" into a music-based Arts Integration specialist when she recognized technology as a powerful means to engage students and began to discover interdisciplinary access points between music and other subject areas. Jasper was drawn to a STEAM approach to music education when he discovered the efficiencies afforded by early music notation software. Overall, each music educator described a heuristic, exploratory approach to learning and exploring music technology beyond their initial discoveries of inter- and trans-disciplinary potentialities for teaching music through technology.

Ring 3: Invention

The third ring of *Invention* was a significant theme in the experience of one participant in particular, whose music teaching practice is centered around musical instrument design and creation. Initially, Ben was troubled by the question of where he should draw the line between the aims of music education and the aims of the STEM components of instrument design and manufacturing. However, upon reflection, Ben maintained and doubled down on his conviction that *Invention* is a necessary part of musical experience. When we broaden the concept of *Invention* to include and expand beyond the creation of musical technologies, we find *poesies* as a counterpoint to *techne*. The idea of *invention* might also imply the act of music composition. In

the tradition of Bach, whose inventions were not only musical masterpieces but also demonstrations of new music technology (Ledbetter, 2002), Ben invented and explored new compositional styles that could make musical use of the delay and time latency that is inherent in the digital transmission of sound over the internet. In another participant's experience of Invention, Jasper showed extraordinary commitment to creating a classroom environment that might best encourage and inspire students to invent. In both Ben and Jasper's classrooms, students wrote complex computer code to program synthesizers and used open-ended hardware kits such as Makey Makey platforms to create musical instruments through which to play their compositions. Jasper's clear and critical objection to the prevalence of so-called STEAM "kits" with prescribed step-by-step instructions shows his commitment to constructivism and to designing the kind of authentic, heuristic experiences for students that best support musical exploration and Invention.

Ring 4: Practice

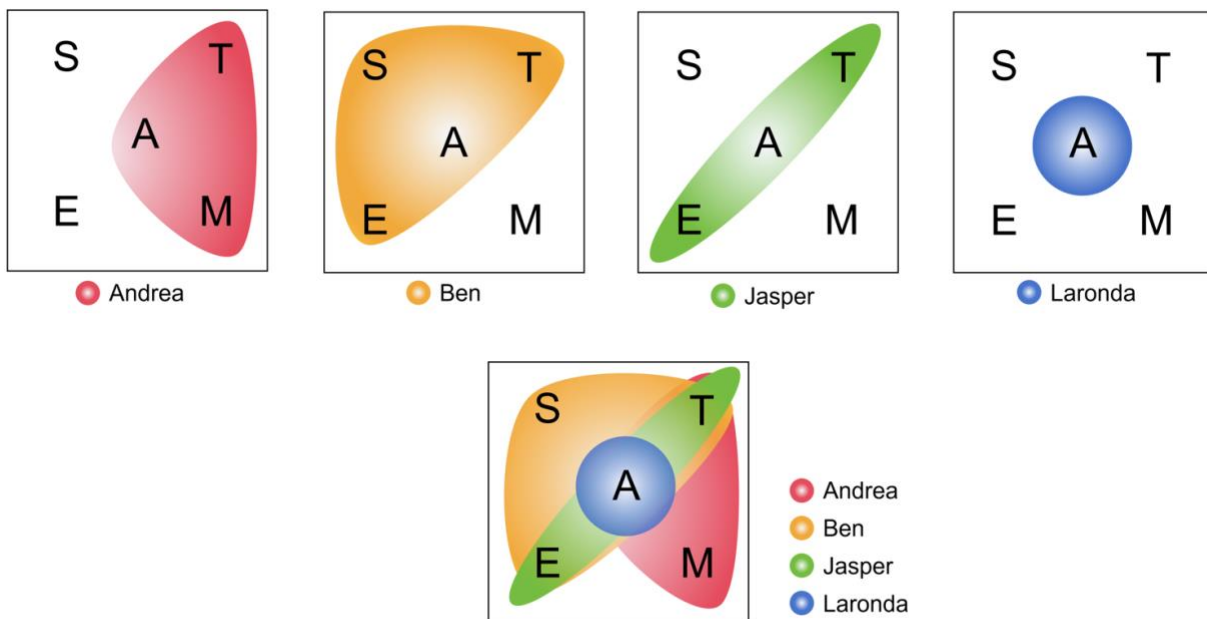
The teachers in this study may be characterized as sources and makers of STEAM; hence, the fourth ring of the primary research question of *practice*. Visualizing the various configurations of disciplinary engagement and practice in each participant's reported experience can be assisted by a thumbnail overview. If we imagine a Venn diagram with "A" (for music) at the center, framed by a square formed by the letters "S" "T" "E" and "M," we can envision a two-dimensional map showing how the reported practices of the participants are distributed over the nominal disciplinary elements of STEAM.

The diagrams in Figure 2 may fall short of the kind of dynamic, multidimensional representation needed to reflect the complex and dynamic phenomenon of STEAM. The transdisciplinary thought experiment of a multidimensional *cloud Venn* described in Chapter II

might be better suited for the task. Despite its limitations and the acknowledgment that STEAM clearly does not fit neatly in a box, the composite overview shown in the bottom figure in Figure 2 shows the disciplinary habitat or the *paw tracks* of the participants on the ecotone of STEAM.

Figure 2

Two-Dimensional Overview of Interdisciplinary Practices Reported by Participants



Andrea, Ben, and Jasper share the interdisciplinary overlap between music, as the “A” of STEAM at the center, and digital technologies, as both the “T” and “E” of STEAM or technology and engineering, respectively. Since Laronda did not discuss specific details of her experience integrating STEM disciplines in her teaching practice, her reported practice appears as the only non-interdisciplinary case in this study in the strict context of STEAM. However, the diagram fails to represent Laronda’s rich interdisciplinary practices that transcend the boundaries of arts education, including her work to re-imagine and re-situate music education in the context of Career and Technical Education, where it is integrated with business education. In addition,

sophisticated use of technology is central to the practices of DJing and electronic music production that Laronda brought to the music classroom as an administrator. Therefore, despite its limitations, the diagrams in Figure 2 represent the specific *reported* practice rather than the implied practice of each participant. The interdisciplinary practices of Andrea, Ben, and Jasper feature overlays between music, technology, and engineering. Andrea and Ben identify as “technology-based music educators.” Jasper’s practice is more complex, as it has drifted away from music education as its center point and is now covalent with technology. Now, with two foci of arts and technology at his elliptical center points, Jasper labels himself an “Arts and Arts Technology Coach.”

Ring 5: Implementation

The four “skunks” who participated in this study demonstrated a diverse array of skills and strategies to implement STEAM in their districts, schools, and classrooms, hence, the fifth and most outer ring of the primary research question of *implementation*. In this section, I will discuss the participants’ perspectives on the institutional structures, practices, and outlooks that either support or obstruct the possibility of interdisciplinary music education, as well as their approach to either working to change the organizational systems and structures they occupy from within, or by subverting them. In addition to the critical perspectives described in Chapter V, each participant expressed frustration and confinement as they attempted to transgress disciplinary and organizational boundaries in their efforts to implement STEAM.

To the extent that an organization’s structure is a reflection of its values and priorities (Ahmady et al., 2016), the values and priorities of an educational system are reflected by curriculum (UNESCO, 2016), how it allocates funding (Allegretto et al., 2022), and resources (UNESCO, 2017). A variety of factors can initiate curriculum change, including innovation,

development, and adaptation, and can be planned or unplanned or be caused by internal or external influences (Leung, 2016). In this study, each of the participants was similarly situated as music educators and curriculum leaders working in the organizational system of public schools and districts, and as such, each indicated they were “working within” their respective systems to implement their own visions and versions of STEAM education. Their strategies are consistent with organizational theory, in which Fullan (2007) highlights the strategy of working incrementally within a system as essential to the successful implementation of change initiatives. The four participants also shared similar outlooks and goals as self-described practitioners and advocates of STEAM and faced common structural and organizational challenges.

On the surface, one of the common obstacles the participants faced was scheduling and programming. Ben, Andrea, and Laronda noted that interdisciplinary, collaborative teaching and learning was more of an exception than a rule in their organizations and, therefore, they were not often a top priority. As Laronda lamented, “There’s not enough time in the typical American school day.” According to all four of the participants, the scheduling and programming hurdles they faced could be attributed to an underlying core problem: the imperative of attaining the highest possible student achievement on standardized tests. All four also named standardized testing as a problematic obstacle to interdisciplinary initiatives such as STEAM. Given the common set of situations, objectives, and structural obstacles that the participants faced in their efforts to implement and advocate for STEAM, each brought their own unique and distinctive strategic response to the problem of how to negotiate the shared obstacle of standardized testing. Their responses ranged from acceptance, to subversion, and to assimilation.

The Specter of Standardized Testing

At the beginning of our first conversation, Andrea revealed that among the motivating factors that first led her to explore Arts integration was the funding crisis that the 2002 No Child Left Behind Act brought to underachieving school districts such as her own. Under that policy, schools were compelled to vie for increased federal funding by improving student performance on standardized exams, and that largely meant prioritizing math and English language skills over other curricular elements (Darling-Hammond & Wise, 2015). “There was such a focus on testing and test scores and rote memorization, and you know, drill and kill, but kids weren’t connecting with the content.” Under the circumstances, Andrea explains that “[arts] was a way that I thought that learning could come to life for students...And so, I thought, we could bring the arts in and make it more fun.” Andrea goes on to explain how her advocacy for the arts was initially motivated by their potential utility to build skills in STEM subject areas for the purpose of boosting student achievement on standardized tests. “And so by having it come to life through using the arts, in my opinion, was a good way to try to tap into a community that was struggling desperately.”

Andrea maintains that increased Arts Integration (and, therefore, STEAM) augments students’ performance on standardized tests, but she concedes that her claim is not supported by research. Nonetheless, Andrea embraces an “*If you can’t beat ‘em, join ‘em*” philosophy regarding prioritized standardized testing. She views testing as part of a necessary and balanced educational whole in that testing is “product-driven,” whereas STEAM is “the process that leads you to that product.” However, the COVID-19 pandemic appears to have changed Andrea’s position on standardized testing. As the imperative for testing “went by the wayside,” more opportunities for innovation in curriculum began to appear since administrators “had bigger fish

to fry.” While she seemed delighted with the new freedoms and opportunities that were afforded by the sudden lack of scrutiny and oversight during the pandemic, Andrea’s primary strategy of embracing standards and standardized testing as a means of implementation remained unchanged.

