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TRYING TO CHANGE THE SCIENCE CONVERSATION IN SCHOOLS: A CASE STUDY OF TEACHER PREPARATION AT THE AMERICAN MUSEUM OF NATURAL HISTORY

Dissertation by

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ABSTRACT

This dissertation focuses on how the MAT program in Earth Science at the American Museum of Natural History (AMNH MAT), a one-of-a-kind, museum-based urban teacher residency, conceptualized and enacted the project of learning to teach science for urban school contexts. The AMNH MAT is situated within the two nested contexts. The first context is its emergence as one of a number of new, state-approved graduate schools of education that offer teacher preparation, endorse teachers for certification, and grant master's degrees but are not part of or connected to universities. The larger study of which this case study is part termed this phenomenon "new graduate schools of education," or nGSEs. The second context is the program's mission of preparing teachers for urban schools, a goal that is shared by other teacher preparation programs within the domain of nGSEs.

This descriptive, interpretive case study analysis poses two major questions: How and to what extent does the American Museum of Natural History infuse its long-standing beliefs about **science** learning and public service into a teacher preparation program? How and to what extent does the museum conceptualize and enact science teacher preparation for the specific context of **urban** high needs public secondary schools? Analysis of multiple data sources revealed that the AMNH's mission of disseminating science knowledge in service of a more science-literate public was instantiated in a teacher preparation program that *centralized and continually reinforced* a vision of preparing **science** teachers but had a *less central and more limited* approach to preparing **urban** teachers.

This case study analysis of an innovative teacher preparation program in one of our nation's largest cities has important implications for urban science teacher education research and practice. First, the AMNH MAT's model of science teacher preparation offered two key

features that are useful for the field. The first feature was its coherence around the development of a science teacher identity that included deep science content knowledge and a commitment to bringing informal science teaching and learning practices into schools. The second model feature was the MAT program's required four-residency structure, which essentially reinvented the "field" in teacher preparation fieldwork. At the same time, the project of learning to teach at the AMNH MAT, like that of many other urban teacher preparation programs, revealed the difficulties and dilemmas involved in preparing teachers for urban contexts, particularly the responsibility of developing a new generation of antiracist educators.

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My life has changed dramatically in the past six years. I became a mother. I moved. I changed jobs- twice. The one constant in my life in these years has been my role as doctoral student and researcher at Boston College. I have never worked harder at anything in my life than I have in this program. In my studies and early discussions with my teachers and cohort members, I learned that there were labels and whole schools of thought for predicaments and problems that had always troubled me about schools and schooling. In this way, my studies made me feel less alone, offering new perspectives on teaching, a great love of my life. Being a member of a research project with a brilliant leader, Dr. Marilyn Cochran-Smith, and the smart, dedicated Drs. Elizabeth Stringer Keefe and Molly Cummings Carney taught me that scholarship, though not without its moments of seclusion, does not exist in a bubble. No one can do her best thinking, writing, or work in general alone. Our contributions to research, to practice, to people are always built on the ideas and work of others. In the final part of this experience, writing the dissertation, I have learned that in addition to collaboration, being a researcher also paradoxically requires sustained solitude. I found the process of re/analyzing, re/thinking, re/writing over and over and over again not only humbling, but also fortifying.

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TABLE OF CONTENTS

LIST OF FIGURES

Chapter 6

CHAPTER ONE

A Study of Urban Science Teacher Preparation:

The Intersection of Three Converging Trends

According to its founders and leaders, the American Museum of Natural History's Master of Arts in Teaching program (hereinafter, the "AMNH MAT") is unique in that it is the only urban-focused, museum-based teacher preparation program in the world (Hammerness, Contino & Macdonald, 2020). Since 2011, one of the most "beloved," (Quenqua, 2012) resource-rich science museums in the United States has been preparing an increasingly ethnically and culturally diverse cadre of teachers (Hammerness et al., 2020). According to the program's own reports, more than 90% of graduates from the first three cohorts of the program (2012-2015) have remained teachers of record in urban and high-needs schools in New York beyond the four years required by the program (Hammerness et al., 2020; Institutional Document #25, *Summary of Research Findings*). Drawing on the affordances of the AMNH, which are expansive and expertly curated, the goal of the MAT program was specific: "to attract individuals who are expert in earth and related sciences to a residency program specifically designed to prepare earth science teachers to successfully teach in diverse high-needs urban schools" (Institutional Document #6, *CAEP Accreditation Document*). Not only did the AMNH MAT program aim to mitigate the shortages of earth science teachers, but it also worked to produce teachers whose presence as scientists would boost the value and importance of science, working to "change the science conversation in schools" where its residents became teachers (Interview #7, Program Leader). These features of the AMNH MAT made it an intrinsically interesting case for empirical study of these questions: How and to what extent does an institution with the rich history of the AMNH infuse its long-standing beliefs about science learning and public service into a teacher preparation program? and To what extent does the museum instantiate its mission into the (re)conceptualization of science teacher preparation for the specific context of urban and high needs public secondary schools?

According to Gupta et al. (2010), Director of Youth, Learning, and Research at the AMNH, science museums might need to shift institutionally to be better aligned with their audiences, however "a delicate balance…needs to be preserved between changing enough to connect better with an audience and changing so much that institutional identity is lost" (p. 691). The AMNH MAT aimed for such a "delicate balance" between a continued commitment to the value of informal science learning and deep content knowledge as a way of contributing to a science-literate society, on the one hand, and the goal of ameliorating the critical shortage of qualified urban secondary earth science teachers, on the other.

In addition to the AMNH MAT itself being a unique and intrinsically interesting teacher preparation program to study, this dissertation is also unique in that it is the first in-depth empirical analysis of the AMNH MAT conducted by a researcher *not* affiliated with the museum since the program's inception in 2011. As such, this study offers a different kind of analysis of the AMNH MAT from what has been previously done.

The publications, presentations, and evaluation reports written or commissioned by museum and MAT faculty are useful in terms of understanding the role and impact of an informal science environment on the process of learning to teach (Gupta, Trowbridge, and Macdonald, 2016; Trowbridge, 2018), especially in terms of confidence-building, identity, and agency for prospective teachers (Adams & Gupta, 2017). In a conference presentation, Senior Director of Science Education at the AMNH and co-founder of the MAT program, Ro Kinzler, along with colleagues (2020), stated that the program promoted culturally responsive-sustaining science teaching through several of the practices and protocols used consistently throughout the program. Zirakparvar (2014, 2015), a museum scientist, described his growth as a teacher of science as a result of his experiences working in the MAT program. Fallona and Doykos (2017), independent researchers employed by the museum, concluded that situating a teacher education program in the context of museum "is an effective expansion of teacher preparation opportunities" (p. ii). Another evaluator commissioned by the museum, Silvernail (2017) found that the AMNH MAT program had been successful in preparing beginning teachers to effectively improve the academic performance of students in high need urban schools.

This dissertation case study of teacher preparation at the AMNH MAT, while interested in informal science settings and their relationship to the process of learning to teach, has a different purpose from research that has been conducted by those employed or commissioned by the AMNH MAT. The first aim of this dissertation is to contribute to a larger study, *Teacher Preparation at New Graduate Schools of Education (nGSEs),* which has as a major goal "document[ing] and theoriz[ing] how teacher preparation is conceptualized and enacted within and across multiple [new graduate schools of education] from the perspectives of the participants" (Cochran-Smith, 2021a, p. 1). Contributing to this larger goal, this study aims to understand—not to advocate for, but also not to judge—how teacher preparation was conceptualized and enacted according to program participants, including AMNH museum leaders and educators, MAT founders and faculty, program graduates, and teacher candidates, called "residents." This dissertation also specifically examines whether and how the museum's mission was woven into the envisioning and enacting of science teacher preparation.

Another aspect of the case study that is different from previous explorations carried out by museum-affiliated researchers is that I do not have a background in museum-based education or in science education, as is the case with most of the other researchers who have examined or evaluated the AMNH MAT. Rather my background is in teaching and teacher preparation for urban secondary schools. Because of this, the second aim of this study is to explore whether and to what extent the AMNH MAT prepared its residents for the context of urban schools in particular.

In sum, the AMNH MAT stood alone as an interesting phenomenon to study *and* this case study uniquely focuses on the program's conceptualization and enactment of teacher preparation for urban, secondary science classrooms and school contexts. Examining this teacher preparation program, which was independent of any university, is in part a process of understanding whether and how the program maintains the "delicate balance" it sought in upholding museum ideals while supporting the complex process of learning to teach science and credentialing teachers in New York State as well as unpacking the sociocultural and sociopolitical processes involved in the pedagogy and instruction required for successful teaching in urban school contexts.

Research Problem

Over the past thirty-five years, three converging trends in teacher education have created the conditions and the context for the emergence of independent, new graduate schools of education, including the MAT program at the AMNH: a new educational policy paradigm, persistent critiques of university teacher preparation, and a new paradigm of educational philanthropy. In addition, because many nGSEs, including the AMNH MAT, specifically prepare teachers for urban schools, there are also important issues in urban teacher preparation that are relevant to the research problem that this dissertation addresses. In particular, these issues include prioritizing social justice in the learning to teach process and addressing critical shortages in key content areas in urban schools, including and especially science.

A New Education Policy Paradigm

Mehta (2013) argues that American educational policy underwent a radical transformation in the 1980s, which started with *A Nation at Risk's* (1983) proclamation that U.S. public schools "were being eroded by a rising tide of mediocrity" that threatened the future of the nation's economy. This indictment led to a shift in education policy that was more tightly controlled by the federal government and produced a paradigm of reform-minded approaches engendered by the following beliefs: educational success is imperative to national, state, and individual economic success; schools rather than social forces are responsible for academic outcomes; and success should be measured by externally verifiable tests (Mehta, 2013). This schools-as-economic-saviors paradigm redefined educational policy in the 1990s and first decade and a half of the 2000s to focus on reform at the federal and state level, evidenced in such policies as the *Elementary and Secondary Education Act* (1994), Goals 2000, *No Child Left Behind* (2001), *Race to the Top* (2008), and *Every Student Succeeds Act* (2015) (Apple 2006; Mehta, 2013).

For teacher education, this new education reform policy contributed to what Cochran-Smith et al. (2018a) defines as the "era of accountability," which was fueled by the following "three-part logic:" holding teachers accountable will increase the quality of teacher education programs; quality teacher education will produce quality teachers (defined by student achievement), and; high student achievers will create a prosperous nation (p. 27). The reauthorization of the Higher Education Act in 1998, along with the Bush administration's *No Child Left Behind Act* of 2001 created an atmosphere in teacher education and the profession of teaching in general of high-stakes accountability: more rigid requirements and credentials for teacher licensure, the onset of standardized testing for K-12 students, and “objective” and mandated standards for teaching and learning. As Kumashiro (2015) points out, this heightened level of accountability was managed by the states but controlled by the federal government (Cochran-Smith et al., 2018a). This “audit culture” (Apple, 2006) prioritized outcomes, namely in the form of effective teachers and high-performing student achievers in K-12 schools, over the varied and rich knowledge sources teachers and students from different backgrounds, cultures, and heritages bring into schools and classrooms.