As a fellow pragmatist, Laronda grappled with the question of how to negotiate the power dynamics between test-driven subject areas and the arts. On one level, Laronda fully concedes to the reality that standardized testing is “running the show” as she embraced the strategy of “being the dessert” in relation to what she refers to as the “testing grades.” On another level, Laronda calls for the kind of structural overhaul that would be needed to “put standardized testing in its place” and break through the reinforced walls of disciplinary silos for an interdisciplinary approach to education to thrive on a large scale. Like Andrea, her ready willingness to play second chair to the academic “testing grades” may not be taken as a concession as much as a strategic, pragmatic move to promote the perception of the value of the arts in her organization. While she acknowledges that “to do that [would take] so much time, structure, energy, systems,” the mission is not impossible. “I won’t say that it’s not attainable, right? I would say that it has to be of value within an organization. The challenge is that value has to be at the core for it to work,” she says. Laronda’s approach to instilling the value of arts education in her district has involved a highly strategic approach to disruption, favoring a measured, incremental approach over “trying to break and completely restructure the silos,” she explains.

When presented with the same proposition for the arts to help “sweeten” core academic subject areas, particularly as a strategy to increase performance on standardized tests, Ben responded that he found the suggestion “repulsive” because “it denigrates the other subject areas

when you talk about integrating like that.” Ben explicitly rejects what he understands to be Arts Integration because he believes that it corrupts the mission of arts education.

I have the idea of teaching arts for the sake of teaching arts. And yes, they do interrelate with the other subjects, but the idea of integration connotes that we’re using arts to teach something else, which I completely disagree with.

Moreover, Ben suspects that Arts Integration may be a wolf in sheep’s clothing as it may be ultimately driven by an ulterior motive of increasing performance on standardized tests.

Finally, Jasper espouses an alternative view of the testing culture at his school that sets him apart from the other participants in this study. For Jasper, the emphasis that his district places on achievement on standardized tests steers administrators’ focus away from the inner workings of his classroom. This “cover” provides the desirable level of opacity needed for him and his students to “fail forward” without scrutiny from administrators and parents who may not understand the value of such an approach. Hence, Jasper believes that standardized testing provides an unintentional tactical advantage for implementing STEAM.

Creative Strategies and Tactics

The challenges of implementing STEAM may come as much from internal politics and conditions of schools and districts, as much as from structural constraints. As Barrett observes, music teachers face an increasing din of “white noise” in their school contexts, which consists of competing initiatives, mandates, and various distractions. Such inhospitable conditions have left many music educators feeling hesitant about introducing new curricula that explore interrelationships with other subject areas for fear of lacking curricular footing (Barrett, 2023). Therefore, I argue that *strategic* implementation and advocacy for interdisciplinary approaches such as STEAM are critical to its survival. Cultivation of the delicate, early roots of

interdisciplinary education calls for finesse and know-how, or *techne*. The following sub-section explores the creative, strategic approaches the four participants have taken to implement STEAM.

Of all the participants, Andrea's approach to implementing STEAM is the most technical, as she advocates for a standards-based approach to interdisciplinary education at the root level. Andrea embraces this painstaking and pragmatic approach to implementation to gain legitimacy for the process in the eyes of other stakeholders. The enforcement of exacting requirements of aligning standards across disciplines and cognitive demand levels may be a pragmatic approach as it successfully leverages the existing framework of defined standards. By doing so, STEAM gains conceptual clarity within the limited paradigm of mono- and multi-disciplinary thinking that tends to be dominant in what Giroux (2016) characterizes as a neoliberal institutionalized educational system. Andrea's skunk-like preference for ecoclines and her dual (and sometimes opposing) perspectives as administrator/teacher, teacher/learner, and digital native/digital immigrant may uniquely qualify her as an arts integration advocate, especially as these have fostered a pragmatic, solutions-oriented approach to problem-solving. Her resourcefulness and openness to explore have also served this end for Andrea. After taking on an administrative role early in her career, Andrea returned to the classroom as a music teacher. In that role, even though she considered herself a digital immigrant at the time, she ventured into the unfamiliar territory of teaching music through technology. Andrea's experience as an administrator gave her the perspective of being "on the outside looking in," leading her to insights that she would not have had from her perspective as a teacher alone.

For Andrea, the philosophical fog of *aporia* rising around the contentious topic of STEAM may find a dual purpose as the fog of war; her ability to appeal to both sides as an

insider makes her an ideal double agent. Through this lens, Andrea's initial proposal for the arts as an enhancement for standardized test prep may be taken as a pragmatic and strategic gambit for arts educators who must find a way to subsist in a test-driven world, but taken more broadly, it is a bold declaration of citizenship, ownership, and belonging across borders. Andrea's admonition for teachers unwilling to venture outward and collaborate in Arts Integration is to "find a way of latch on for the ride." When the Arts Integration movement was in its early stages, Andrea latched on for the ride and became an early adopter of the project. Her previous experience as an administrator made her skeptical about the efficacy of a top-down approach, and so she felt that it was essential that an arts educator "steer the ship," lest they "screw it up." Paradoxically, the prescribed orthodoxy of Andrea's approach to "Arts Integration" may be its own hierarchical and dichotomous structure in which gatekeepers decide what qualifies as STEAM and what does not, cultivating their own garden while pairing away and excluding ideas that do not fit their conception of STEAM. In the end, such an orthodox approach may do more to ossify the arborescent nature of the disciplines than to make them more pliant.

As a counterpoint, Laronda shares the same training, and many perspectives that Andrea has of STEAM, but her strategy for implementation is significantly different as it involves a strategic uprooting and transplantation of the music curriculum into the soils of Career and Technical Education. Like Andrea, Laronda also embraces the aims and objectives of STEM and the academic subject areas, at least as a temporary gambit, as she is willing to "let music education "be the dessert," borrowing from the language and imagery from the "Race to the Top" initiative of the early 2000s (U.S. Department of Education, 2009). Laronda also embraces a standards-based approach to STEAM as the kind of pragmatic compromise that is required if STEAM is to stick. In her view, initial compliance is a strategic way to assimilate enough to

begin to affect change in an institutional culture in which “school leaders think materially and in terms of the ‘almighty standards.’” But instead of digging deep to wrestle with the arboreal roots of disciplines as Andrea does, Laronda opts for a transplant instead. The re-seating of music in the context of Career and Technical Education (CTE) in her district serves as an exemplar of how curricular and organizational structures might be re-imagined. The program’s home in a CTE context allows for artists and experts from the community into the classroom who would otherwise not have met the demands of teacher certification, opening a door that would have otherwise been tightly locked under the constraints of the standard music curriculum in the music classroom. The change of curricular venue to CTE implies an emphasis on business and entrepreneurial aspects of performing arts and calls for grounding in technological literacies (Emdin, 2022) and, based on my own teaching experience, may include both digital and crafts-based musical instrument design. In Laronda’s case, the entrepreneurial focus of a CTE approach to music education allowed for increased inclusion and culturally responsive approaches to the thriving House music community she and her husband are part of and support the real-world efforts of students who wish to pursue careers as DJs.

My own skunk tracks match Laronda’s. I spent four years teaching in two separate urban schools in which music was funded and supported through CTE programs. In my experience, both school settings promoted rich project-based learning (PBL) opportunities and were particularly conducive to interdisciplinary teaching and learning that included but extended beyond STEAM. In my classroom, music-making necessitated the integration of technological literacies, economics, mathematics, language arts, and physical science as students were tasked with creating their own musical products in the marketplace. In addition, as in Laronda’s case, the CTE pathway afforded opportunities that may not have been possible in traditional school

music programs. These included the flexibility of bringing practitioners into the classroom as teachers (via lowering the requirements for formal music education), thereby creating more immediate opportunities for culturally responsive music education (Gay, 2010).

Laronda fully embraces the role of a "disruptor" as part of her mission as a music educator and stresses the urgency of making radical changes to school structure and practice. "We ourselves are disruptors in this field of music education, so it's necessary. Because if we don't disrupt, I believe there won't be a field left," she declares. At the same time, Laronda is willing to make the pragmatic concessions that she deems necessary for the survival of the arts, including the use of arts as enhancement and reward to traditional academic areas, including STEM subjects and Language Arts, as well as protectively transplanting music education in the context of Career and Technical Education pathway.

Ben's efforts to implement a STEAM approach to his music classroom have involved a balance of conceptual ideation and pragmatic strategies. His work to articulate a rationale for his digital instrument design curriculum helped him gain the permission he needed to implement his vision of STEAM from his school administrators as well as from skeptics in the scholarly community. In contrast to Andrea and Laronda, Ben advocates for a pure, music-centered, interdisciplinary approach to STEAM without ceding any ground to the instrumental aims of the academic disciplines. He muses about the possibility of obliterating all disciplinary boundaries in schools, as he considers them often to be "impediments of knowledge" as Parsons (2004) describes them. Despite his vision and idealistic philosophical outlook, Ben demonstrated pragmatic ingenuity as he leveraged openings resulting from disruptions caused by the COVID-19 pandemic. He successfully built bridges with and garnered support from teachers in non-arts academic areas as he offered them technical support and helped them adapt their curricula to fit

the constraints of remote learning. Such bridges will likely serve Ben as he works to implement collaborative interdisciplinary lessons in the future.

Jasper's privileged position as a veteran teacher in a well-resourced and self-contained school district set him apart from the other participants to a significant degree. Financial resources and curricular constraints were not as much of an obstacle to the implementation of a STEAM approach in his classroom, raising a larger question of how economic privilege or disadvantage influences the implementation of STEAM and other interdisciplinary approaches. As Dewey (1938) observes, economic privilege often means access to "constructivist approaches to education [which] emphasize active learning, hands-on experiences, and meaningful engagement with the material." Jasper admits that his efforts to implement a STEAM approach have benefitted from his positionality. Jasper also says that he takes further advantage of what he describes as the "blind spot" created by an increased focus on attaining higher scores on standardized tests for reading and mathematics in his district. This blind spot also affords protection from the scrutiny of uninitiated administrators and parents, who may not understand or appreciate the special conditions required for a constructivist, interdisciplinary approach. In Jasper's experience, implementing those conditions requires a semi-transparent process that permits and encourages students to take risks and "fail forward" (Price, 2018) without judgment or consequence. In contrast to the other participants, Jasper's work to implement STEAM has centered around building a "box of crayons" in classroom environment as a reflection of his commitment to constructivist pedagogy. It is noteworthy that even in his economically privileged context, Jasper still uses the political tools of resistance and disobedience to circumvent the policies and practices that may not be conducive to his vision of STEAM and to clear the space he believes he needs to foster and cultivate a constructivist approach in his classroom.

Branches and Twigs of Inquiry

The First Branch: Ecology

In the previous section, we looked inside the “trunk” of the principal research question, considering the five rings of *understanding, discovery, invention, practice, and implementation*.