The ushering in of these federal policies, which was meant to correct the perceived problem of subpar teacher preparation and teaching, situated teacher education as what Cochran-Smith (2005) calls a “policy problem…where the goal is to determine which of [teacher education’s] broad parameters that can be controlled by policymakers is most likely to enhance teacher quality and thus have a positive impact on desired school outcomes” (p. 4). This approach is predicated on the idea that teacher education can be fixed by manipulating policies related to teacher supply, preparation, and evaluation. With the support of the Bush and Obama administrations, these policies paved the way- and even encouraged- alternate pathways of teacher preparation, including labor market innovations related to certification, entry pathways, preparation, and recruitment. This has had particular consequence for urban teacher preparation, as I will discuss below, because many alternative pathways to becoming a teacher are particularly designed to attend to shortages in specific areas, such as urban schools and particular content areas (e.g., special education, math, science).

In addition to opening the door for competitive approaches to preparing teachers, Ellis and McNicholl (2015) suggest that positioning teacher education as a “policy problem” has an "inherent danger" (p.16): it assumes that the issues facing schools and schooling can be solved by directly altering school-based and teacher education-related protocols, processes and programming. Making this assumption ignores outside of school factors, such as increasing poverty rates and living in a racialized society, that have great consequence for young people, especially those in urban schools who are primarily from historically marginalized groups (Kantor & Lowe, 2016). Taken from this perspective, seeing issues in education as problems to be fixed by changing policies diminishes the deep impact outside of school factors has on the teaching and learning that takes place inside schools (Kozol, 1991). It also wrongly assumes that schools, teachers, and teacher educators alone can do the work of redressing societal inequities (Cochran-Smith, 2010). Finally, the heavy emphasis on high-stakes policies over the past several decades has made it more challenging for new teachers to critically analyze injustice themselves and to engage their students in activities geared towards dismantling the perpetuated inequities in schools and society (Picower, 2011).

In the next two sections, I describe two additional trends in teacher education that converged with the education policy paradigm shift in creating the space in the field of teacher preparation for new, independent graduate schools of education like the AMNH MAT: persistent critiques of university teacher preparation and the increase in philanthropic funding for new pathways to teacher preparation. Both of these trends supported the idea that alternate pathways are policy solutions to the problems of teacher education.

Persistent Critiques of University Teacher Preparation

Despite *A Nation at Risk*'s (1983) unprecedented public denouncement of schools, teachers, and teacher educators as problematic and the public, political response this engendered, critiques of teacher education did not start in the 1980s. In fact, for almost as long as there have been formal teacher education programs, there have been questions about their effectiveness (Cochran-Smith & Fries, 2001). These debates about the proper conditions, structures, and requirements for preparing teachers have persisted despite the fact that from the mid 20th century until the 1990s, teacher education has occurred primarily in universities and schools of education (Fraser & Lefty, 2018). According to Fraser and Lefty (2018), "To say that there is no agreement about the best system of teacher preparation, even within university schools of education, is a drastic understatement" (p.3). However, with policy and political context described above, teacher education has been under particularly heavy scrutiny in the past thirty years, mostly for its perceived inability to prepare a diverse teacher workforce of qualified teachers who remain in the profession and who prepare a competitive labor force.

For instance, shortly after *A Nation at Risk,* the Holmes Group, a consortium of members from 96 teacher education programs located in research universities across the country, established itself and issued *Tomorrow's Teachers,* a report that called for education reform focused on professionalizing teaching, raising accountability and brokering connections to K-12 schools in university-based teacher education. Over the next decade, this group published two additional reports, *Tomorrow's Schools* and *Tomorrow's Schools of Education,* arguing that university teacher education programs did not incorporate enough opportunities for practice and practical learning in their preparation (Holmes Group, 1990; 1995).

The conception that university teacher preparation was failing the nation's schools was predicated on a few overarching beliefs, which over time became codified as a dominant narrative, or a "common sense" understanding of the general state of teacher education. One belief was that university teacher education programs were inadequately preparing teachers because, generally speaking, the process, procedures, and requirements for becoming a teacher were cumbersome, disconnected, and unnecessary for teacher candidates (Hess, 2002). Another belief was that there wasn't substantial evidence that universities produced more effective teachers than alternative routes (Ballou & Podgursky, 2000). A third pervasive belief was that university teacher preparation was too heavily weighted on theory and beliefs, and not connected enough to the daily practice of teaching (Ball & Forzani, 2009).

This pervasive and convincing narrative about university teacher education, referred to as "a narrative of derision about the alleged failure of university teacher education" (Zeichner, 2014, p.556) and a "crisis mentality" (Spring, 2011, p.15), was strengthened throughout the 1990s and 2000s by reports from the U.S. Department of Education, conservative think tanks, private advocacy programs and philanthropic organizations, leaders from the business community, and some education scholars and professionals (Cochran-Smith et al., 2018; Hollar, 2017; Zeichner & Conklin, 2016). However, there was also a critique and calls for change from those who worked inside of universities. For instance, a robust professionalization agenda, with Linda Darling-Hammond as its major advocate, pushed for greater consistency and accountability across preparation, licensure, and accreditation of teacher preparation programs (National Commission on Teaching & America's Future, 1996; 1997). Along different lines, over the past thirty or more years, some teacher education scholars have argued for teacher preparation programs with a deeper focus on equity, justice, and the community so that prospective teachers would be prepared for serving poor and minoritized children and to help disrupt systemic inequities in schools and schooling (McDonald & Zeichner, 2009; Sleeter, 2009; Villegas, 2008).

All of this, plus international attention to teacher quality, has given rise to unprecedented attention to teacher education and raised questions about where, how, and for what purposes teachers should be prepared (Cochran-Smith et al., 2018a). There were many controversial reports that arose out of the perceived crisis in American teacher preparation, which contributed to an environment that was conducive to the emergence of new, independent graduate schools of education. Two widely disseminated reports were Levine's (2006) *Educating School Teachers* and the National Council for Teacher Quality's (2013) first annual *Teacher Prep Review: A Review of the Nation's Teacher Preparation Programs*. Using data gathered from over 5,000 surveys of deans, chairs and directors of U.S. education schools and departments regarding their demographics, practices, personal experiences, attitudes and values, Levine's report (2006) concluded that many university-based teacher preparation programs were failing: "The challenge facing education schools is not to do a better job at what they are already doing, but to do a fundamentally different job" (p. 104). By "fundamentally different," Levine (2006) meant more focus on classroom practice, using student achievement to measure teacher education program success, establishing quality control measures for teacher preparation programs, and finally, closing failing teacher education programs and strengthening the rest by incentivizing outstanding students and career changers to enter the field. Zeichner and Conklin (2016) argued that the data from this report were not empirically sound and that its findings were misused for the political purpose of promoting alternate routes to teacher preparation.

NCTQ's 2013 evaluation of the quality of preservice preparation programs, the *Teacher Prep Review,* evaluated 583 programs in all 50 states and the District of Columbia. A self-described "consumer guide" (p.4), this report rated schools of education on a four-star scale, claiming to create "the largest database on teacher preparation ever assembled," which would reportedly "set… in place market forces that will spur underachieving programs to recognize their shortcomings and adopt methods used by high scorers" (p. 4). The idea here was to help school districts and aspiring teachers (i.e., consumers) determine which teacher preparation programs were good and which were not. Finally, this report painted a bleak picture of American university teacher education, purporting that in general, prospective teachers left these programs bereft of proper content knowledge and adequate classroom management skills for the nation's diverse classrooms. Just as in the case with Levine's widely referenced report, NCTQ's reports have been critiqued because they have not been subject to peer-review, and also due to their "lack of transparency and flaws related to data collection, ratings, reliability and validity" (Cochran-Smith, Piazza & Power, 2013, p. 24).

Another claim in the failure narrative was that university teacher education programs did little to prepare teachers for the actual work of teaching in classrooms, with too heavy an emphasis on theory. Two examples of discourse that contributed to this claim were former Secretary of Education Arne Duncan's (2009) now famous remarks on reforming the "uncertain profession" of teacher preparation and the widely-known National Council for the Accreditation of Teacher Education Commission's Blue Ribbon report on practice in teacher education, *Transforming Teacher Education through Clinical Practice: A National Strategy to Prepare Effective Teachers,* commissioned by the (NCATE, 2010).

Duncan (2009) promoted teacher residency programs, a relatively new model at the time, which were being awarded upwards of $100 million dollars in government grant money to build their programs. Heralding teachers – "not socioeconomic status, not family background"- as "the single best influence on student academic growth," Duncan (2009) also called for states and districts to partner together for the specific goal of mitigating teacher shortages in high-needs areas. Along these same lines, NCATE's 2010 report praised clinically-based teacher preparation as way to "ensure that candidates will be ready for the students with whom they will work…

[which is] critically important in preparing teachers to be successful in hard-to-staff, low-performing schools" (p.27). In particular, this report cited "the urgent need to address the staffing and learning challenges facing high-need and low-performing schools" (p. v). These widespread reports no doubt helped to pave the way for the national expansion of clinically-rich teacher preparation, including teacher residencies like the AMNH MAT.

The four public documents outlined above argued both that many university-based programs were not producing quality teachers for today's changing world and that dramatic changes were in order. The implication of these harsh critiques, and other likes them, was that many university-based teacher preparation programs needed serious overhaul and oversight in order to mitigate their perceived inability to prepare all of the nation's youth to thrive in a prosperous nation. Taking these documents as examples, it is easy to see how increased accountability for outcomes and more attention to clinically-based teacher preparation have generated enthusiasm- and political support- for the development of independent graduate schools of education, which are separate from the bureaucracy of universities, free to market themselves to solve specific problems in teacher education and claim to be more focused on practical classroom experience.

A New Paradigm of Educational Philanthropy

A new paradigm of educational philanthropy also helped to pave the way for new, independent graduate schools to enter the field of teacher education. This was related to venture philanthropy's generous funding for new, alternative pathways to teacher preparation (Zeichner & Peña-Sandoval, 2015; Zeichner 2016a). Previously, philanthropic funding to education tended to be in the form of smaller-scale, local donations without attached expectations or outcomes (Cochran-Smith, 2021a). According to Hess (2005, 2012), however, this changed when venture philanthropists began making large-scale donations aimed at disrupting bureaucracy and attached to accountability for K-12 student outcomes.

Over the last decade or so, there has been increased opportunities for the private sector to enter the historically public space of teacher education, including philanthropists, think tanks, advocacy groups, and charter management organizations and charter affiliates. Mungal (2016) argues that,

> the market-driven educational reform movement created an opportunity for independent organizations such as TFA [Teach for America] and Relay [Graduate School of Education] to recruit and prepare teachers for the classroom. The competition aspect of market ideology saw school districts close down what they deemed to be failing local public area schools and hand over control to EMOs [education management organizations] and to charter school networks. (p.8)

Market-based approaches to teacher preparation opened the door for education philanthropists, whose efforts had previously primarily been in improving K-12 schools, to fund new pathways to teacher preparation, which have been referred to as "start-ups" (Fraser & Lefty, 2018) or "entrepreneurial outfits" (Anderson, 2019).

Using field theory and the concept of strategic action fields, Atkinson and Dotts (2019) examine the interconnected web of independent graduate schools of education (like nGSEs), charter management organizations, and private/philanthropic funders. These researchers argue that the collusion of these groups, combined with U.S. Department of Education's support (Duncan, 2009; Garner et al., 1983; U.S. Department of Education, 2002, 2008, 2009, 2011), has created the political climate for independent teacher preparation programs. Fraser and Lefty (2018) assert that, "If we follow the money- from the federal government, state legislatures, and some of the nation's most prestigious foundations- the track leads to alternative routes into teaching, be they TFA, residency programs, or new providers, such as the rapidly growing Relay Graduate School of Education" (p.21). In the second chapter of this dissertation, I further describe current critiques of new graduate schools of education, including the implications of their recent philanthropic support. Importantly, this directly relates to the AMNH MAT, which was heavily supported by private and governmental funding when it launched in 2011 as the first ever museum-based urban teacher residency.

The paradigm shift in policy to focus on education reform, the prevailing narrative that university schools of education were failing to produce quality educators, and philanthropy's turn toward more muscular funding for disruptive education initiatives, including new pathways of teacher preparation, are three interrelated trends in teacher education that supported rapid and dramatic changes in the field.

Urban Teacher Preparation

Many new, independent graduate schools of education, like the AMNH MAT, prepare teachers for urban public and urban charter schools with the aim of mitigating critical shortages in the teaching workforce. Teacher shortages is a problem faced by most urban schools. In addition, many teachers in urban schools are white while most of the students are Black or Latinx (National Center for Education Statistics, 2015; Partelow, 2019). It is also well-known that many students in American urban public schools have historically been underserved in terms of experiences, resources, and outcomes (Carter & Welner, 2013). Because of the intertwined imperatives of a lack of qualified teachers and historical inequity, there is a severe need to improve the recruitment, preparation, and retention of teachers for urban schools.

At the outset of any discussion about "urban" teacher preparation, there is the matter of defining the term "urban." Vernikoff, Goodwin, Horn & Akin (2018) point out that "many teacher education programs use 'urban' as a synonym for 'culturally diverse,' or as a euphemism for deficit-based and often racialized characterizations of students, regardless of where those students live or go to school" (p.2). Milner et al. (2015) delineates three types of urban school districts: *urban intensive* (in large metropolitan areas), *urban emergent* (in large, but not major cities), and *urban characteristic* (not traditionally urban, but have some characteristics often associated with the term). Jacobs (2015) argues for a need to dismantle the deficit framework implicit in the term, "urban," since it can serve as a "stand-in for more sensitive words, such as, 'Black,' 'poor,' and 'uneducated' without fully explicating what is meant" (p.23). Welsh and Swain (2020) examine the variations in how "urban education" is defined through a comprehensive review of literature as well as analyzing data from Stanford Education Data Archive (SEDA) and National Center for Education Statistics (NCES). They found that "most definitions of 'urban' identify a set of districts with high concentrations of Black and Latinx students; with high levels of racial, ethnic, and socioeconomic segregation, and; in communities with high income inequality, high poverty, and high educational attainment" (p. 97).

Collectively, these researchers point out that intentionally or not, many have used the term "urban" to mean much more than place; it has come to stand in for issues of race and class. Attaching assumed deficits to public schools in major cities that are filled with young people from historically marginalized groups ignores opportunities and successes within these schools. Hammerness, Craig & Kosnick (2016) argue that acknowledging the different features of particular urban areas is a way to understand teaching in these same urban areas. For the purposes of this case study, I define "urban schools" as those in major U.S. cities where the students represent multiple heritages, cultures, cognitive abilities, and languages. Given this definition, the AMNH MAT, an Earth Science residency program which prepares its prospective teachers primarily for New York City schools, is an "urban" teacher preparation program.

Urban schools are places of possibility, inclusivity, and diversity that are impacted by historical, social, and cultural inequities. The tension between urban schools as places of opportunity for personal growth, on one hand, and as places of systemic oppression, on the other, creates a challenging workplace for urban public school teachers. Arguably, one consequence of this tension is that about half of urban educators leave the profession after just five years (Ingersoll, 2001; Waddell, 2010), which negatively affects student learning (Ronfeldt, Loeb, & Wyckoff, 2013). To put a finer point on this, urban schools have long experienced critical shortages in content areas such as math and science (Ingersoll & Perda, 2009), as well as English as a second language and special education (Partelow, 2019). The pandemic has worsened this issue, with almost every state reporting shortages in math and science in 2020-2021 (DiNapoli, 2021). Research points to several reasons for these persistent shortages, including: inadequate mentoring for new teachers (LoCascio, Smeaton, & Waters, 2014; Matsko, 2010), lack of support from school leaders and colleagues (Wynn, Carboni, & Patall, 2007), disconnectedness between aspiring teachers' social justice ideologies and the realities of urban schools (Alkins et al., 2006; Arce, 2004), and difficulty with classroom management (Morris & Morris, 2012).

In terms of science teacher shortages in New York State and New York City in particular, there is a dearth of qualified earth science teachers. This scarcity of teachers was- and remains- problematic because the geoscience workforce in general has experienced a steady decline (United States Department of Labor, 2012), particularly when compared to other STEM disciplines (Gonzales and Keane, 2010). There is also the problem that many university science and science education professors have been criticized for being overly didactic, teaching a "transmissive pedagogy" (Dawborn-Gundlach et al., 2017, p. 215) or teaching "school science" (Mervis, 2013). This is in part because "science professors typically lack formal training, and sometimes interest, in how to be effective and engaging science teachers" (Zirakparvar, 2014, p. 511). This is particularly an issue because, as I point out in the next chapter, research points to the prevalence of teacher-centered, information transmission-oriented activities in urban secondary science classrooms (Barton, 2003; Tate, 2001).

Urban schools also face the challenge that often, those who are teaching have had different life experiences than the experiences of the students themselves. Currently 80% of the U.S. teaching force identifies as non-Hispanic white (Partelow, 2019) whereas more than half of students in American public schools identify as people of color (National Center for Education Statistics, 2015). This can be problematic because, as many scholars have pointed out, students of color tend to perform better and have better school experiences when they learn from teachers of color (Ahmad & Boser, 2014; Dee, 2005; Villegas 2007; Wright, 2015). The solution to this problem may not simply be a matter of recruiting and retaining more teachers of color, however. Philip and Brown (2020) argued that there is over usage and under-problematizing of the term "teachers of color," suggesting that an over-emphasis on hiring teachers of color as the solution to the problems of urban education could detract from the important work of transforming schools. They caution researchers and policymakers against liberally using the term "teachers of color," as it is "a term so prone to slippage into essentialism" (Philip & Brown, 2020, p.4), making it susceptible to false assumptions about the capabilities and characteristics of teachers of color. This is a point I return to in Chapter 6. Amidst these important considerations there lies the need for qualified teachers and qualified teachers of color to enter and remain in urban public schools, especially to act as agents of transformative change for public education.

Many scholars have argued that the history and current reality of racial and cultural oppression ought to be an integral component of urban teacher preparation (Banks & Banks, 2019; Cochran-Smith, 2000; Delpit, 1988; Kozol, 1991; Ladson-Billings, 1995, 2006; Milner, 2015, and Sleeter, 2011). My analysis of literature on urban teacher residencies and on urban secondary science teacher preparation, which is elaborated in Chapter 2, reveals that there is a need for prospective urban teachers of secondary science to explore their own positionalities, to learn how to embrace the knowledge and assets of their students, and to learn how to be change agents in the sociopolitical area of urban public schools (e.g., Garza et al., 2018; Marco-Bujosa et al., 2019; Mensah et al., 2018; Strom et al., 2018). Many scholars have also argued that improving teacher preparation and bolstering teacher quality alone will never be enough to improve urban schools (Cochran-Smith, 2010; Ladson-Billings, 2006; Milner, 2015). Rather fixing urban schools requires many structural and systemic changes (Kantor & Lowe, 2013) as well as attention to the ways teachers are recruited, selected, prepared, supported, and evaluated (Achinstein & Ogawa, 2011).

Over the last decade, urban teacher preparation has responded to these challenges in a variety of ways. Efforts include: new urban-focused and community-focused preparation programs initiated by university schools of education; “alternative route” preparation programs that focus on recruiting teachers for urban schools, such as Teach for America; teacher preparation for urban charter schools operating completely independent of universities (i.e., Relay GSE, Sposato GSE); teacher preparation programs funded by urban charter management organizations to prepare teachers for urban charter schools, urban teacher residency programs, and hybrids of some of the above. These varied pathways have prepared thousands of candidates to teach in urban schools, and more prospective teachers each year enter teaching through alternative pathways at the same time that enrollment in university programs has dropped (Partelow, 2019). One of these pathways, new, independent new graduate schools of education, or "nGSEs," a term that is explained in the next section, is the focus of the larger study from which this case study arises.

Context of the Larger Study

This dissertation was conducted as part of the larger, Spencer-funded project, *Teacher Preparation at New Graduate Schools of Education.* As far as we know, this is the first independent empirical study of teacher preparation across multiple new graduate schools of education, or "nGSEs" based on direct access to program materials, design components, and participants. Our research team coined the acronym "nGSE" (Cochran-Smith, Carney & Miller, 2016) to refer to the small but growing phenomenon of initial teacher preparation at new graduate schools of education that have emerged since 2005 as part of the education reform movement and that prepare and endorse teachers for certification, grant master's degrees, are state-authorized to certify new teachers, and are not affiliated with universities (Cochran-Smith et al.,2018b; 2019; 2020). Through extensive and ongoing searches of all Departments of Education of all 50 states and the District of Columbia, we identified 11 nGSEs coast-to-coast (Cochran-Smith et al., 2020). Two of these are for-profit, online higher education organizations, while the rest are non-profit. Five were founded by charter school leaders and charter management organizations; two are outgrowths of existing local or regional centers for teachers' professional development; two are new stand-alone graduate schools, and; one (the AMNH MAT) is embedded within a graduate school at a major museum (Cochran-Smith, 2021b). One feature of nGSEs that is worth pointing out is that seven of the 11 existing nGSEs prepare teachers for urban public or urban public charter schools. Interestingly, the AMNH MAT, which is the focus of this dissertation, is one of only three nGSE preparing teachers for urban schools that is not connected to charter schools or charter networks (Reach Institute for School Leadership in Oakland, California and Rhode Island School for Progressive Education, are the others).

The three converging trends in teacher education described above created a climate that was not only amenable to the emergence of nGSEs, "but also to a certain extent privileged and supported the expansion and legitimization of teacher preparation at non-university professional schools and other sites" (Cochran-Smith, 2021a, p. 5). In this way, nGSEs can be seen as controversial, although the aim of the larger study is not to evaluate nGSEs or to determine whether or how they are a "better" pathway for prospective teachers. Rather, the study aims at understanding the remarkable growth of these institutions, which entered the field as graduate schools in 2005 (Cochran-Smith, 2021b). In addition to unpacking how nGSEs operate as new organizations within the changing institutional field of teacher preparation, the larger study also zeroes in on how teacher preparation is conceptualized and enacted at nGSEs. We have argued that this is important to pay attention to because although nGSEs "are responsible for only a small portion of the teachers prepared each year in the United States, they have garnered considerable media attention and a disproportionate share of the private and public funding allocated to teacher education" (Cochran-Smith, 2021a, p. 10).

Our larger study had three phases (Cochran-Smith, 2021a, 2021b; Cochran-Smith et al. 2018b, 2018c, 2019, 2020). Phase 1 centered on defining the institutional domain of teacher preparation at nGSEs. Phase 2 consisted of a within-case analysis of how teacher preparation is conceptualized and enacted at the four case sites. Each site is considered information-rich and interesting in its own rite, what Stake (2006) called "intrinsic" cases. The larger study has produced three qualitative case studies: Sposato Graduate School of Education (Miller, 2017), High Tech High Graduate School of Education (Sanchez, 2019), and TEACH-NOW Graduate School of Education (now Moreland University) (Carney, 2019). This case study of teacher preparation at the AMNH MAT is the fourth case study within the larger study. These sites were selected for their variation in terms of mission and vision, their willingness to participate, and their national span (Cochran-Smith, 2021a; 2021b). Phase 3 was a cross-case analysis of the phenomenon of teacher preparation across our four nGSE sites. Here, cases were considered "instrumental" (Stake, 2006) in that they were examples of the larger nGSE phenomenon (Cochran-Smith et al., 2018; 2019; 2020; 2021). Through our cross-case analysis, we found that there were institutional and programmatic patterns across nGSEs, but that within each of these patterns there was remarkable variation (Cochran-Smith & Alexander, 2021). For instance, in terms of teacher preparation, we found that while all four nGSE case sites were characterized as having a sharply-focused shared vision of good teaching that pervaded their respective programs, each nGSE enacted this vision in different ways (Olivo, 2021).