In this section, I will move up the metaphorical tree of inquiry to summarize how the data informs and illuminates each of the three branches of research sub-questions and their respective twigs in this study, beginning with the first: *How do the participants perceive their community of practice, and how do they make sense of their own learning ecology specific to music technology as a discipline?* Over the course of the interviews, the participants in this study described aspects of their communities of practice centered around shared interest in STEAM education and Arts Integration. Communities of practice can take various forms as they provide opportunities for professional development, knowledge sharing, and collaborative learning among educators. As such, communities of practice are recognized as effective structures for supporting innovation in teaching practices and fostering a culture of continuous improvement among teachers (Lave & Wenger, 1998). Key characteristics of communities of practice described by Lave and Wenger may be thought of as six twigs, which include *shared interest* or domain of knowledge that unites the group, a sense of *community* and belonging among members of the group, a shared *practice* through which members share practical knowledge and approaches to problem-solving to improve their practice; informal *learning* that is situated within the context of the community; the formation of collective and individual *identity* around shared interests; and porous *boundaries* that allow for interactions with other communities and resources. Boundary crossing between communities of practice facilitates the exchange of ideas, perspectives, and knowledge across different contexts.

In her first years teaching middle school music technology after a short hiatus working as a school administrator, Andrea talks about how she teamed up with another colleague with a similar background to “steer the ship” as the Arts Integration initiative was first introduced in her district. Andrea emphasizes community building, which she views as an essential component of implementing STEAM and Arts Integration. She tells a cautionary tale: Teachers who had not “jumped on board with Arts Integration and helped lead it...ended up getting cut.” As her work as an Arts Integration specialist continued, Andrea talked about building bridges with teachers from other disciplinary areas. She now has a small group of “go-to people” with whom she regularly collaborates when she is developing integrated lesson plans. Andrea also describes how she enjoys but also often feels humbled in the process of learning about different disciplines from colleagues who teach in those areas. Altogether, Andrea’s community of practice is characterized by twigs of *shared goals, practice, learning, and porous boundaries*.

Similarly, Ben says that his school’s collegial culture promotes collaboration with colleagues from the other side of the tracks in STEM areas. He says, “I’ve actually gotten to be very good friends with them because our interests line up.” He notes a particularly strong alignment with the technology department in his school, but he notes that it has been difficult to find opportunities to meet with this community of practice since schedules don’t often align. Nonetheless, Ben reports that teachers make an extra effort to co-plan and collaborate asynchronously. We may also include administrators as a component of Ben’s community of practice, as they have challenged him in a supportive and collaborative way to justify and define his inclusion of digital instrument design in the music curriculum. As a result of this challenge, Ben says that he has developed newfound clarity and increased confidence in his practice as a

teacher. Hence, Ben's community of practice may be defined by the twigs of *shared interests, community, learning, practice, and porous boundaries*.

Although Jasper has exiled himself from the music department in his district and has shifted his identity away from music in the direction of technology, he has sought out his own virtual community of practice of like-minded teachers to collaborate via social networking. "We're sharing projects as fast as we can," he says. "I got years of material from two ladies from around the world who shared their projects with the [group]," he adds. Jasper reports that he has also forged relationships with "a small group of elite teachers" in his building who enjoy many of the same liberties, privileges, and mobility that Jasper enjoys in his position. He identifies these privileged conditions as a uniting factor in his group. He speculates that working closely with teachers from outside districts would be challenged by differences in learning standards and an increased level of accountability that he feels would deprive him of necessary "room to experiment." Hence, Jasper's community of practice might be best characterized by the twigs of *shared domains* of interest, philosophy, and privilege; a strong component of *identity* as Jasper has depended on a found shared community of practice in his disciplinary exile; and in contrast to other participants, non-porous boundaries (at least in one sense) intended to exclude partnerships with teachers in other districts who may not share the same level of privilege. In other ways, however, Jasper's community of practice is disciplinarily diverse and promotes interdisciplinary exchange across the boundaries of knowledge.

While Laronda did not explicitly describe her community of practice in the context of her school environment, she did make a clarion call for a collaborative community as she emphasized the general importance of in-person interaction as a necessary component for STEAM and Arts Integration. She notes that "there needs to be so much planning, and planning

takes time, and planning cannot be in isolation.” She adds that “we have to be sitting at a table to create this and implement it.” When collaborative discourse happens, Laronda says she enjoys the rapid back-and-forth of the dialectical process of building a curriculum in a community. Laronda bemoans a lack of participatory initiative in newly hired music teachers and singles out a deficit of collaboration and communication skills as the cause. In Laronda’s experience, it is a lack of strong communities of practice that underlies what she perceives to be one of the primary problems of teacher readiness. “You’re really talking about a community of educators who are actually uneducated in how to connect,” she says. As a self-described advocate for STEAM, Laronda conceives of another sort of community of practice centered around the goals of progressive and culturally responsive visions and versions of music education. She ended our first conversation with a call to action for like-minded music educators to unite in their efforts to disrupt the status quo and clear the way for new curricular approaches. Laronda’s experience of a community of practice might be described by the twigs of a shared goal of her advocacy, as well as a lack of *community* and shared *practice* among new generations of music teachers.

The Second Branch: STEMiness

The second branch of research sub-questions seeks to understand *how and to what extent the participants’ experience of teaching, learning, and artistic practice led to engagement with STEM subjects. In what ways was their learning in STEM areas supported by their environments?* While all participants described themselves as technology-based educators who are advocates for STEAM education, only Andrea, Ben, and Jasper described and talked at length about their interest and expertise in technology. Laronda did not explicitly discuss her experience with teaching or learning science, technology, engineering, or mathematics, although she did express her enthusiasm for the use of music technology in a CTE context.

In their classroom environments, Andrea, Ben, and Jasper were avid technologists and spoke extensively of their technology-centered approaches to music education. The question of how they engaged with the other three subject areas in STEM may be addressed by the lesson plans they provided for analysis for this study. As a teacher educator and Arts Integration specialist in her district, Andrea creates STEAM-oriented lesson plans and content as part of her daily work; she, therefore, offered the most abundant evidence for analysis. Most noteworthy was her nearly complete omission of the subject of engineering in her own analysis of her lesson plans. I believe that this may have been the result of the possibility that Andrea may have been stifled by her own orthodoxy in the process of trying to align engineering standards written in a generalized language with the more specific and refined strands of standards in other disciplines.

Jasper's teaching experience tells of a fuller embrace of STEM subjects. His strong convictions as a constructivist have been a central influence reflected in his approach to teaching and are especially visible in his classroom environment, where students are invited to use technology in ways that were, by comparison to the other participants in this study, significantly more advanced. Jasper reports that his students' level of sophistication with technology often surpassed his own. "There are some crazy gifted children who are doing coding more than I ever will know, and I'm just trying to create an environment where they can be geeky with each other, and it's okay," he explains. Jasper's statement resonates with Bruner (1962), who asserts that teachers should work to create new opportunities for students to explore and discover new ideas, concepts, and perspectives, allowing them to eventually surpass their teachers' level of expertise and knowledge.

Jasper, who earned a doctorate in music education and worked as a music educator for decades, embraced his interest in STEM to such a great extent that it changed his identity as a

teacher and learner. “I find myself more on the tech side of the world,” he says. Now, instead of attending NAFME (National Association for Music Educators) conferences, he says he attends ISTE (International Society for Technology in Education) conferences. Jasper also identifies himself as an “Arts Technology and Technology Coach” in his profile on a professional social media website. Perhaps the most pronounced expression of how STEM subjects are grounded in Jasper’s pedagogy is the environment of his classroom, which he describes as a technological “sandbox.” To the extent that the technology classroom may be thought of as a kind of curriculum (Koehler & Mishra, 2006), Jasper has created a vibrant learning “play space,” as Burnard (2024) describes, in which students may freely engage in open-ended projects with technology and the arts that promote critical thinking and problem-solving skills. If we widen the iris and pull the focus back to see the larger picture, we find that Jasper is similarly situated in the sandbox of his school, where he has been permitted to put down one toy and play with another in his own educational bricolage. The privileges afforded by the financial security of Jasper’s district have allowed for the same conditions for Jasper as a teacher as he is able to create for his students his classroom.

Ben’s STEM teaching journey was not unlike Jasper’s in that it delivered him to the unexpected ecotone between music and technology. Ben’s willingness to “go out on a limb” of STEM by creating a high-tech unit on digital instrument design initially raised concerns with administrators, who feared that Ben’s curriculum may have reached out too far from the core trunk of music education. Perhaps the limb would break, as it did for Jasper. Administrators are often the source of the kind of disciplinary gatekeeping that Janett Barrett (2023) refers to as “boundary patrolling,” however Ben’s principal was a former music teacher and was able to understand the STEM-infused project through the lens of music education and understand

musical instrument design as a form of musical expression. Surprisingly, pushback about Ben's disciplinary transgression came as much from fellow music educators. At music education conferences, they asked, "Why should [students] learn to make instruments when they can just as well learn to play an instrument?" Ben says that the call to defend his "version" (as Eisner would say) of music education forced him to stop and reflect. "I was really struggling with how to justify it verbally," Ben says, "but I know inherently that what we're doing is important for the music education of my students." By doing so, Ben was not only following his best instincts as a teacher but engaging in praxis in the Socratic sense as new words surface and are born from innate understandings. Ben's trespass into the territory of STEM reminds me that the resistance to change and the call to "break the silos" of established disciplinary boundaries can come from without and within communities of practice, as well as from within the individual.

The second twig sprouting from the branch of the second research sub-question inquiries about *STEM learning* among participants. Because I am partially drawn to STEAM as a teacher because I enjoy learning, I was attuned to the possibility of resonating with like-minded educators in the process of conducting this study. I wanted to see to what extent technology-based music educators who were drawn to STEAM might also have a voracious appetite for learning about STEM and other disciplines. I mention my expectations of like-mindedness with the participants as a form of bracketing, a critical element for Chapter phenomenological research (van Manen, 2014).

At the outset, it may seem useful to draw a distinction between formal and informal learning since most of what the participants described of their experiences of STEM learning might be categorized as informal rather than formal. Although the dichotomy has been widely discussed in the discourse on education as a binary, I would suggest that a more transdisciplinary

understanding might once again be a kind of ecocline. John Seely Brown and Paul Duguid (2000) place informal learning as the central feature of communities of practice, as it is “characterized by its situatedness in authentic contexts, social interaction, and participation in communities of practice.” This is contrasted with formal learning, which “tends to be decontextualized, abstract, and focused on standardized curriculum.” However, they caution against a reductionistic dichotomy between the two learning forms as being “artificial and misleading.” Wenger (1998) concurs, writing that the dichotomy is “problematic because it fails to capture the dynamic and fluid nature of learning practices, which often transcend traditional boundaries and categories.

Ben is the only participant who explicitly mentioned formal learning in STEM disciplines, as he described his master’s degree capstone project of creating new technology for telephonic improvisation. The other participants in this study did not explicitly mention any formal education in STEM disciplines. However, Jasper earned a master’s degree in music technology, implying exposure to STEM subject areas.