I joined the research project in the fall of 2016, about one year after its inception. As a central member of this team, I have contributed to our analysis of nGSEs as it has conceptually developed over the years, including presenting our work at regional and national conferences (Cochran-Smith et al. 2018c, 2019; Olivo, 2021) and in a peer-reviewed journal article (Olivo & Jewett Smith, 2021). I am also the primary researcher for the AMNH MAT case site, gathering and generating the bulk of the data (the methods of which I outline in detail in Chapter 3).

Purpose and Research Questions

The rise of nGSEs, which emerged within in the context of the converging trends described above, has received relatively little empirical attention (Cochran-Smith et al., 2020; Zeichner & Pena-Sandoval, 2015). There has been even less empirical work addressing issues of urban teacher preparation in particular at nGSEs. This dissertation is an analysis of how teacher preparation is conceptualized and enacted at the AMNH MAT, a unique nGSE that has conducted regular evaluations of its own program. This case study also examined how teacher candidates are prepared for urban school culture, context, and community. These goals are in line with the purpose of the larger nGSE study, which does not intend to judge or to evaluate nGSEs, but instead aims "to develop an understanding of the nature, quality, and impact of this emerging phenomenon within a shifting organizational field wherein new organizations have laid claim to institutional ground and program legitimacy long reserved for schools of education at universities" (Cochran-Smith, 2021a, p. 1-2).

This dissertation addresses the following research questions about teacher preparation at the AMNH MAT. The two parts of the first question focus on how teacher preparation is generally conceptualized and enacted at the museum, which are taken up in Chapters 4 and 5. The two parts of the second question examine how the museum conceptualized and enacted teacher preparation for *urban school contexts*, questions that are taken up in Chapter 6. While Questions 1 and 2 focus primarily on the perspectives of the museum and program leaders and program faculty, Question 3 also draws on the perspectives and interpretations of the program's teacher candidates. Finally, Question 3 is taken up across Chapters 4, 5, and 6 since the perspectives and experiences of the candidates and the program graduates are invaluable both in understanding how teacher preparation is conceived and carried out, and in understanding the extent to which participants felt prepared for teaching in urban schools.

Question 1 When an urban science teacher preparation program is embedded within a museum, how is teacher preparation conceptualized and enacted?

a. What are the program's visions, goals, and assumptions about learning to teach, knowledge for teaching, the nature of practice, and good science teaching?
b. What are the pedagogies and practices of the teacher educators? How are the candidates socialized into teaching?

Question 2 How are the candidates specifically prepared to teach for the complex context of urban schools?

a. What aspects of the program are intended to prepare candidates specifically for urban schools, and/or for high needs schools? What are the intended goals of these aspects, and how do teacher educators describe them?
b. How do the teacher education pedagogies, faculty roles, and program arrangements contribute to how candidates are socialized into teaching specifically for urban school contexts?

Question 3 How do the candidates and program graduates experience and make sense of the program?

a. How do the candidates describe and understand the intended goals of the program?
b. How prepared do the candidates and program graduates believe themselves to be for teaching in urban contexts in general and for secondary science classrooms in particular?

Collectively, this set of research questions required unpacking how the AMNH MAT's informal science learning environment intersected with, and influenced, participants' experiences learning to teach secondary earth science in high needs schools in New York. In other words, these questions guided my investigation of how the AMNH MAT's unique position as the only museum-based urban teacher residency in the world both shaped and was shaped by the understandings and assumptions of those involved. Chapters 2 and 3 of this dissertation discuss the theoretical frameworks, related literature, and research methodology that guided this case study analysis of teacher preparation at AMNH MAT, particularly along the lines of the three major research questions. The beginning of Chapter 4 provides a brief history and institutional overview of the AMNH MAT, describing its origins, mission, and current operations.

Arguments

This dissertation is focused on how this one-of-a-kind, museum-based urban teacher residency conceived and carried out the project of learning to teach science for urban school contexts. The construct "the project of learning to teach" has two components. First, it includes a program's implicit or explicit conceptions of what it means to teach well, including beliefs about the knowledge, skills, and practices needed as well as the interaction of and relationship among knowledge, skills, and practices. Simply put, this gets at how learning to teach is *conceptualized* by program founders and leaders. The second component of the project of learning to teach is how teacher preparation is *enacted*, which involves the program's organizational structures, arrangements, curriculum, and pedagogies.

When analyzing any particular program's approach to teacher preparation, it can be difficult to disentangle program leaders' and faculty members' implicit and explicit conceptions about learning to teach from the program's components, including coursework, fieldwork, organizational structures, and arrangements. This was no different for my case analysis of the AMNH MAT program. That is, how co-founders, program leaders and faculty conceived of teacher preparation was often manifested in the decisions they made about how, when, and which courses should be offered, whether and how residencies should occur and for what purposes, and which major and supplementary requirements candidates needed to complete. For heuristic purposes in this dissertation, however, in order to analyze and interpret the AMNH MAT's strong program coherence around the project of preparing science teachers, I have identified and parsed out the key ideas, beliefs, and concepts that animate how this program conceptualized teacher preparation in Chapter 4 and identified and analyzed the key pedagogies, practices, and arrangements involved in the program's enactment in Chapter 5.

To make the argument that there was very tight coherence between the AMNH MAT program's conceptualization and enactment of the project of learning to teach science, Chapters 4 and 5 are closely complementary. Together, these chapters answer the first and third research questions of this dissertation. To guide my argument in Chapter 4, I use Cochran-Smith and Lytle's (1999) conceptual framework for understanding the relationship between knowledge and practice in teacher preparation programs. I demonstrate that the AMNH MAT was *conceptually coherent* in that three sets of highly-interrelated beliefs undergirded the program and were seen in all aspects of the program: beliefs about the nature of science teaching and learning, beliefs about the nature of good science teaching, and beliefs about the nature of students as science learners. As this dissertation argues, collectively, these beliefs were pervasive and were closely directly to a common phrase heard around the museum-- "science is king."

Chapter 5 is an extension of this argument, revealing that in addition to being conceptually coherent, the museum MAT program was also *structurally coherent* in that the beliefs that animated how teacher preparation was conceptualized were tightly coupled with the program's enactment of the project of learning to teach, which prioritized placing the residents, who were newcomers to the field, at the nexus of three overlapping communities of practice. In this chapter, I employ Lave and Wenger's (1998) conceptual framework *communities of practice* to examine the ways in which the AMNH MAT enacted its beliefs about teacher preparation by socializing candidates into three specific and interrelated communities of practice: the community of scientists, the community of good science teachers, and the community of New York City science teachers, students, and schools. Participation in these three communities was meant to produce effective teachers of science. Along these lines, one particular program assessment tool, which is described at length in Chapter 5, reflected these ideas about what makes for good science teachers, and this tool was used in many aspects of the program and was considered reflect what "effective teaching" looks like.

Taken together, Chapters 4 and 5 argue that the AMNH MAT exhibited an unusually high level of program coherence in terms of how it conceived and carried out **science** teacher preparation. It was precisely the program's deep commitment to producing effective earth science teachers that was meant to "change the science conversation in in schools" (Interview #3, Program Leader). I argue that this was a goal consistent with the museum's larger mission to disseminate science knowledge to the public because it was based on the idea that MAT graduates would be deeply influential in schools given that they brought deep science content knowledge as well as familiarity with and access to museum resources and practices. The assumption was they the program's graduates would contribute to higher percentages of students interested and enrolled in earth science courses, which in turn would produce a greater success rate for students on state standardized testing in this discipline and contribute to a more science-literate society in general. In fact, this point was crystallized by one program leader:

> The problem was the driver for us. The fact that there was this shortage in earth science was a big problem and it impacts schools and students on many levels, and it also impacts the fields of earth and space science themselves because what students learn in K-12 affects what they do in college. And it impacts the planet because what we know about that earth is really important for the decisions that we make in terms of being scientifically literate citizens who can vote and purchase and consume, [participate] in ways that are beneficial to the planet. (Interview # 1, Program Leader)

Chapter 6 makes a quite different argument altogether, attending to the second and third research questions of this dissertation. Here I argue that the AMNH MAT's approach to preparing teachers for **urban** schools was not as much of a priority within the project of learning to teach when juxtaposed with its incredibly coherent programming for **science** teacher preparation. Here, informed by the principles of Milner's (2010; 2020a) widely-known conceptual framing for analyzing urban teacher preparation, the *opportunity gap framework,* I unpack how and to what extent the AMNH MAT's courses and practices, tools and supports, and commitments and arrangements prepared residents for urban teaching. Milner's principles include: *rejecting colorblindness* and *context-neutral mind-sets and practices, debunking deficit mind-sets and shifting low expectations,* and being able and willing to address *cultural conflicts* and *the myth of meritocracy* in classrooms. My analysis suggests that like many urban teacher preparation programs, the museum MAT offered some unique and provocative opportunities for its residents to understand teaching in urban contexts. However, also like many other urban teacher preparation programs, its efforts were not as robust or as comprehensive as Milner's

(2010; 2020a) framework calls for, making for a limited and somewhat uneven approach to preparing teachers for the specific context of urban schools. This chapter concludes by suggesting that the program's efforts to prepare residents for **urban** schools were more limited and supplementary in comparison to its powerful and coherent programming to prepare teachers of **science**, which was centralized and continuously reinforced.

Chapter 7 concludes the dissertation by presenting the key overarching themes and implications that emerged from this case study of teacher preparation at the AMNH MAT. Specifically, I suggest that while program coherence in teacher preparation is often a sought-after accomplishment (Darling-Hammond, 2014), it is not in and of itself necessarily a desired goal. This case study analysis reveals that examining what a teacher preparation program *coheres around* is equally as important as whether or not a program exhibits coherence in the first place. My findings provide important insights for science teacher preparation, urban teacher preparation, the larger field of nGSEs, and the intersection of all three of these domains.