Of greater interest may be participants’ descriptions of informal learning of STEM, which largely favored the “T” for technology. Andrea tells us that her learning journey with music technology was necessitated when she returned to the classroom to teach music in a computer lab. A professional development workshop on GarageBand got her started, and from then on, she says she was “hooked.” Andrea reports that she has begun to understand more about the sciences and mathematics through her work with teaching colleagues in those areas. Ben’s account of informal learning is enmeshed with his artistic practice. He reports that during the COVID-19 pandemic, he spent many hours “playing” with various music software, including highly technical digital music production tools such as Max MSP, which requires users to have a

foundational knowledge of object-oriented programming. Jasper's learning experience with STEM is perhaps the most dramatic, as it carried him to new shores as a teacher. Along his journey, Jasper shared that his computer science skills have been honed by students whose coding knowledge and skills far surpassed his own. Jasper's situation recalls my own experience learning new technologies from students and recalls John Dewey's observation that "the teacher is no longer merely the-one-who-teaches, but one who is himself taught in dialogue with the students, who in turn while being taught also teach" (Dewey, 1916).

The third twig, stemming from the branch of the second research sub-question, asks how participants' *artistic practices* have led them to engage with STEM subjects. Of all the participants in this study, only Ben described his own musical experience in relation to technology. As a result of his experimentation with Max MSP during the pandemic, Ben reports that he started to compose music and, in the process, "discovered" and gained a new aesthetic appreciation for Electronic Dance Music (EDM). Other participants did not volunteer any information about their artistic practices as they relate to STEM.

As I ask the question of how STEMy the participants in this study are, I reflect and wonder if such an inquiry may be inadvertently feeding into an ingrained hegemonic trait of disciplines, as the politics of knowledge seeks to purify and distill them (Foucault, 1972). Should the "S" of science only count as science if it is happening at the 300 or 400 course level at a university? If so, then I wonder what the threshold might be that would qualify a person as *doing* STEM or *doing* art, for that matter.

The Third Branch: Praxis

The third and final branch of research sub-questions investigates *what participants are doing, what they consider the most STEAM-like elements or aspects of their teaching and*

learning practices to be, and how do they relate their praxis to the goals of music education. The queries of this sub-question have been largely addressed in chapters V and VI of this dissertation, but I will briefly summarize exemplars of STEAM praxis found in this study.

Lesson plans in the teacher resource book on Arts Integration that Andrea published over the course of this study serve as examples of what Andrea considers to be best practices for a STEAM approach to music education. They are described and discussed in Chapter V. Andrea relates each of her lesson plans to her understanding of the goals of music education through a rigorous alignment of national and state standards. Similarly, Ben's chapter in a book on how to align STEM to music education includes a project-based learning (PBL) lesson plan in which students design and create digital musical instruments using object-oriented programming in Scratch and Makey Makey as a user interface. Like Andrea, Ben aligned his lesson plan to national standards. As he searched for justification for his foray into developing a particularly STEMy unit for his middle school general music class, Ben looked to the National Core Arts Standards as a guide and rationale. Jasper described a soundtrack project as his exemplar of STEAM practice, in which students were tasked with writing music and providing sound design for an animated film clip. In his description of this project-based learning experience, Jasper emphasized the importance of a constructivist approach in which grade thresholds were lowered, thereby creating an environment safe for failure and experimentation. Finally, Laronda talked about how she was able to connect her students to the DJing and House music industry in her community through a Career and Technical Education pathway. Laronda's version of an interdisciplinary approach to music education involved an emphasis on practical business education and technology, positioning it as an alternate vision of STEAM that forewent the usual

emphasis on lofty science, mathematics, and engineering concepts in favor of pragmatic skills and understandings that might benefit a larger swath of students.

New Branches

Phototropism

While many aspects of the experiences of the four participants resonated within the trunk of the research question and were caught in the branches and twigs of the sub-questions of this study, many of the data that lay outside the framework of the questions were not. These airborne phenomena, taken together with new theoretical insights from the data, suggest the need for the initial research questions to change and grow. As this study commenced and I started to learn more about the individual understandings and practices of STEAM of each participant, some aspects of my questions began to appear as well-intentioned but misguided itineraries that no longer seemed relevant or useful in the shifting sands of the phenomenon. As I acknowledged in Chapter III, phenomenological research calls for a constant process of reframing research questions as new themes and meaning structures emerge from the studied phenomenon (Creswell & Poth, 2018; Yin, 2015). Through the revelations of the data, a new light of understanding is shining, and the original tree of inquiry may now give way to new growth.

STEAMy Ways of Being: What Makes a Skunk a Skunk?

An emergent theme that was not adequately addressed by the initial set of research questions concerns the dispositions, attitudes, and conditions that might be thought to contribute to and support or impede and limit the practice of STEAM teaching and learning. Are music educators who are interdisciplinary skunks defined by common values, perspectives, or dispositions? And, if so, might these values, perspectives, and dispositions be instilled as part of

teacher education with the aim of creating new generations of interdisciplinary educators who may therefore be better equipped to teach in the evolving landscape of the 21st Century? In the following sub-sections, I will explore how the experiences of the participants relate to these new questions.

STEAM as an Inherently Constructivist Practice

As a starting point, I identify a common philosophical perspective that unites the perspectives of the four participants in this study: To various degrees, all participants explicitly or implicitly embrace a *constructivist* approach and understand themselves as co-learners alongside their students who are engaged in the continuous process of exploring, questioning, and adapting their teaching practices. This process requires teachers to exhibit humility, vulnerability, and the courage to take risks in the classroom (Brooks and Brooks, 1993). Jasper is perhaps the most outspoken, as he proudly and explicitly embraces constructivism as a core pedagogical value that has guided his teaching journey to unexpected destinations. Jasper speaks at length about his commitment to accommodate the possibility of “safe failure” in the environment of his classroom. “Failure is always an option; then that’s where the learning takes place,” he says. Smith and Henriksen (2016) underscore the importance of *safe failure* as a condition for creativity in schools, and the practice of intellectual risk-taking is well-established as an integral component of creativity (Martins & Terblanche, 2003). The ethos of safe failure and the encouragement of risk taking begins with the constructivist teacher, who must also be willing to take risks and possibly even fail in front of their students (Brooks & Brooks, p. 10). When Jasper’s students expressed interest in using advanced coding to create original media that was beyond his bailiwick, he was willing to switch roles to become a student and allow his students to teach him. For all his expertise in technology, Jasper says that he once again felt as if

he was a “digital immigrant” (Prensky, 2001). The experience was not only valuable for the new understanding of advanced coding techniques that Jasper had gleaned, but also for a renewed empathetic understanding of learner’s perspectives. The greatest evidence of Jasper’s sustained commitment to a highly student-centered and constructivist approach may be found in the environment of his classroom. The open space of his sandbox-like classroom features free and open access to expensive equipment that most other teachers might guard. Jasper’s open-door policy resonates with voices in the literature on constructivism who identify flexibility and access to technology as key features of the constructivist classroom (Kara, 2018),

Ben is also explicit about his identity as a constructivist, stating that as a teacher, he loves “being in a situation where I need to learn something new.” Following his instincts and in response to his students’ interests, Ben says that he “went out on a limb” to incorporate digital instrument creation as a centerpiece of his music curriculum. Ben adds the approach of “constructionism” (Papert, 1980) as a descriptor of his philosophy of practice, noting that constructionism is defined more by “the actual hands-on manipulation of materials to gain understanding.” Ben explains that,

Both [constructivism and constructionism] rely on the social aspect: sharing what it is that you are doing with other people and getting feedback and going through those design process steps and those iterative processes in order to get further understanding.

When asked what qualities are required to be a STEAM educator, Ben ranks “personal courage” and the willingness to “embrace vulnerability” high on his list. There is consensus in the literature on constructivism (Alber, 2009; Brooks and Brooks, 1993; Palmer, 2017) that the approach requires teachers to become comfortable with a sense of personal and pedagogical

vulnerability in order to move out of prescribed roles of authority and to join students as co-learners in the classroom.

Andrea identifies herself as a “lifelong learner,” a concept that stems from constructivism (Mohammed & Kinyo, 2020). While she does not explicitly mention constructivism *per se*, she shows commitment to supporting intellectual risk-taking for teachers and offers the advice that “as a teacher, you have to be willing to not know everything [and say] ‘Hey, we’re going to try this together. I know where we’re necessarily gonna go.’” When asked what qualities best support STEAM teaching and learning, she identifies a *solutions-oriented mindset*, *courage*, and *vulnerability* as key factors. “Having that vulnerability with your students really can sometimes work miracles and wonders in terms of getting them to be open to trying new things,” she says. From these comments and others like them, it is implicit that Andrea views her practice as a constructivist one. It is noteworthy that Andrea and Ben mention *courage* as an essential attribute for practitioners of STEAM education. Burnard et al (2021) write that “transdisciplinary educators must develop dispositions and qualities that transcend their disciplines, such as empathy and openness to new ideas and experiences” Smith and Henriksen (2016) add bravery (as an openness to failure) and trust to the list of transcendent attributes described by Andrea, Ben, and Jasper.

Like Andrea, Laronda does not explicitly mention constructivism, but she describes her practice as a teacher and administrator as being “culturally responsive” to the needs of her students. Laronda evokes Culturally Responsive Teaching (CRT) (Gay, 2008; Ladson-Billings, 1995; McKoy, 2013), which is a reform movement that seeks to “increase the engagement and motivation of students of color who historically have been both unsuccessful academically and socially alienated from their public schools” (Gay, 2008). As an educator of color in an urban

school, Laronda has applied the principles of CRT to find ways to put rich cultural experiences in her community at the center of learning in schools rather than being left outside the gate or on the periphery. Ladson-Billings (1995) describes CRT as being an inherently constructivist approach, as it builds on the cultural context that students live in as a foundation for learning.

In summary, each of the four participants either explicitly or implicitly described practices that are consistent with a constructivist approach as it is described in the literature.

Table 5 provides a breakdown of constructivist teacher attributes described by each participant.

Table 5

Constructivist Attributes Described by Participants

| Participant | Mention of Constructivism | Desired Teacher Attributes Mentioned |
|-------------|---------------------------|--|
| Andrea | Implicit | <ul style="list-style-type: none"> ● “solutions-oriented mindset” ● “courage” ● “vulnerability” ● “lifelong learner” |
| Ben | Explicit | <ul style="list-style-type: none"> ● “personal courage” ● “being in a situation where I learn something new” ● “constructionism” ● risk “go out on a limb” ● “lifelong learner” |
| Jasper | Explicit | <ul style="list-style-type: none"> ● “safe failure” ● open “sandbox” environment ● open access to technology ● “lifelong learner” |
| Laronda | Implicit | <ul style="list-style-type: none"> ● “lifelong learner” ● “culturally responsive” |

In the following sub-section, I will describe deficiencies and negative disposition, attributes, and practices described by the four participants that may limit or impede constructivist, interdisciplinary teaching and learning.

Skunks Without Stripes

In addition to the positive teacher attributes and traits the participants identified in the previous section, they also described undesirable qualities that counteract the kind of interdisciplinary approach that would support their vision of STEAM. Laronda strikes a more critical tone when she talks about the deficits, she sees in some of the teachers she manages, especially many newly hired teachers who, she believes, are generally ill-equipped to engage in interdisciplinary teaching and learning. Laronda explains that such teachers often enter the educational workforce with undeveloped communication and collaborative skills, a lack of knowledge or interest in curriculum, and fundamental misunderstandings about their role in the context of a school organization. In order to support initiatives such as STEAM, Laronda asserts that new music teachers must first relinquish solipsistic attitudes and mindsets that may have been engendered during their post-secondary music education. “We have a crisis because students are taught the way that teachers were taught,” she says. As a result, Laronda’s new teachers (music teachers, in particular) lack the basic skills they need to connect with their students. She says, “I want to say, ‘You are beautiful as a performer. Amazing. But can you translate that knowledge for the next generation? Cause if you can't, it will die on that hill with you.’”

In addition to their difficulty connecting with students, Laronda observes that many newly hired music teachers in her district lack the basic abilities and dispositions needed for collaboration, which are essential to support “infinitely diverse ways” and “continuous adaptations” required of 21st-century teachers (Darling-Hammond, 2006). She says they are often so isolated that they don’t see the benefit of connecting in the first place. “So then you hear about collaboration in curriculum, it honestly feels completely overwhelming, like a wave that's

eight feet over for you because you're not prepared for that," she says. "And if you're saying, okay, we got to create a curriculum that connects with students and connects with STEAM and so on, it's too much. You're really talking about a community of educators who are actually uneducated in how to connect." Without these critical skills and understandings, Laronda says that new teachers tend not to grasp the urgency of promoting and advocating for music education to their students or throughout the school. Given the dwindling enrollment in music classes in Laronda's district, coupled with challenges introduced by the COVID-19 pandemic, there is a need for arts teachers to advocate for their programs in order to sustain them in the face of school board budget cuts. Consequently, many scholars argue that advocacy for arts education is needed more now than it has ever been historically (Taylor, 2020). Laronda says new teachers tend to be oblivious to the unique demands and attitudes of twenty-first-century students, whom she describes as "a different kind of customer." Students today have many "beautiful options" to choose from and require a compelling rationale for pursuing studies in the arts. Laronda also notes a general deficit in technology skills in new music teachers, noting that she herself "never touched a computer" while in music school. "I think back to when I was a music major. When did I use a computer? Never," she admits. Laronda's observation about the challenges and difficulties music educators face in integrating technology is widely discussed in the literature (Bauer, 2014; Cslovjcek, 2018) and seen as an imperative for music teacher education programs in the 21st century (Frankel, 2009). Laronda's critical perspective of music teachers in her district resonates with overwhelming consensus in the literature around the need for teacher education programs to better prepare future teachers for the realities of the classroom, especially concerning their preparedness for technology integration and collaborative, interdisciplinary

teaching. Taken altogether, Laronda's might best be characterized as a lack of a "growth mindset," as opposed to a "fixed mindset" as defined by Dweck (2006).

As a fellow Arts Integration specialist and administrator, Andrea shares some of the same frustrations, although with more experienced teachers rather than new teachers. When presented with the opportunities that a STEAM approach might offer, Andrea reports that many veteran teachers respond by saying, "I have enough to do. It's not my job." A similar kind of teacher Andrea identifies are "gamers," who, she explains, lack motivation and are not "finding things on their own...and being super creative." In order to motivate them, Andrea explains that "just like you do with kids, you have to kind of trick them" into authentic engagement in professional development. Andrea also says that she understands why teachers might be skeptical about investing "professional capital" (Fullan & Hargreaves, 2012) in what might appear to them to be the latest initiative in their district, as many have come and gone like a passing fad. While Andrea understands the time constraints these teachers are under, she also feels disappointed that they do not seem to see the intrinsic value of interdisciplinary teaching and fail to see what Andrea describes as the "wisdom" of engaging in collaborative teaching to enhance job security. As previously described and discussed in Chapter V, Andrea explicitly mentions teachers' lack of motivation or incentive to make the efforts required to modify their established teaching routines, fear of straying from assessment-driven agendas, a lack of a problem-solving ethic, and complacency with low level digital literacy skills. Again, the negative dispositions and attitudes Andrea describes may be interpreted as lack of a "growth mindset."

In the limited capacity that Jasper still manages music teachers in his district, his experience with younger teachers contrasts with others and most of the literature; newer generations of music educators tend toward more traditional methods and approaches than older

teachers in his district. He shares, “When that [older] band director retires, and someone comes in who’s 20, or 22, or whatever, can I get them to not make it a John Phillips Sousa concert? Like, can I do it?” Jasper also notes that even teachers with strong backgrounds in music technology in his district still tend to default to traditional, performance-centered approaches to band and ensemble classes. He speaks of his colleagues’ lingering commitment to traditionalist approaches and the challenges of “breaking those patterns.” Jasper’s critical perspective of his son’s experience of STEAM reveals the negative attribute of “laziness” of teachers who resort to the use of STEAM kits and close-ended projects that he believes are antithetical to his more constructivist understanding of and approach to STEAM.

In contrast to the other participants, Ben did not express significant critical perspectives about the dispositions or perspectives of his colleagues or music educators in general. He did, however, acknowledge a tacit skepticism that he sensed when he presented his digital music instrument creation lesson plans at a national conference for music educators. “At least they agree with me in public,” he says, but he needs to reassure traditionalist colleagues that music technology is “not replacing their band or orchestra instrument.” Ben also points to what he perceives as a lack of music technology courses offered by many undergraduate music and music teacher education programs and expressed astonishment that his own program offered little in the way of practical technology training for music educators. However, while Ben may not have critically or directly addressed the question of teacher dispositions and approaches to interdisciplinary education, he is the only participant who explicitly voiced a critical perspective of STEAM, as he mused that “maybe STEAM is too restrictive. Maybe we need to do away with subject areas altogether.” Ben’s suggestion implies a key critical perspective: perhaps educators are not adequately challenging the limitations of interdisciplinary initiatives such as STEAM

which often go unchecked as they are presented and accepted as liberative alternatives to the *old school*, insular tyranny of disciplines. Implicit in Ben’s remark, is the idea that teachers may lack criticality, especially when presented with what appears at face value to be progressive and emancipatory concepts for curriculum.

Table 6

How Participants Identified Teacher Limitations

| Participant | Mode of Expression | Undesirable Teacher Attributes Described |
|--------------------|---------------------------|---|
| Andrea | Explicit | <ul style="list-style-type: none"> ● Lack of motivation to engage with teachers from other disciplines ● Lack of deep knowledge of standards ● Territorialism ● Does not see intrinsic/extrinsic value in a holistic, integrated approach ● Lack of “growth mindset” ● Lack of problem-solving initiative or skills ● Unwilling to take risks in front of students or administrators. ● Low-level digital literacy ● Fear of straying from assessment-driven agendas |
| Ben | Implicit | <ul style="list-style-type: none"> ● Overall lack of criticality regarding STEAM and related initiatives |
| Jasper | Explicit | <ul style="list-style-type: none"> ● Orthodox adherence to traditional methods and pedagogy ● Preference for a dominant performance-centered approach that excludes other pathways ● Lack of a constructivist approach that often entails the use of STEAM kits and close-ended projects |
| Laronda | Explicit | <ul style="list-style-type: none"> ● Undeveloped communication skills ● Undeveloped collaboration skills ● Undeveloped pedagogical skills ● Lack of knowledge and interest in curriculum ● Difficulty empathizing with and connecting with students ● Low-level digital literacy ● Lack of “growth mindset” |

Taken altogether, participants either explicitly or implicitly identified deficiencies and negative dispositions, attributes, and practices that may limit or impede constructivist, interdisciplinary teaching and learning. A summary of the attributes discussed by participants is shown in Table 6.

In conclusion, it can be shown that the participants' lived experiences address the emergent question of what specific dispositions, attitudes, and conditions might support or inhibit the practice of STEAM teaching and learning. The findings in this section suggest correlation between constructivism and interdisciplinary teaching and learning. They also begin to show an emerging outline of common attributes, both positive and negative, that might help to define interdisciplinary praxis in music education and inform future research.

Harvest from the Branches

STEAM as a Boundary Object

The findings of this dissertation come both from the lived experiences of the four music educators who participated in this study and from theoretical insight that I have gleaned along the way. A short summary of what I found and discovered should begin with the diffraction of my initial (and perhaps naïve conception) of a single, common understanding of STEAM into to a mirror maze array of multiple versions and visions. Among the multiplicity of images were versions in which STEAM is considered to be a controversial “hot topic” and even a “bad word” that unnerves academic publishers, to my surprise. As it is diffused, projected, and reflected throughout a hall of mirrors, STEAM resists definition and classification. However, the elusive and illusionary phenomenon of STEAM can be explained as a kind of a *boundary object*, or “a knowledge-practice construct that can be shared by different communities and networks, yet with each one holding a particular understanding of the theory or representation” (Burnard et al.,

2019). A boundary object is a phenomenon which stakeholders view and understand differently from multiple perspectives. The word “stakeholders” is appropriate here because each disciplinary community of practice engaged in STEAM has much at stake, including the field of music education.

For decades, STEM had been a tautly bound, highly charged, and yet stable molecule, with the “S” for the sciences as the nucleus of its presumed hierarchy (It’s not METS, after all). The introduction of the “A” for the Arts may appear inconsequential to STEM so long as the “A” is non-radical and inert. The arts in schools, after all, have maintained the façade of neutrality, as they may be seen to be harmless (if not at all mildly helpful) as they promote vague and anodyne conceptions of the well-worn and arguably now-hackneyed term “creativity.” Who could object to *creativity* in schools, especially if it were neutral, harmless, and entertaining? It has been my contention that the arts are not neutral, and that the energy of an atomic reaction is implicit in the cold fusion of a radical “A” with the otherwise stable ion of STEM. However, such a super collision would never be permitted if it were explosive and disruptive. The energy emitted from the fusion of STEM + A is fully expected to be harnessed and channeled to power innovation for economic prosperity. Hence, the arts must maintain the semblance of harmless neutrality.