CHAPTER TWO

Review of Literature

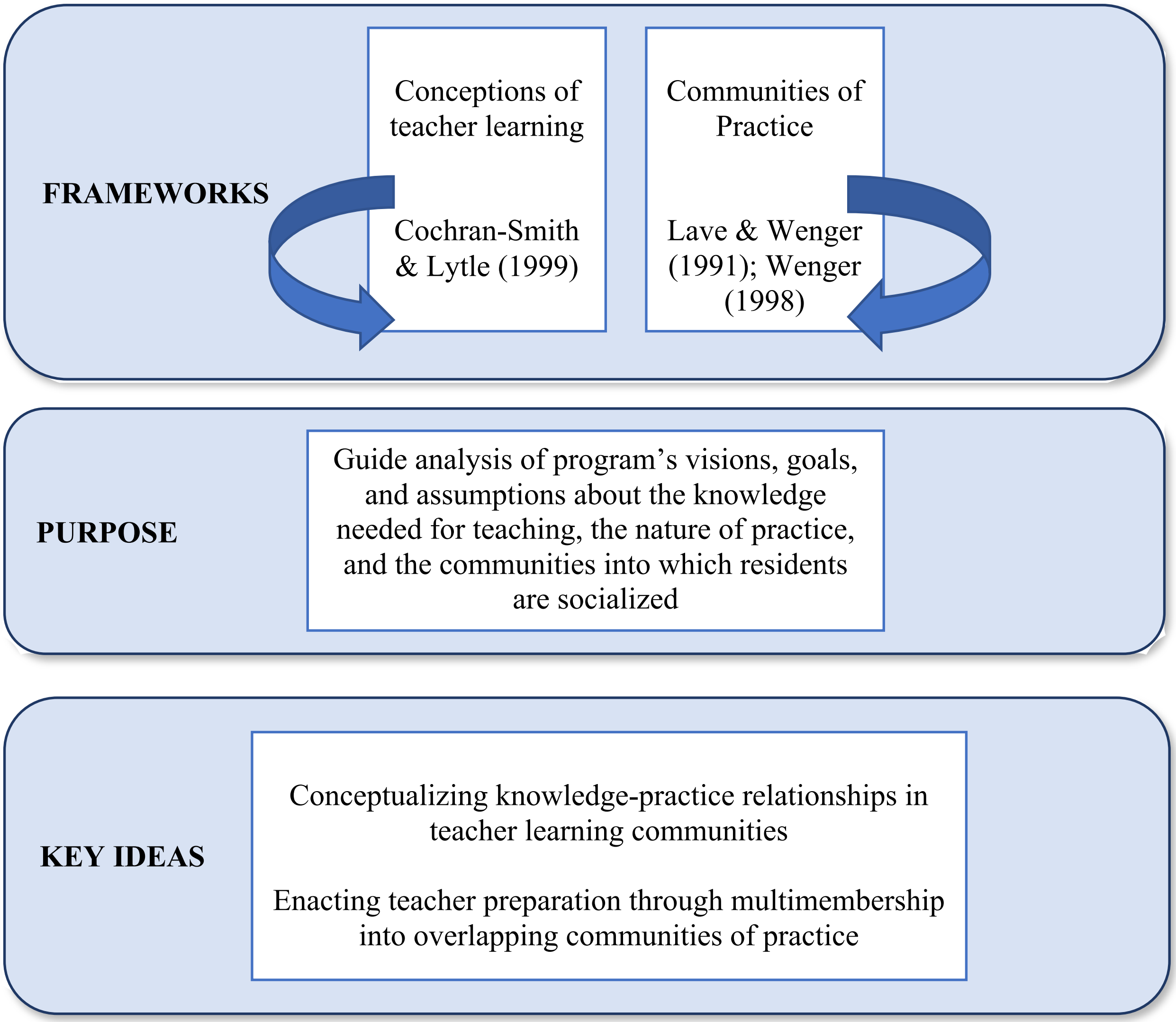
In this section, I present theoretical frameworks and a review of literature that inform my analysis of teacher preparation at the AMNH MAT. First, I discuss two sets of theoretical frameworks that guided the research design and methods of this case study, including data interpretation and analysis. Next, I offer a review of the ways in which the recent and rapid growth of nGSEs has been interpreted by education researchers, policy institutes, think tanks, education reform organizations and advocate groups as well as a review of three interconnected bodies of research that are closely tied to this study: research on urban teacher residencies, research on urban secondary science teacher preparation, and research on museum-based teacher preparation.

Theoretical Frameworks

This dissertation is informed by two pairs of theoretical frameworks. The first pair of frameworks focuses on understanding teacher learning in communities. Cochran-Smith and Lytle (1999) offer a framework for understanding teacher learning in terms of underlying assumptions about the relationships of knowledge and practice, while Lave and Wenger (1991; Wenger, 1998) present the concept of communities of practice, which situates the learning of teachers (and many other professional and other groups) as social practice. Together, these frameworks informed my analysis of how the AMNH MAT program conceptualizes and enacts the project of learning to teach, particularly how underlying assumptions about knowledge, practice, and community play out in the design, structure, and implementation of the AMNH MAT program. The second pair of frameworks focuses on preparing teachers for urban school contexts. Matsko and Hammerness's (2014) framework outlines the features of what they call "context-specific teacher preparation,” or preparation targeted at creating opportunities to help prospective urban teachers learn to work within a district, a community, and its schools. This framework informed my analysis of how and to what extent AMNH residents are specifically prepared to teach in the complex context of urban schools, particularly what understandings about the overlapping layers of urban school contexts are addressed in AMNH MAT coursework and clinical work. Along related but different lines, Milner’s (2010; 2020a) opportunity gap framework “is anchored in the principle that young people succeed when opportunity structures are in place to support their learning and development” (Milner, 2020a, p. 21), which is particularly important to consider when teaching in urban school contexts where there is great diversity in cognitive ability and cultural background. His framework is useful for analyzing, explaining and naming educational practice for highly diverse and urban school contexts and for identifying aspects of the program that are intended to specifically prepare AMNH residents for urban schools. Figure 1 outlines the purpose the first pair of frameworks served in this case study and provides an overview of the key ideas of each.

Figure 1

Understanding knowledge-practice relationships in teacher learning communities



Understanding Teacher Learning at AMNH: Knowledge, Practice, and Communities

In the following two sections, I describe how the pair of theories in Figure 1 worked together to unpack how teacher preparation was conceptualized and carried out at the AMMH MAT. In particular, these frameworks guided my analysis of the AMNH MAT's visions, goals, and assumptions about the knowledge needed for teaching, the nature of practice, and the communities into which residents were socialized.

Cochran-Smith and Lytle's Conceptions of Teacher Learning

Cochran-Smith and Lytle (1999) aim to "provide an analytic framework for theorizing teacher learning on the basis of fundamental ideas about how knowledge and practice are related and how teachers learn within communities and other contexts" (p. 251). This framework for understanding teacher learning organizes the "the images and assumptions that underlie methods and…the education purposes that drive various teacher learning initiatives" (Cochran-Smith & Lytle, 1999, p. 251) into three prominent conceptions, which they call: knowledge-*for*-practice, knowledge-*in*-practice, and knowledge-*of*-practice. Importantly, these three conceptions of teacher learning "are invoked by differently positioned people in order to explain and justify quite different ideas and approaches to improving teaching and learning" (p. 251). In other words, various initiatives related to teacher learning, either at initial or ongoing levels, co-exist with one another and may even use some of the same language in their descriptions. But their underlying assumptions about knowledge and practice can make for quite different practices, pedagogies, and ideas about good teaching. Furthermore, these three classifications are not necessarily mutually exclusive: if an organization or teacher preparation program approaches teacher learning employing the knowledge-*for*-practice concept in certain programmatic aspects, for instance, it may also reflect knowledge-*in*-practice concepts in other areas. Cochran-Smith and Lytle (1999) offer this framework as a way to understand how images and assumptions about the relationship between knowledge and practice inform enactment of various methods commonly used in teacher preparation programs and other teacher learning initiatives, such as mentoring, clinical work, reflection, or teacher research.

Cochran-Smith and Lytle unpack approaches to teacher learning by focusing on four categories that together comprise their three knowledge-practice relationships: images of knowledge, images of teachers, images of teaching and professional practice, and images of teacher learning and teachers' roles in educational change. Cochran-Smith and Lytle (1999) use the term *images* here to mean "the central common conceptions that seem symbolic of basic attitudes and orientations to teaching and learning" (p. 253). As a way to differentiate the three conceptions of teacher learning and by extension to understand the underlying assumptions of diverse teacher education initiatives, they suggest that it is necessary to look beneath the surface of things and beyond the sometimes overlapping language (e.g., "reflection," "inquiry," "case study") related to teacher learning initiatives by asking, for example:

> what teachers were reflecting on and for what ultimate purposes, or what counted as a case of something and how and in whose interest it was enlisted, or what inquiry groups were inquiring about and what they presumed were the "givens" of teaching and schooling, or whether a school-wide group or a school-university partnership operated from a shared idea about the larger intellectual and political project in which participants were engaged. (Cochran-Smith & Lytle, p. 253)

The first conception of knowledge and practice, knowledge-*for*-practice, assumes that what teachers need to know is primarily subsumed in university-based, formal knowledge. In other words, subject matter knowledge and education theory are privileged knowledge sources for teachers; these are assumed to be needed *for* their learning of the practice of teaching. Given this conception of how knowledge and practice interact, there is an emphasis on *what* knowledge is learned, not *how* teachers learn; it is assumed that what there is to know about teaching is already known, primarily by university-based educators. Given this assumption, teachers are not seen as knowledge generators, but rather knowledge receivers and users; "the image of practice in this first conception of teacher learning, then, is one of knowledge *for* use- teachers are knowledge users, not generators" (Cochran-Smith and Lytle, 1999, p. 257).

Efforts animated by knowledge-*for*-practice involve "teacher learning center[ed] around enhancing teachers' knowledge of subject matter, of the standards and content of the various professions, and of research-based strategies for effective teaching and classroom organization" (Cochran-Smith & Lytle, 1999, p. 258). This places heavy emphasis on high-stakes teacher assessments that privilege formal knowledge, as well as defining a successful classroom as one that centralizes deep subject matter knowledge, and as a place where solutions are offered, rather than problems-posed. The conception knowledge-*for*-practice also includes Shulman's (1987) now well-known concept "pedagogical content knowledge," which is generally understood as a teacher's ability to organize, structure, and execute her mastery of content knowledge in ways sufficient for student learning in her particular content area, grade level, and classroom culture. Knowledge-*for*-practice as an orientation that assumes that teacher learning coalesces around a set of "certified best practices" to be used in classrooms, rather than teacher generation of ideas with and through their students.

The second conception of teacher learning, knowledge-*in*-practice, assumes that practical knowledge, or what teachers learn in the field, is paramount to teacher learning, and that "the knowledge teachers need to teach well is embedded in the exemplary practice of experienced teachers" (Cochran-Smith & Lytle, 1999, p. 263). This is especially true where

> the emphasis is on knowledge in action: what very competent teachers know as it is expressed or embedded in the artistry of practice, in teachers' reflections on practice, in teachers' practical inquiries, and/or in teachers' narrative accounts of practice. A basic assumption here is that teaching is, to a great extent, an uncertain and spontaneous craft

> situated and constructed in response to the particularities of everyday life in schools and classrooms. (Cochran-Smith & Lytle, 1999, p. 262)

In this conception of teacher learning, knowledge is assumed to be rooted in experience, in the observation of experienced teachers, and in the reflection of experience. Knowledge comes from reflection and inquiry in and of practice, or as in what Dewey referred to as “the crucible of action.” From the knowledge-*in*-practice conception of teaching learning, it is assumed that the knowledge teachers need to teach well is embedded in the very practice of teaching, not produced by education scholars or experts who have studied about teaching and learning. Here, teacher learning hinges on enhancing teachers’ understandings of their own actions, assumptions, reasoning, and decisions as well as their inventions of new practical knowledge based on shifting classroom situations.

Interestingly, however, the concept of *practical knowledge* is not universal; different teacher learning initiatives operate according to different conceptions of what is included in practical knowledge, where practical knowledge is at times juxtaposed with formal knowledge, at times combined with formal knowledge, and also at other times combined with notions of teaching as socially contextual and situated. In this way, understandings of the practice of teaching can be co-opted, or used in different teacher preparation programs for different aims or purposes.

The third conception of teacher learning, knowledge-*of*-practice, involves generating local knowledge in inquiry communities and working to theorize and construct the practice of teaching for the purpose of connecting teaching to larger social, cultural, and political issues. In this conception of teacher learning, teachers play an important role in the generation of knowledge throughout their life span by making their classrooms and schools places of inquiry, "connecting their work in schools to larger issues, and taking a critical perspective on the theory and research of others. Teacher networks, inquiry communities, and other school-based collectives in which teachers and others conjoin their efforts to construct knowledge are the major contexts for teaching learning in this conception" (Cochran-Smith & Lytle, 1999, p. 273).