The Myth of the Cyclops

As I observe the diffused reflections of STEAM that are described by the participants, I am struck by their ambiguous projections of the arts as they appear inert and harmless at one moment and then radical and subversive at another. I am perplexed as to whether this flickering ambiguity is inadvertent or deliberately and ingeniously strategic. If intentional, their strategies call to mind Homer’s story of Odysseus’s escape from the cave of a giant cyclops. After defeating the Cyclops by poking his one and only eye, Odysseus hugged the underbelly of a

lamb to avoid detection. “Who did this to me?” cried the blind cyclops as Odysseus slipped away. “What is your name?” Odysseus answered, “My name is ‘Nobody.’” Later, when the gods asked the cyclops who had blinded him, the cyclops could only say that “‘Nobody’ did it.” In the context of STEAM, the Arts may be as artful and guileful as Odysseus as they pretend to be “Nobody” and cling to the image of neutral innocence to evade detection. Laronda appears lamb-like as she appears to have surrendered to the juggernaut of standardized testing in her school, even appropriating the language of oppression as she embraced the metaphor of music in the curriculum as the “dessert.” Meantime, not far beneath the surface, Laronda has quietly uprooted the territory and has found a way to unlock an established and well-guarded school gate to finally allow authentic and culturally responsive education inside the music classroom. Laronda rightfully describes herself as a “disrupter” and calls her fellow music educators to wake up and enact radical change—She is a wolf cloaked as a lamb. Other participants’ strategies to smuggle STEAM into school conjure the image of the blinded cyclops (a creature unable by its nature to perceive dimensionality). Jasper takes full strategic advantage of a “blind spot” in his administrators oversight as he protects the semi-transparent space needed to enable his students to “fail forward.”

Andrea is highly strategic as a double agent who straddles the gap between teacher and administrator, and whose agenda has been to smuggle STEAM into the classroom by means of embracing the authority of arborescent standards. Andrea says she took advantage of the low visibility during the COVID-19 pandemic, during which time teachers had temporary relief from standardized test mandates, as “they went on the back burner” and reveled in the opportunity to help teachers develop technology skills and better equip them to teach 21st Century Skills, which she associates with STEAM. Although her agenda appears to reinforce existing systems more

than to challenge them, Andrea hinted at a glimmer of radicalism when she explained her motivation for getting involved in the Arts Integration movement in her early years as a teacher. “If I don’t get involved in this,” she remembers herself thinking, “they’re gonna screw it up,” referring to administrators without arts teaching backgrounds. With that concern in mind, Andrea went out of her way to amass power in the decision-making process for Arts Integration so that she might “steer the ship.” Power and control appear to be central to Andrea’s agenda to promote and defend her conception of STEAM, a large part of which may come from the “grid” of the powerful structures she embraces. Additionally, Andrea’s orthodox approach as a “gatekeeper” of STEAM may prevent her from acknowledging what is clearly evident to others. The marked absence of any reference to engineering in her book on “integrating STEM with music” demonstrates the impractical rigidity of the standards she so closely adheres to in the production of her version of STEAM. The rich and abundant yet unacknowledged engineering content in Andrea’s music technology lesson plans becomes the proverbial elephant in the room. I wonder if the elephant comes from a lack of understanding of engineering education, a willful blindness, or if Andrea’s editorial hands were simply tied by her publisher or other unseen forces. I also wonder what other disciplinary elephants may be invisible and unacknowledged in the STEAM room under the watch of institutionalized visions of “Arts Integration.”

A Peaceable Kingdom?

In contrast to the others, Ben indicated that he had little need for guile and strategy. Even when pressed, Ben maintained that his school’s administrators and colleagues welcomed his ambition to “go out on the limb” of the music curriculum and found to his delight that they regarded his proposition to be in line with the school’s commitment to interdisciplinary teaching and learning. The tranquil picture that Ben paints of his school’s harmonious disciplinary

ecology calls to mind a real painting: *The Peaceable Kingdom* (1834) by Edward Hicks. The painting depicts an idyllic tableau in which wild animals lie together in harmonic repose (Figure 3).

Figure 3

The Peaceable Kingdom



Note. Edward Hicks (c. 1834). One of 62 versions created by Hicks, based on Isaiah 11.6: “The wolf will live with the lamb, the leopard will lie down with the goat, the calf and the lion and the yearling together; and a little child will lead them.”

In the background, we see European colonists trading peacefully with Native Americans (some versions of the painting show a tall ship in the river behind them). Hicks’s tableau may be taken to represent the more convivial vision of STEAM envisioned by Ben, in which the lion of science, the ox of engineering, the bear of mathematics, and the tiger of technology lie in peace with the lamb (or cherubic muses?) of the arts. It is a sanguine vision devoid of conflict, oppression, the horrors of slavery, or any suggestion of injustice. However, beneath its layers,

Hicks's painting projects a dark vision of globalism in which so-called "civilized" capitalistic colonialists "tame" the wilds of nature for their own profit, while claiming that prosperity and peace are achieved through the *thanks-giving* and *thanks-taking* of their so-called "fair trade" across uneven borders. Therefore, as a theoretical finding in this dissertation, I point to the ubiquitous, uncritical embrace of a *Peaceable Kingdom* conception of STEAM, in which historic power relationships between disciplines are concealed, the politics of knowledge are generally denied and ignored, and a toxic agenda-laden cloud of institutionalized, industrialized STEAM may falsely appear in the house of mirrors to be healthy, emancipatory, and free-floating.

Future Rhizomatic Growth and Tropes

As I consider the themes, theoretical insights, and findings that have emerged from this study, new areas of critical research come into focus, raising new questions that may be considered for continued research on how technology-based music educators may understand and practice STEAM. Possible inquiries might include a more critical interrogation the politics of knowledge as arts and arts teachers engage with the boundary object of STEAM; an exploration of how the new *ecotonic* versions of music education may be optimal soil for emancipatory praxis and alternate ways of knowing in the field especially as music as it is taught through technology invites a hybrid of categorical (arborescent) thinking and open-ended (rhizomatic) creativity; how music technology education might (or might not) be an ideal site for transdisciplinary teaching, learning, and thinking as it produces new technological metaphors for music; and a broader view of how music teachers might understand and practice constructivism vis-à-vis STEAM. Finally, I would propose a deeper exploration into the question of how accessibility and economic privilege and/or disadvantage might be correlated with a STEAM

education, with music technology as a focus, as I believe the question was not sufficiently addressed by the four participants in this study.

In the next and final chapter, I will draw on the findings described in this chapter as I consider their implications for the future of music education.

THE TREES

There is unrest in the forest
There is trouble with the trees
For the maples want more sunlight
And the oaks ignore their pleas

The trouble with the maples
And they're quite convinced they're right
They say the oaks are just too lofty
And they grab up all the light

But the oaks can't help their feelings
If they like the way they're made
And they wonder why the maples
Can't be happy in their shade

There is trouble in the forest
And the creatures all have fled
As the maples scream "Oppression"
And the oaks just shake their heads

So the maples formed a union
And demanded equal rights
"The oaks are just too greedy
We will make them give us light"

Now there's no more oak oppression
For they passed a noble law
And the trees are all kept equal
By hatchet, axe, and saw

– From "The Trees" by Rush

CHAPTER VII: CLOUDBURST

A New Renaissance

Despite the insistence of staunch modernists in our field, the landscape of music education has undeniably transformed into a postmodern one. Just as the molten flow of volcanic lava reaches the sea in a cloud of steam as it forms new land, the rupture and flow of new technologies, new ways of knowing, and hence new ways of teaching and learning are emitting a cloud of STEAM as it seeps into the cool sea of education. The newly formed geothermal land of our times is still unstable and inhospitable to the rigid, arborescent structures of modernism and the 20th century. Education must become pliant and porous enough not only to adapt to new terrain for survival but also to harness and take full advantage of its new qualities and conditions. In this churn, the field of music education is in flux as it is undergoing transformation spurred by vibrant philosophical discourse, a growing body of research on best practices and repertoire, greater emphasis on musical creativity, and a re-visioning of music teacher education programs, as Barrett (2023) observes. Ground that had begun to dry and harden under dominant, traditional conceptions of music education has been upheaved by the disruptions of the COVID-19 pandemic and the rise of rapidly developing forms of artificial intelligence *accelerando con moto*. The rupture has necessitated a return to fundamental questions about the nature and purpose of education and a dire need to further understand the implications of new ways of thinking about knowledge in a post-human world.

The terrain of music education takes on a new look as it becomes increasingly complex, multifaceted, and decidedly interdisciplinary. As such, our field may be best thought of as a kind of disciplinary ecotone that lies between established boundaries and borders of knowledge, practice, and culture. In the rich, igneous soils of our ecotone, horizontal, rhizomatic, and

relational thinking tends to be more generative than vertical, siloed, and deeply rooted thinking alone. As Ralph Waldo Emerson (1870) reminds us, “We are not strong by our power to penetrate, but by our relatedness.” Hence, a “new renaissance” of music education is afoot, in which “lines between disciplines, fields, and aesthetic frames dissolve” (Chase, 2013), and relational, metaphorical, and poetic thinking prevails.

Novel forms of flora and fauna appear on the landscape as new visions and versions of school music curricula take root in new areas. Among them are new curricular strains that include hip-hop, digital production, instrument design, composition, and other variations that create new openings for richly relational music teaching and learning. The specialized fauna drawn to inhabit these “in-between” spaces may be considered metaphorical skunks who thrive in the epistemological ecocline between music, STEM, and various other subject areas. Skunks must vie for territory, food, and ideal environmental conditions to survive. Therefore, the borderland garden of technology-based music education is an ideal habitat for such creatures: a richly diverse Eden that simultaneously attracts and produces rugged, adaptative, epistemological omnivores with a taste for musical and culinary fusion.

Among the wide range of varieties of epiSTEAMological skunks that may be found in the field of music education, the technology-based music educator is uniquely situated and equipped in a newly developing, porous, and pliant periphery where the rapid evolution of technology maintains a constant state of flux. If the outer surface of any living thing is most often the site of new growth, the relatively new experimental space of the music technology laboratory might be one of the places where we might look for hints, clues, and previews of what lies ahead in the field of music education. Because it lies at an intersection, it must be a space congenial not only to other disciplinary areas but also to the times we live in and the world

outside the school building. As Eisner (2002) argues, new varieties and “versions” of arts education are the “products not only of visionary minds and persuasive arguments, but also of social forces that create conditions that make certain aims congenial to the times” Musical skunks are not only positioned as the first responders and cultural telltales who are well situated to leverage the social forces that might bring about new varieties of music education that are “congenial to the times” to the forefront, but they are also rugged agents of change in changing times. Change is tough, and epiSTEAMological skunks tend to prefer a diet of rhizomatic roots over the arborescent dichotomous roots and twigs of disciplinary trees. Barrett notes that it is the “interdisciplinary perspective” of a musical skunk that “resists classification and rigid definition while opening space for catalytic turns and openings” (2023, p. 216). I think of the kind of unexpected, catalytic (and perhaps sometimes cataclysmic) turns and openings that took Jasper on an unplanned migration to a new disciplinary home or how Laronda courageously uprooted and transplanted a music program in new soil to allow it to simply breathe in the community it lived in, and Ben’s integrity and confidence in his curricular instincts despite his struggle to find the right words and definitions to justify and defend them. I would consider these stories to be Odyssean feats that required courage, vision, and integrity. However, I wonder if virtues like these are enough in the turbulent times we live in and if these are merely battles won in the context of a larger war.

Trouble in Eden

As I reflect on the findings of this dissertation, I wonder if the skunks among music educators are fully cognizant and alert to the opportunities, challenges, and unique conditions of the times and how they understand the highly charged political and philosophical implications of the arts situated in the context of STEM. In the new context of STEAM, I argue that the arts

cannot remain neutral and inert, nor can arts educators. If academic disciplines are socially constructed and politically maintained, as Parsons (2004) argues, interaction between them must imply hidden layers of power dynamics to which an interdisciplinary skunk must be attuned (p. 785). The question of cognizance raises a larger epistemological question: If the skunks have only eaten from the tree of knowledge rather than burrow for the roots of complex rhizomatic knowledge, how can their critical perspectives be anything but arborescent? Like Andrea, they may only envision structural tropes articulated in the language of institutionalized education as vehicles for change. To return to Plato's allegory of the cave, I wonder to what extent teachers who are proponents of STEAM may or may not perceive the cave-like entrapment of all-encompassing, self-reinforcing, hegemonic systems of education driven by the forces of self-preservation and capitalism. Who among them would enthusiastically and uncritically opt for teaching with closed-ended, step-by-step STEAM kits while fully convinced they were "doing STEAM"? Such an approach would not meet Janet Barrett's (2023) criterion for STEAM of *generativity*, through which "the curriculum can be judged as *emancipatory* as well, as [it] releases persons to attend to their own growth and becoming, to address the pressing challenges of our time..." (pp. 15-16). Plato's cave is so immersive and its influence so pervasive, that it is not possible for its prisoners to even know they are entrapped. For Plato, it is only through an awakening of enlightenment or discovery, or *anagnorisis* in Greek (ἀναγνώρισις), that the prisoners in the cave may free themselves from ignorance and ascend to a higher level of understanding. Aristotle also uses the term in his Poetics to describe the discovery of one's own identity or true character in a drama (Luhmann, 1988). The "pressing challenges of our time" call for what Maxine Greene (2010) describes as "wide-awakeness," which echoes Plato's concept of *anagnorisis*. Arts educators must not only awaken but be *wide awake* to their situation in the

landscapes and ecologies of transitional spaces and their potential to unleash the imaginations of their students. I stress this point because I believe that music educators may largely be asleep or unaware of their potential to leverage music education's liberative and emancipatory possibilities, especially as they might exist in highly charged disciplinary ecoclines that stretch between music and other disciplines.

Considering the arguments, I posit that music education, as it may be delivered through critical pedagogy and a conscientious interdisciplinary approach, may once again find its way back to its throne in the constellation of the liberal or *liberative* arts. As an extension to this argument, I contend that the music educator must first be educated as a liberal artist: one whose understandings, disposition, and openness allows her to freely navigate the clouds of human (and non-human) knowledge, who fearlessly trespasses into unfamiliar domains and willing to investigate and explore alternative ways of knowing, and whose broader perspective may lead to practices and environments that empower her students to discover the web of disciplinary threads that bind and fuse music with other disciplinary areas across multiple dimensions. At the ground level, the interdisciplinary music educator strives to liberate education from the constraints of questionable instrumental claims that the arts can improve test scores, that great music is specific to one culture or one time, or that the arts are politically inert and anodyne within the charged framework of academic disciplines. However, I wonder how music education might harness even greater emancipatory powers that bring about *anagnorisis* and free minds. I take this to be the role of the skunk. However, skunks may not know they are skunks, and they may not fully understand the magnitude of their potential as denizens on the epistemological ecotone. Nor may they be equipped to take a transdisciplinary, integrative approach called for by an emancipatory

vision of STEAM in which STEAM is not necessarily a continuation of STEM and in which music may find its way, once again, as a liberal art.

Evaporation

The unanswered, extended questions raised in this dissertation must return to their vaporous state. However, before I conclude, I return to the title of this dissertation to attempt to make the connection between practitioners of STEAM and the liberal arts. It may be tempting to conclude that the epiSTEAMological skunk, the technology-based music educator, is particularly well-situated and equipped to bring forth new visions and horizons for the field of music education as it is reforged in the crucible of our changing times. After all, the view from the edge has its advantages. The newly formed periphery of music education takes the form of the music technology classroom. The room is often called a “laboratory,” implying experimentation, invention, and innovation. It is an outward-facing space of commerce and exchange and an interface with the high percentage of students who may never have set foot into a band room or picked up an instrument. It is also a place where, by definition, disciplines intersect, as this room is sometimes not a music classroom at all but rather a computer lab or Career and Technical Education “maker space.” In this room, students create and interact with musical genres that are often rarely heard in the band room, and it is also a room that is accessible to them without the entry requirement of music theory classes, proficiency in an instrument, or the desire to perform. The membrane surrounding this room is often porous and pliable, allowing free commerce of students, projects, teachers, and musical ideas. The space of the music tech lab may be seen as both *same* and *other* by music teachers on the inside, and it may equally be seen as *same* and *other* by STEM teachers on the outside: it is both foreign and familiar from all perspectives. John

Dewey (1938) dreamt of such a music classroom when he wrote, “I imagine observing music teachers as they create the enviroing conditions that bring students’ rich insights to the surface.”

Additionally, as I have argued in this chapter, it is not only the space of the music technology ecotone but the creators and keepers of the space that matter. The skunk-like music educators who inhabit this space are often situated in the periphery, straddling borders and occupying multiple spaces simultaneously. Sometimes, they are outsiders, as they may not have the same credentials as traditional music teachers at the center. At times, they are insiders, as they must have considerable technical knowledge and strong engineering problem-solving skills, yet they quickly become outsiders again as soon as technology changes. They must occupy and negotiate multiple cultural and political spaces between students, parents, administrators, traditional music teachers on the “inside,” and visiting artists on the “outside.” Like Ben and Laronda, they are also often practicing artists with feet solidly planted in educational and artistic communities of practice. They are situated far enough away from the center that not all traditional music educators speak their language and may not always feel at home. Likewise, differences in musical and technological literacies and preference for one side or another of the composition/performance continuum may cause the technology-based music educator to feel out of place in the band, chorus, or orchestra room (Elliott & Silverman, 2015). Finally, their view from the periphery enables them to develop critical perspectives of the established and institutionalized practices and perspectives of music education.

Given the unique environmental conditions of the music technology laboratory and the special dispositions and positions of the skunk-like technology-based music educator, it could be argued that the work of such a person and the effect of such an environment could be thought to share the same goal and end of liberal education to “free minds.” Nonetheless, the preponderance

of literature on STEAM education aligns it with 21st Century Skills (i.e., the four Cs of critical thinking, creativity, collaboration, and communication together with problem-solving as its stated categorical learning objectives [National Research Council, 2014]). Critics of the 21st Century Skills movement argue that its agenda devalues the liberal arts in schools (Selingo, 2015), as it narrows the curriculum and shifts focus away from the humanities to STEM subjects (Giroux, 2011) and emphasizes instrumental economic aims for education (Biesta, 2009). Therefore, even with shared objectives of critical thinking and creativity, STEAM, as it may be conceived as a movement that aligns with 21st Century Skills, must be disambiguated from the liberal arts.

The STEAM of 21st Century Skills seems a far cry from the poetic reaches of my undergraduate mathematics tutor's sweeping conceptional unities and *lines of flight* of transdisciplinary thought. As a tutor at St. John's College, Mr. Simpson was required to lead learning (dare I say "teach") across the entire Great Books curriculum, including leading courses, or "tutorials," in language and linguistics through the study of Attic Greek and modern French; mathematics spanning from Euclid to Lobachevsky; the sciences from Aristotle to Einstein; and music from Hildegard von Bingen to John Cage. As a tutor, he would also co-lead bi-weekly evening seminars with readings spanning from Homer to Du Bois, covering seminal works of philosophy, literature, economics, psychology, and political science. All tutors were required to do this. Mr. Simpson possibly had the advantage of being an alumnus of the college, but he was nonetheless a constant and lifelong student of great ideas (of the West and East). While he was not equally equipped as an expert in the dauntingly wide and expansive range of thought represented in the program, Mr. Simpson humbly submitted to the requirement that all tutors must teach across the curriculum, regardless of their fields. Mr. Simpson's understanding of

something of the nature of knowledge itself allowed him to think critically and playfully across disciplines with agility and depth.

The vision and version of STEAM that I first encountered in the context of liberal arts has propelled me on a lifelong learning journey. *This is what it means to be educated*, I thought. When I reflect on the nature of other conceptions of STEAM, such as the dominant 20th Century Skills version or Andrea's standards-aligned version, I pause to wonder if such grounded versions can ever take flight in the minds of students. Groundedness itself may not be the difficulty. The program at St. John's College is so deeply grounded in tradition that many critics see it as anachronistic and authoritarian embrace of a Eurocentric tradition to the exclusion of non-Western perspectives, and one which countervails its own claim to freedom by rigid and unwavering commitment to and reinforcement of a fixed set of canonical texts (Bloom, 1987). Paradoxically, what easily appears to be an orthodox conservatory of arborescent knowledge proves to have an emancipatory effect on those who experience it.

With this ambiguity, I return to the vision of a quasi-arborescent garden that flourishes in the ecotones and ecoclines between modalities of knowing and thinking. I also return to the epiSTEAMological skunk, which thrives in such diverse habitats and may well emerge in our changing times as a new breed of liberal artist surrounded by a profoundly richer and politically charged cloud of a new kind of STEAM.

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Appendix A:
IRB Approval



Teachers College IRB

Exempt Study

To: Charles Mangum
From: Myra Luna Lucero, Research Compliance Manager Subject:
IRB Approval: 19-428 Protocol
Date: 11/04/2019

Thank you for submitting your study entitled, "*Modulating Disciplinary Domains: The Music Technology Teacher as a Practitioner of STEAM Teaching and Learning.*;" the IRB has determined that your study is **Exempt** from committee review (Category 2) on 11/04/2019.

Please keep in mind that the IRB Committee must be contacted if there are any changes to your research protocol. The number assigned to your protocol is **19-428**. Feel free to contact the IRB Office by using the "Messages" option in the electronic Mentor IRB system if you have any questions about this protocol.

Please note that your Consent form bears an official IRB authorization stamp and is attached to this email. Copies of this form with the IRB stamp must be used for your research work. Further, all research recruitment materials must include the study's IRB-approved protocol number.

As the PI of record for this protocol, you are required to:

- Use current, up-to-date IRB approved documents
- Ensure all study staff and their CITI certifications are on record with the IRB
- Notify the IRB of any changes or modifications to your study procedures
- Alert the IRB of any adverse events

You are also required to respond if the IRB communicates with you directly about any aspect of your protocol. Failure to adhere to your responsibilities as a study PI can result in action by the IRB up to and including suspension of your approval and cessation of your research.

You can retrieve a PDF copy of this approval letter from Mentor IRB. Best wishes for your research work.