The knowledge-*of*-practice conception of teacher learning positions teachers as knowers and agents in the classroom as well as in the larger educational context. It is assumed that teachers carry with them distinctly critical views of education and the power relations it entails. The idea of knowledge-*of* -practice presumes that throughout their own learning and work, teachers make problematic subject matter and curriculum and the traditional structures and roles of schools and schooling. This conception of teacher learning regards inquiry as a stance for deepening teacher knowledge and practice, where teachers are responsible for co-constructing their curriculum in ways that incorporate their students and their families. Moreover, "the knowledge-*of* -practice conception stands in contrast to the idea that there are two distinct kinds of knowledge for teaching, one that is formal, in that it is produced following the conventions of social science research [e.g., knowledge-*for*-practice], and one that is practical, in that it is produced in the activity of teaching itself [e.g., knowledge-*in*-practice]" (Cochran-Smith & Lytle, 1999, p. 273).

Throughout this dissertation, Cochran-Smith and Lytle's (1999) framework was very useful for analyzing the unique and complex aspects of teacher preparation at the AMNH MAT. Given that one of the primary goals of this study was to analyze how teacher preparation was conceptualized in this program, the application of these conceptions of teacher learning helped unpack how the participants of the museum MAT experienced teacher preparation. For instance, this framework enabled me to answer such questions as: Which knowledge sources were privileged by faculty and staff? What practices were assumed to be necessary to learn and be able to in order to be a good science teacher? What was assumed about the roles teachers play in the larger context of urban schools, and in the urban communities in which they teach?

Lave and Wenger's Communities of Practice

While Cochran-Smith & Lytle's conceptual framework for understanding teacher learning was particularly useful for understanding how the museum MAT faculty and staff conceptualized teacher preparation, Lave and Wenger's (1991) and Wenger's (1998) concept of *communities of practice* was a crucial "thinking tool" (Wenger, 1998, p. 7) for understanding how teacher preparation was enacted at the museum. The concept of *communities of practice* evolved out of Lave and Wenger's (1991) concept of *legitimate peripheral participation,* which is meant to serve as a "a conceptual bridge" (p. 55) for understanding the situated, relational, contextual, and iterative process of learning within any given community of practice. This learning is negotiated by newcomers, and at least at first, is facilitated by old-timers. The idea here is that being a "peripheral" learner in a community is an opening, a way of gaining access to the knowledge, skills, and sociocultural practices embodied by the practitioners in a given community. Legitimate peripheral participation scaffolds the trajectory towards full participation in a community of practice, which is accomplished through "a greater commitment of time, intensified effort, more and broader responsibilities with the community, and more difficult and risky tasks" (Lave & Wenger, 1991, p. 111).

Two central beliefs are at the core of the concepts of legitimate peripheral participation and *communities of practice*. The first belief is that "learning and a sense of identity are inseparable: They are aspects of the same phenomenon" (Lave & Wenger, 1991, p. 115). The second central belief is that "leaning is, in its essence, a fundamentally a social phenomenon"

(Wenger, 1998, p. 3) and can be seen as “an activity in and with the world …[where] agent, activity, and the world mutually constitute each other” (Lave & Wenger, 1991, p. 33). In this way, participation in a community of practice can be understood to involve ongoing negotiation with and evolution of one’s own learning, as well as interacting with the learning of others across varying levels of experience and throughout the span of participation in a community of practice.

The concept *community of practice* is meant to be an analytical tool for understanding how people learn, interact, and become participants in particular social contexts, professional configurations, and communities. Weaving together the constructs of community, practice, identity, and meaning, Wenger (1998) defines a community of practice as “a joint enterprise [that] brings the community together through the collective development of a shared practice…[whereby] the definition of that enterprise- and therefore the meanings of the shared practice- are to be negotiated among the participants” (p. 209). Wenger-Trayner and Wenger-Trayner (2015) elaborate that communities of practice are “groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly.” Communities of practice, whether formed intentionally or unintentionally, are made up of practitioners with a shared area of interest who engage in joint activities to learn together, ultimately developing a shared repertoire of routines, strategies, and tools based on sustained interaction. In order for a group to be considered a community of practice, three aspects are crucial. The first aspect is a commitment to the *domain,* or a shared competence that distinguishes members from other people. The second aspect is a sense of *community,* where members interact and learn from and with each other. Finally, the third aspect necessary for a community of practice is the *practice* of collaboratively developing a shared repertoire of resources (Wenger-Trayner & Wenger-Trayner, 2015).

According to Wenger (1998), *practice* is both explicit, including "the language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts" and also implicit, including such characteristics as "relations, conventions, subtle cues, untold rules of thumb, recognizable intuitions, specific perceptions, well-tuned sensitivities, embodied understandings, underlying assumptions, and world views" (p. 47). Meaning produced by practice involves ongoing negotiation that takes place "in the dynamic relation of the living world" (p.54). To help explain this, Wenger (1998) offers that communities of practice are constituted by a *participation/reification duality,* where *participation* refers to the "social experiences" and "active involvement" in membership in social communities (p.54) and *reification* is "the process of giving form to our experiences by producing objects that congeal this experience into 'thingness'" (p. 58). In other words, what makes a community of practice thrive is the ongoing negotiation between members being engaged in work together while at once codifying their understanding of their work in tangible ways. This duality is a central component to the development of communities of practice, the relationships and identities of participants, and broader networks in which they exist.

With this larger understanding of *practice* and the duality of *participation/reification* that it entails, Wenger (1998) argues that practice defines the coherence of a community through three dimensions: *mutual engagement, joint enterprise,* and *shared repertoire.* At its core, *mutual engagement* is essentially the practice of people who work together in a community of practice "by which they can do whatever they do" (p. 73). Mutual engagement relies on diversity, since it "involves not only our competence, but also the competence of others. It draws on what we do and what we know, as well as on our ability to connect meaningfully to what we don't do and what we don't know- that is, to the contributions and knowledge of others...mutual engagement is inherently partial" (p. 76). For a community of practice to be successful, it is made up of a "medley of people" (p. 75) whose regular engagement in work relies on each other, develops because of each other, but honors the unique identity of each member.

The second dimension of practice necessary for a coherent community of practice, *joint enterprise,* is what happens when members of a community of practice work together to "negotiate response[s] to their situation," making their experience "belong…to them in a profound sense" (p.77). The joint enterprise of a community of practice is the participants' response to their conditions, and therefore is *their* enterprise; the community itself mediates its own production of practice. Wenger (1998) suggests that "the enterprise is joint not in that everybody believes the same things or agrees with everything, but in that it is communally negotiated" (p. 78). Together, participants in a community of practice make things "real and livable" (p. 79) through their joint enterprise. Wenger (1998) likens joint enterprise to the rhythm in music, in that it makes the whole of which it is a part "interpretable, participative, and sharable" (p. 82).

The third dimension of practice is the development of a *shared repertoire,* which is defined as resources developed as a way to negotiate meaning. Wenger (1998) argues that coherent communities of practice create a shared repertoire of "routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions, or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice" (p. 83). These tools are developed and perpetually revised by members of a community of practice. A shared repertoire also includes "the discourse by which members create meaningful statements about the world, as well as the styles by which they express their forms of membership and their identities as members" (p. 83). A shared repertoire is as much spoken as it is unspoken.

Finally, Wenger (1998) argues that there are two types of connections necessary for communities of practice, because "joining… involves entering not only its internal configuration but also its relations with the rest of the world" (p. 103). The first connection is referred to as *boundary objects,* or artifacts, documents, terms, concepts, and other forms of reifications around which communities of practice can organize their interconnections. Boundary objects offer a "nexus of perspectives" (p. 107) and are designed "for participation rather than just use" (p. 108). The second connection necessary for a community of practice is called *brokering,* which Wenger (1998) defines as connections provided by people who can introduce elements of one practice into another. Brokers are "able to make new connections across communities of practice, enable coordination, and- if they are good brokers- open new possibilities of meaning…[this job] involves process of translation, coordination, and alignment between perspectives" (p. 109). Brokers have the "experience of multimembership" and are able to model the "possibilities for negotiation inherent in participation" (p. 109). For newcomers to a community of practice, boundary encounters occur in three forms: one-on-one conversations, immersion into the community, and delegations of involvement in various aspects of the community (Wenger, 1998).

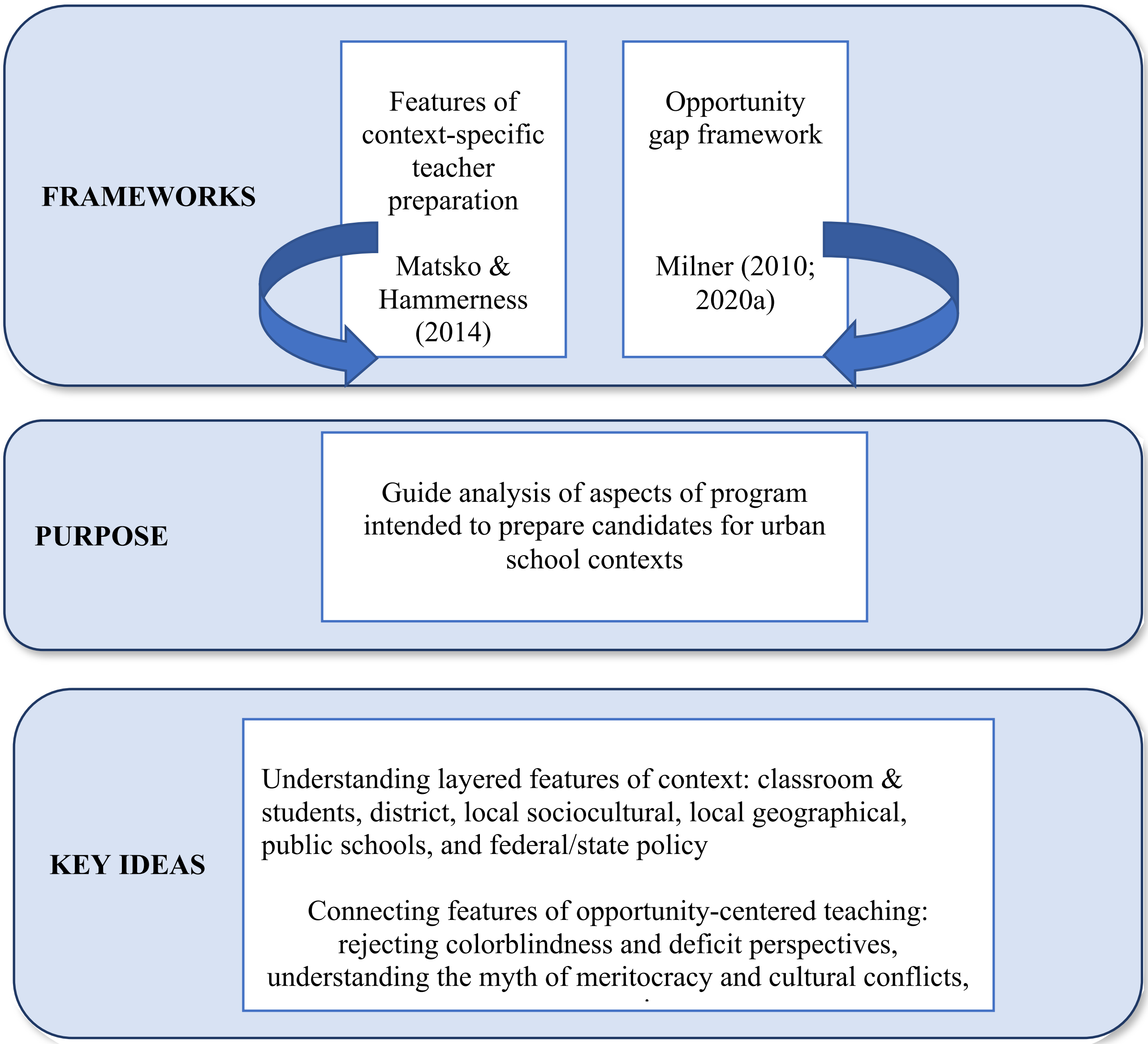
Lave and Wenger's (1991) and Wenger's (1998) analytical tool for understanding social learning, communities of practice, was particularly useful for understanding how the AMNH MAT enacted teacher preparation. For starters, the pedagogies and practices of AMNH teacher educators were aimed at socializing teacher candidates into teaching, with particular emphasis on overlapping communities of practice. Analysis of these communities in terms of their intentions and interrelationships helped understand the kind of teacher AMNH aimed to produce. Also central to the learning to teach process was how each resident's identity as a teacher came to be, was shaped, and evolved over the course of their foray into teaching. As Wenger points out, "In our communities of practice we come together not only to engage in pursuing some enterprise but also to figure out how our engagement fits in the broader scheme of things" (p. 162). In a later elaboration of this theory, Wenger-Trayner et al. (2015) point out that "identity…is best understood not as a function of participation in a single community of practice but in terms of multimembership" (p. 79). How AMNH residents came to know themselves as urban teachers of science is directly impacted by the multiple communities of practice into which they are induced and encouraged to join throughout their experience at the museum MAT.

Understanding Teacher Learning at AMNH: Urban School Contexts

This section describes the second pair of conceptual frameworks, Matsko and Hammerness's (2014) *context-specific teacher preparation* and Milner's (2020) *opportunity gap framework*. In this dissertation, these two frameworks worked together to unpack how AMMH MAT aimed specifically to prepare residents for urban school contexts. Figure 2 outlines the purpose each pair of frameworks served in this case study and provides an overview of the key ideas of each.

Figure 2

Understanding teacher learning for urban school contexts at the AMNH MAT



Matsko and Hammerness's Features of Context-Specific Teacher Preparation

In their descriptive theory building study, Matsko and Hammerness (2014) analyzed how one urban teacher residency program, University of Chicago's Urban Teacher Education Program, or UTEP, taught contextual features of the larger public school district of Chicago and how the program helped teacher candidates learn about these layers of context. The researchers identified six features of context-specific teacher preparation useful for analyzing how preparation programs approach preparing teachers for urban schools, which are explained below. These "layers of context were nested, overlapping, and often interrelated in programs' day-to-day work" (Matsko & Hammerness, 2014, p. 132).

Matsko & Hammerness (2014) argue that "to equip teachers to work effectively in schools that predominantly serve students of color, candidates need to develop the capacity to analyze the particular setting of any school in which they will eventually teach with an in-depth and nuanced understanding" (p.129). This kind of targeted analysis of setting used in teacher preparation is what these researchers referred to as *context-specific teacher preparation,* where teacher preparation programs create opportunities to help novices learn to work within a district, a community, and its schools. An underlying assumption of this framework is that much more must be known about the pedagogies and practices of urban teacher preparation programs in terms of how they approach preparing prospective teachers for the contexts where they will teach. This is particularly important given the fact that, as I mentioned in Chapter 1, more than half of new teachers leave the profession in the first five years (Ingersoll, 2001; Ingersoll & Perda, 2009; Partlow, 2019, and; Waddell, 2009). Matsko and Hammerness (2014) assert that "opportunities to learn about these aspects of context may help deter candidates from forming simplistic generalizations about districts, cities, or geographical regions, and enable them to move beyond cultural stereotypes and dig into the nuances of local schools and classrooms that at the end of the day will inform their teaching" (p. 138). Preparing teachers who understand the layers of context that surround urban schools has the shared goal of fostering asset-based perspectives about the schools, students, and families and communities where prospective teachers will teach and learn.

Matsko and Hammerness (2014) describe the multidimensional aspects of UTEP's context-specific focus in six distinct categories. The first category, federal/state policy context "refers to the broader educational policy landscape" (p. 132). The purpose of learning about this feature of context is that "learning about policy and politics helps students begin to understand the complicated array of challenges associated with achieving equitable education for all students" (Matsko & Hammerness, 2014, p. 133). The next category, the public school context, has to do with the history of American public schools, including historical figures and structures and their impact on the profession of teaching. At UTEP, candidates read seminal works about the history of urban schools in particular, with the aim of making them "better armed to experience the local urban school landscape" (Matsko & Hammerness, 2014, p. 133). The next feature, local geographical context, has to do with the history, demographics, and cultural and physical landscape of a city's ethnic neighborhoods. At UTEP, prospective teachers accomplished this by first studying the history of Chicago and then by comparing the different settings at their respective residency schools. The fourth feature, local sociocultural context, refers to learning about the many ways culture impacts learning. The purpose of learning about this layer of context is to "actively help [teacher candidates] debunk misconceptions associated with low-income communities of color by examining how systems of privilege and oppression manifest at the structural level" (Matsko & Hammerness, 2014, p. 134). The district context refers to understanding the policies, mandates, and requirements of the particular urban district where prospective teachers will become teachers of record. In major urban cities, this includes learning about such features as school closures, in-district charters, and schools in "turnaround" status. Finally, the classroom and student context involves "the capacity to learn about the strengths, needs, resources, culture, and educational background of each student they will teach"

(Matsko & Hammerness, 2014, p. 133). At UTEP, this learning takes place in the school residencies in which candidates engage and in the culturally relevant pedagogy they are taught to enact.

Hammerness and Craig's (2016) used this framework to guide their empirical analysis of the features of context incorporated into the curriculum of one New York City urban teacher residency program. In applying this framework, the researchers found that teacher candidates felt confident in their understanding of the broader contexts of U.S. school systems, the impact of race on learning, especially the impact of oppressive schooling on students of color, and social justice practices of teaching (Hammerness & Craig, 2016). Overall, however, prospective teachers also reported a lack of preparedness for the particularities of New York City school settings, where they would ultimately become teachers of record (Hammerness & Craig, 2016). In applying Matsko and Hammerness's (2014) framework, Hammerness and Craig concluded that while the context is meaningful content in the preparation of urban schoolteachers, there remain many questions about *how much* context and *for what purposes* (Hammerness & Craig, 2016). In this dissertation, Matsko and Hammerness's (2014) conceptual framework was used for analyzing the salient features of the AMNH MAT's preparation for the layered context of urban school settings. Additionally, because the museum MAT was laser-focused on preparing its candidates for one specific context, secondary earth science classrooms in New York high-needs schools, it was important to analyze the aspects of the program that addressed local geographic and sociocultural contexts, the intended goals of these aspects, and how they were perceived by teacher educators, program graduates, and current residents.

Milner's Opportunity Gap Framework

Milner's work, including the *opportunity gap framework*, which was used in analyzing teacher preparation at the AMNH MAT, is predicated on the following belief: "We have a social, psychological, moral, intellectual, and civic responsibility to cocreate systems and structures with young people to ensure they have a fighting chance to maximize their humanity" (Milner 2020b, p. 157). For instance, arguing that teacher education has been "grossly under-theorized where race is concerned," (p. 536), Milner and Howard (2013) advance a research agenda for teacher education that prioritizes the disruption of "pervasive narratives common in teacher education" (p. 537), particularly those that only partially address race and racism or that present teachers, students, or parents of color from a deficit ideology. Milner and Laughter (2015) argue for teacher education policy reform in terms of revising curriculum to center race, poverty, and the intersection of the two. In addition, Milner, Murray, Farinde, & O'Connor (2015) suggest that there are particular outside-of-school factors that are important for prospective and beginning teachers to understand and put into practice in order to meet the needs of students in urban schools: student and family homelessness, geography and social contexts, policy and school funding, and parental and family involvement. Finally, in the 15th *Annual AERA Brown Lecture in Education Rese*arch, Milner (2020b) introduces the concept of *curriculum punishment*, a tool building on Eisner's (1994) notion of null curriculum, which describes the harm done to students when they are not exposed to potentially transformative, racially just learning opportunities. Taken together and alongside the *opportunity gap framework* outlined below, these are examples of Milner's push for "radial reform… [in order to] live up to the idea and ideals of a democracy: an education system where every child has an opportunity to succeed because it is not only his or her constitutional right, but also our nation's moral responsibility and imperative" (Milner, 2015, p.26).

Milner's (2010; 2020a) *opportunity gap framework* is an analytical, explanatory tool that "focuses on how educators think about and conceptualize their work to center opportunity over outcomes" (p. 21). Furthermore, this framework is positioned as an "alternative paradigm:"

> Rather than focusing on gaps in achievement, test scores, or other outputs, the Opportunity Gap Framework shepherds educators into reflective spaces where they consider inputs—mechanisms, practices, policies, and experiences that influence students' opportunities to learn… [and it] is anchored in the principle that young people succeed when opportunity structures are in place to support their learning and development. (Milner, 2020a, p. 21)

Milner's framework includes five principles: (1) *rejection of color blindness*; (2) ability, willingness, and skill to understand, build on, and work through *cultural conflicts*; (3) ability and willingness to understand how the *meritocracy myth* operates; (4) ability and willingness to recognize, disrupt, and shift *low expectations and deficit mind-sets*; and (5) willingness to counter and rethink *context-neutral mind-sets and practices*. Milner builds on the ideas and theories of many teacher education researchers, particularly Lisa Delpit, Gloria Ladson-Billings, Christine Sleeter, Elliott Eisner, Marilyn Cochran-Smith, William Tate, and Kenneth Zeichner. Collectively and for some time, these scholars have disrupted status quo policies, pedagogies, and practices in teaching and teacher education, working toward and calling for deeper interrogation of how and to what extent America's historically racialized society impacts the poor and minoritized young people of the nation's schools.

The first principle of Milner's framework (2010; 2020a) is that a rejection of *color* *blindness* is necessary to advance opportunities for young people to learn and grow. Milner (2020a) asserts that it is important for all educators to acknowledge that race and culture "can influence our ideologies, attitudes, and belief systems, and consequently our practices in classrooms with young people" (p. 23). Conversely, "learning can be hindered when teachers fail to consider their own and their students' racial backgrounds and to think carefully and critically about how race and racism emerge in classroom learning opportunities" (Milner, 2020a, p. 28). Rejecting colorblindness is a way to acknowledge that all educators- even and especially White ones- have a responsibility to co-construct curriculum with their students and to align instructional practice with the perspectives, worldviews, and interests of the heritages and backgrounds represented in their classrooms. Educators who reject colorblindness "consider individual realities as well as systemic and structural cause related to race and racism…[and] are challenged to think through how race shapes what happens in society, schools, and classrooms" (Milner, 2020a, p. 24).