Sincerely,
Dr. Myra Luna Lucero Research Compliance Manager
IRB@tc.edu

Attachments:

- 19-428_Mangum Revised Consent Form Clean

Appendix B:
Interview Protocol

| Objectives | Research Questions | Script/Interview Questions |
|--------------|--------------------|--|
| Introduction | | <p>My name is Chris Mangum and I am a doctoral student at Teachers College, Columbia University. The purpose of this study is to explore music educators' perception and understanding of STEAM education. STEAM stands for Science, Technology, Engineering, Arts and Mathematics. It adds the A for the arts to STEM. Today, I'll be asking you about your experience, your own learning process, and your preparedness to teach in this emerging field. Thank you so much for your time and the opportunity to interview you regarding your understanding and implementation of STEAM in your teaching.</p> <p>This SKYPE (telephone)interview will be audio-recorded. You can choose whether or not you would like to be audio-recorded. If you choose to be audio-recorded, I will notify you when the audio-recorder is started and stopped. If you do not want to be audio-recorded, I will take hand-notes and use that instead. Please let me know which you would prefer.</p> <p>I am now recording (taking notes, if the participant does not consent). Before we begin, there are just a few things I need you to know about the process:</p> <p>First of all, this interview is confidential. Your name will be changed to a pseudonym (or false name), and all recordings/notes will be digitally encrypted and kept under lock and key while they are being transcribed and analyzed, and then destroyed after I am done with them.</p> <p>Secondly, I want to be clear that there is no compensation being offered for your participation in this study. You are not required to answer any question, and you may leave the study at any time for any reason without consequence.</p> <p>Do you understand and agree with all of these terms? Do you have any further questions before we begin?</p> |

| | | |
|--|--|---|
| Definition | <i>How do music technology teachers define STEAM?</i> | <ul style="list-style-type: none"> • What do you currently teach? • What is your understanding of STEAM? • If you were going to explain STEAM to someone who wasn't familiar with it, how would you describe it? |
| Experience Background Motivation Learning | <i>How and to what extent has their own teaching, learning and artistic practice led to engagement with STEM subjects?</i> | <ul style="list-style-type: none"> • How might you describe your artistic practice? (how do you define yourself musically?) • Was there an early experience that led you toward music technology? • How did you first learn about _____?(fill in from above). • To what extent, if any, does science, math, engineering and technology (STEM) factor into what your own problem solving in music technology? • To what extent, if any, does science, math, engineering and technology factor into how you <i>teach</i> music technology? • If you were given the time and money to go back to school and study anything you'd like for your own professional development, what would it be? |
| Challenges | <p><i>What challenges do music technology teachers face in incorporating STEAM education in their practice and how they meet those challenges?</i></p> <p><i>How do they grapple with the concept and implementation of STEAM?</i></p> | <ul style="list-style-type: none"> • As a music technology teacher, what is your relationship to the larger world of music education? • In what ways do you engage with disciplinary areas other than music? • How has your institutional environment encouraged and/or discouraged interdisciplinary aspects of teaching music technology? • Can you tell me about the extent to which you feel free or restricted in crossing disciplinary boundaries? |
| STEAM vs. traditional music | <i>What are the STEAMy aspects of music technology curricula and how do they relate to more traditional goals of music education?</i> | <ul style="list-style-type: none"> • What does your music technology curriculum look like? • What is the relationship, if any, between audio engineering and engineering <i>per se</i>? • Can you identify any areas that might be considered STEM in your curriculum? • In what ways, if any, does your curriculum relate to aspects of the more traditionally defined realm of music education? • How has your approach teaching and curriculum changed over your career? |
| Conclusion | | <p>Is there anything else that you'd like add?</p> <p>Thank you for your time!</p> |

Appendix C:
Electronic Consent Form

Participant Electronic Mail Message Contact

Dear:

My name is Chris Mangum and I am currently in the data collection phase of my dissertation at Teachers College Columbia University. My dissertation focuses on if, how and to what extent music technology teachers identify with, embrace, reject, or employ STEAM education. As part of my research, I will be speaking to a number of music educators who teach through technology throughout the United States. I was wondering if you might be interested in participating in the study, which would entail an initial 45-minute interview and another 45-minute follow-up interview. The interviews will be conducted and recorded via Skype.

Your responses and identity will remain completely confidential. While there is no compensation offered for this study, your participation would potentially enrich future research and understanding of music education and how it relates to STEAM in particular.

I hope that you will be interested in participating in my study. Thank you in advance for your consideration.

Best,
Chris Mangum

IRB #19-428

APPENDIX D:

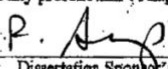
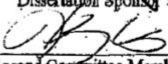
DISSERTATION PROPOSAL

DISSERTATION PROPOSAL HEARING REPORT

Part II - Approval by Dissertation Committee Members

The dissertation sponsor, second committee member and third member (if any), agree that the proposal is practicable and acceptable, that its plan and prospectus are satisfactory, and that the student is competent in the knowledge and techniques required, approve the proposal and recommend that the student proceed according to the prospectus and under the supervision of the Dissertation Committee.

The faculty present and voting **YES** sign here (All committee member signatures are required):

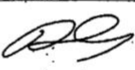
| | | | |
|----|---|-------------------|----------|
| 1. |  | Randall E. Allsup | 10/20/19 |
| | Dissertation Sponsor's Signature | Print Name | Date |
| 2. |  | H. Abel | 10/22/19 |
| | Second Committee Member's Signature | Print Name | Date |
| 3. | | | |
| | Additional Committee Member's Signature (if applicable) | Print Name | Date |

NOTE: An official third member will require a five member Dissertation Oral Defense Committee

The faculty present and voting **NO** sign here:

| | | | |
|----|---|------------|------|
| 1. | | | |
| | Dissertation Sponsor's Signature | Print Name | Date |
| 2. | | | |
| | Second Committee Member's Signature | Print Name | Date |
| 3. | | | |
| | Additional Committee Member's Signature (if applicable) | Print Name | Date |

Part III - To Be Signed by the Department Chair

| | | |
|---|------------|----------|
|  | D. Han | 10/23/19 |
| Department Chair's Signature | Print Name | Date |

(REV. 3/2015)

FOR OFFICE USE ONLY

Date IRB Letter received: _____
Date manuscript received: _____

TEACHERS COLLEGE
COLUMBIA UNIVERSITY
Office of the Registrar

Box 172 • 324 Throldike Hall • 525 West 120th Street • New York, NY 10027
Phone: (212) 678-4630 • Fax: (212) 678-3005

Dissertation Proposal Hearing Report

Dissertation Proposal Hearing Date Held: November 6 2018
Month Day Year

Note: After the successful Dissertation Proposal Hearing, the student applies for IRB approval. The Office of Sponsored Programs (OSP) handles the procedures and provides information on the Institutional Review Board (IRB) application. Upon receiving the IRB approval letter from the Office of Sponsored Programs, the student submits the following to the Office of the Registrar:

- a. The Dissertation Proposal Hearing Report Form with the appropriate signatures
- b. A copy of the IRB letter exempting or approving the student's document.
- c. A copy of the Dissertation Proposal manuscript

- When all documents are complete, they should be submitted to ods@tc.columbia.edu in pdf format.

Please check your degree program:

- Ed.D. - Doctor of Education
- Ed.D. CTAS - Doctor of Education in College Teaching of an Academic Subject
- Ph.D. - Doctor of Philosophy

Part I - Candidate Statement

Student Name: Maunum Charles TC ID #: T3619049
Last Name First Name MI

Day Phone #: +66 64 039 0118 Email: chris@osgoodgroup.com

Department: Arts & Humanities Program: Music and Music Education

Title of Proposed Dissertation: Modulating disciplinary boundaries: The music technology teacher as potential practitioner of STEAM teaching and learning

Dissertation Sponsor Name: Randall E. Allsup

Second Committee Member Name: John M. Broughton Hal Abeles

Additional Member Name (if applicable): _____

Appendix E:

Research Questions

Charles C. Mangum – IRB #19-428

Matrix of research questions, sample interview questions and related concepts

| Research Questions | Sample Interview Questions | Related Concepts |
|---|---|--|
| RQ 1: How do participating music teachers in this study understand, discover, invent practice and implement STEAM education? | <ul style="list-style-type: none"> • What’s STEAM all about and how do you and/or don’t you practice it? How do you see the balance of the letters in the acronym? • Give me an example of something cool you didn’t understand at first, but then came to understand through discovery or experiment. Have you ever made that happen for a kid? How? | <ul style="list-style-type: none"> • Teacher/Learner Identity • Discovery |
| RQ 1a: How do the participants perceive their own community of practice, and how do they make sense of their own ecology of learning specific to music technology as a discipline? | <ul style="list-style-type: none"> • As a music technology teacher and/or artist, from whom and how do you best learn? Are you a different kind of learner (and if yes how so)? • Are you an expert at something? How did you become one? | <ul style="list-style-type: none"> • Navigation • Discovery • Teacher/Learner Identity |
| RQ 1b: How and to what extent has their experience teaching, learning and artistic practice led to engagements with STEM subjects? In what ways is their learning in STEM subjects supported by their environments? | <ul style="list-style-type: none"> • Have you ever invented anything, or have you ever <i>thought</i> that you had invented something, only to find that it already existed? How are you an innovator? Give an example of something you have improved upon. • What was your experience like learning STEM subjects inside and outside of the classroom? How does it relate back to what you’re doing now? | <ul style="list-style-type: none"> • Discovery • Bricolage • Action • Teacher/Learner Identity |

| | | |
|---|---|--|
| <p>RQ 1c: What are they doing? What do they consider the most STEAM-like elements or aspects of their teaching and learning practices to be, and how do they relate their praxis to the goals of music education? How do they relate to STEM education?</p> | <ul style="list-style-type: none"> • What STEAM-like things have you done with your students. • Just how “sciencey” do you ever get in your classes? Has there been any pushback? • At school, where and how do you fit or not fit? What do you think the other teachers in your discipline and others make of you? Do you feel “legit” or not? How and why? | <ul style="list-style-type: none"> • Action • Navigation • Discovery • Bricolage • Teacher/Learner Identity |
|---|---|--|

APPENDIX F:

FLYER



VOLUNTEERS NEEDED

for a research study on

MUSIC TECHNOLOGY TEACHERS AND STEAM

"MODULATING DISCIPLINARY DOMAINS: THE MUSIC TECHNOLOGY TEACHER AS POTENTIAL PRACTICER OF STEAM TEACHING AND LEARNING"

You are invited to participate in a research study seeking to understand how technology-based music educators understand and/or practice STEAM education.

Seeking technology-based music educators with at least five years of full-time teaching experience in a school setting.

- Time commitment: 90 minutes
- Time and place of your convenience
- No compensation

Please contact me at
ccm2129@tc.columbia.edu

IRB # 19-428