The second principle of Milner's framework is that an educator's ability, willingness, and skill to understand, build on, and work through *cultural conflicts* that occur in the classroom can directly influence the quality of learning opportunities for young people. To be sure, cultural conflicts in classrooms are inevitable. This is especially true when the teacher is from a different culture, heritage or background than most of her students, since this most likely means that the teacher sees the world differently than her students- at least at first. What makes for opportunity-centered teaching is when teachers "develop...practices through the building and cultivation of relationships to address and work through [these conflicts]" (p. 260). Milner (2020a) argues that it is possible- and necessary- for teachers from all backgrounds to lean into cultural conflicts, not work to avoid them or, worse, ignore them:

> Teachers across cultural groups can be and are successful teachers of students who are different from them...however, they must work diligently, deliberately, and persistently to understand cultural conflicts in order to address them...they must be willing to build knowledge, attitudes, dispositions, and skill sets to understand the important role culture plays in curriculum development, instruction, relationships, assessments, and broader decision making. (p. 25)

The third principle for opportunity-centered teaching is that educators must possess an ability and willingness to understand how the *meritocracy myth* operates. The myth of meritocracy can be defined in the following way:

> People rarely become wealthy overnight or based on their own merit. Wealth and related resources are built and established over time and tend to be passed through generations of families. Teachers in general can fail to understand that they have gained their status through a wide range of unearned advantages. In contrast, students who grow up in poverty or from a lower socioeconomic status generally do not start their educational or life experiences in a fair or equitable position. In this way, meritocracy is a myth. (Milner, 2020a, p. 45)

To address opportunity gaps, Milner (2020a) argues that "educators must become mindful of, or are at least willing to acknowledge, the many factors beyond merit that shape students' academic and social success, or lack thereof" (p. 25-26). This can take work, because as Milner (2020a) further asserts, "many educators believe that their own success is merited because they have worked hard, followed the law, had the ability and skill, and made the right decisions" (p. 44). This line of thinking is problematic because it leaves out the fact that "there are many forces at play that maintain a caste system" (Milner, 2020a, p. 46). Therefore, acknowledging the myth of meritocracy could involve interrupting one's own lived experiences or belief system, especially if it includes the notion that "if people just work hard enough they will be rewarded and achieve their full potential, regardless of historic or contemporary economic structures" (Milner, 2020a, p. 46).

The fourth principle Milner advances as important for eradicating the gap in opportunity is that educators must possess the ability and willingness to recognize, disrupt, and shift *low expectations and deficit mind-sets*. This feature of the framework urges educators to

> think carefully about the ways in which deficit mind-sets and low expectations position the most vulnerable students as inadequate. Addressing gaps in opportunity means that educators move away from deficit mind-sets and low expectations and consequently avoid placing young people neatly into a predetermined box for what it means to be a successful student and human being. People are diverse and our practices should honor the positive aspects of human identity as students develop and learn." (Milner, 2020a, p. 54)

Taking this stance means working with students to co-create high expectations for learning and working tirelessly to achieve them. It also means understanding that high expectations might look different for different students who happen to be in the same classroom at the same time. This feature of the framework is difficult to achieve because "in education, we tend to determine what students do not know or cannot demonstrate and work to remediate or fill in the areas of need" (Milner, 2020a, p. 51). In other words, education writ large is framed by a deficit-minded approach to understanding student school achievement because it begins with what students do not know. Milner (2020a) suggests that instead of this mindset, "educators [ought to] determine what students actually know and are able to do and build on those experiences as a foundation for supporting their learning and development over time" (p. 51).

The fifth and final feature of Milner's (2010; 2020a) opportunity gap framework is a willingness to counter and rethink *context-neutral mind-sets and practices.* Milner points out that for educators, deep subject matter knowledge is relatively useless without also having a deep knowledge and understanding of the context in which one is teaching. This principle asserts that it is the responsibility of the educator "to understand the role, importance, and salience of place as they work to address gaps in opportunity" (Milner, 2020a, p. 55). Essentially, to create greater opportunities for young people, educators need to see the contexts in which they live and learn as a knowledge source, an asset to their intellectual, social, emotional, and political development. This is especially important because "when educators deepen their knowledge and insights about a sociopolitical context, they also recognize and honor histories and perspectives of those placed on the margins in the community because they may not have the resources to maintain their communities" (Milner, 2020a, p. 59).

In essence, the *opportunity gap framework* offers a way to center race and culture in classrooms and schools, and to see their critical examination as opportunities to grow and learn for teachers and for students. This might feel difficult in certain schools and districts, especially because achievement according to standardized testing is seen as the dominant way to understand learning outcomes. Opportunity-centered teachers are self-reflective, asking themselves questions such as: "What are some of the privileges I have experienced as a result of my race? What are some of the challenges I have faced because of my race?" and "How does our classroom environments promote a context that is racially just and inclusive" (Milner, 2020a, p. 98-99).

It is the responsibility of educators to acknowledge deeply and fully- regardless of their own experiences- that race, culture, and class are deeply connected to the opportunities that young people have. For teacher educators, this means that if the aim of a program is to improve the life experiences and chances of all young people, as Freire urges, then prospective teachers must be prepared to address the gaps in opportunity that exist in the current inequitable education system. Milner (2020a) points out that opportunity-centered teachers adopt mind-sets that honor diversity and create greater opportunities for students, including such practices as building and sustaining relationships, understanding equity in practice, understanding the self in relation to others, and perceiving teaching as a mission and responsibility (p. 180-181). Teacher preparation, then, ought to include pedagogies and programming to ensure that prospective teachers have several chances to practice becoming opportunity-centered teachers.

It is important to acknowledge that while Milner's *opportunity gap framework* primarily addresses the ways practicing teachers can enhance opportunities for rigorous, intellectual work for all students, it is also connected to the "ongoing imperative" (Milner, 2020a, p.183) of teacher education, because this is place where "teachers are prepared to build knowledge, attitudes, mind-sets, paradigms, perspectives, beliefs, skills, and actions essential to meet the instructional needs of all students" (p. 183-4). Because of this, I used Milner's (2010; 2020a) *opportunity gap framework* to understand how and to what extent the program components of the AMNH MAT prepared residents to understand their identities in relation to that of their students, to foster the diverse knowledge sources, skill sets, and talents young people bring to their classrooms, and to honor the richness and resourcefulness of the communities in which they would go on to teach.

As I have previously mentioned, the main purpose of this dissertation is to understand how teacher preparation was envisioned and enacted at the AMNH MAT, which is highlighted in Question 1, with particular attention paid to how this program prepares prospective teachers for urban school contexts, the topic of Question 2. According to Yin (2018), a case study "benefits from the prior development of theoretical propositions to guide design, data collection, [and] analysis" (p.15). Cochran-Smith and Lytle's (1999) and Lave and Wenger's (1991;1998) theoretical frameworks usefully served as a "sufficient blueprint" (Yin, 2018, p. 35) for analyzing how the AMNH MAT conceptualized and enacted teacher preparation, particularly in terms of the decisions program designers and faculty made based on their visions, goals, and assumptions about the knowledge needed for teaching, the nature of practice, and the communities into which candidates ought to be socialized. The conceptual frameworks of Matsko and Hammerness (2014) and Milner (2010; 2020) together "play[ed] a critical role in helping…to generalize the lessons learned" (Yin, 2018, p. 37) when considering the pedagogies and practices the museum MAT specifically designed to prepare prospective teachers for the complex context of urban schools.

Review of Related Literature

Three bodies of literature informed this case study: research on the residency model as an approach to urban teacher preparation, research on teacher preparation for urban secondary science, and research on museum-based science teacher preparation. Before presenting this literature, I provide an analysis of how nGSEs are analyzed and critiqued in an eclectic collection of professional and academic publications, elaborated below.

Analyzing and Critiquing nGSEs

Until recently, there was little empirical work about nGSEs, partly because teacher preparation programs completely independent of universities are not much more than a decade old. Despite this fact, various kinds of publications on nGSEs have grown in recent years. However, to date there is only a small body of empirical work based on direct access to these independent graduate schools, including the work of the larger research project of which this case study is a part. Our research team has conducted case studies of teacher preparation at Sposato Graduate School of Education (Miller, 2017; Keefe & Miller, 2021), High Tech High Graduate School of Education (Sanchez, 2019, 2021) and TEACH-NOW Graduate School of Education[1] (Carney 2019, 2021). We have also published a brief theorized profile of the MAT program at the American Museum of Natural History (Olivo & Jewett Smith, 2021) and have presented and/or published cross-case analyses of these four sites, using a multi-case perspective to understand the mission, institutional logics, conceptions of learning to teach, funding models, and notions of equity and justice at nGSEs (Cochran-Smith et al., 2019; Cochran-Smith et al., 2020; Cochran-Smith, 2021a; Cochran-Smith, 2021b; Cochran-Smith, et al., 2021; Cochran-Smith & Alexander, 2021; Jewett Smith, 2021; Olivo 2021; Stringer Keefe, 2021). In addition to our research, there is a research brief that highlights High Tech High GSE's success in developing "educators who are ready to implement student-centered and equity-focused instruction for deeper learning" (Wojcikiewicz, Jackson-Mercer & Harrell, 2019). There have also been a few dissertations that analyze various aspects of teacher preparation at specific nGSEs, such as Salmacia's (2017) analysis of teachers' data literacy at Sposato GSE and

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[1] On July 9, 2020, the Higher Education Licensing Commission (Washington D.C.) approved a name change- "Moreland University"-for the TEACH-NOW Graduate School of Education; TEACH-NOW will continue to exist under the Moreland University umbrella. Given its new status as a program within an online university, TEACH-NOW no longer fits with our definition of nGSE. However, all the data we obtained on TEACH-NOW occurred when it was an nGSE.

Chatman's (2019) study of cultural responsibility in special education teacher candidates at Relay GSE.

While there is little empirical work based on direct access to programs, materials, and participants involved in nGSEs, there are a number of entities and groups, including policy institutes, think tanks, education reform organizations, advocate groups and education scholars, that have described and critiqued nGSEs, based primarily on publicly-available information, website materials, and other documents. Policymakers and advocacy groups have often run ahead of research in their generally positive descriptions of independent teacher preparation programs like nGSEs. In an effort to capture the varied responses to nGSEs as a growing phenomenon in teacher preparation, I have included in the analysis that follows a broad-ranging collection of materials: a small group of policy/political analyses of aspects related to teacher preparation at nGSEs (e.g. Anderson, 2019; Mungal, 2015; Nagrotsky, 2019; Phillip, 2019), a few case studies (e.g. Arnett, 2015; Chatman, 2019), policy briefs (e.g. Zeichner, 2016), articles published by advocacy groups (Doyle & Han, 2014) or policy institutes (Crowe, 2011), a white paper (Candal, 2014), descriptive chapters or articles (e.g. Gastic, 2014), or magazine articles (e.g. Schorr, 2013). There are also many news articles, blog posts, and social media commentary that feature nGSEs, but these are not part of this analysis.

It is not surprising that the articles on the nGSE phenomenon present a rather polarized picture, since the publications are wide-ranging and from groups with different perspectives. In fact, aside from a few publications that seek to understand- rather than to critique- nGSEs, including our work, there are two general stances on the recent and rapid emergence of nGSEs and independent graduate schools: one that argues that these are a new and promising pathway of teacher preparation (e.g., Arnett, 2015; Gastic, 2014; Schorr, 2013) and one that has critiqued teacher preparation at nGSEs as undermining democratic education (e.g. Anderson, 2019; Souto-Manning, 2019; Philip, 2019; Zeichner & Conklin, 2016).

Promoting nGSEs as a New, Promising Pathway of Teacher Preparation

I grouped the articles in this section together because they collectively promoted nGSEs as the "new generation" (Schorr, 2013) of teacher preparation. The genres and authors of articles taking this stance vary, including both leaders and faculty members of the nGSEs themselves and others who are advocates of this new model of teacher preparation. They were published by nonprofit think tanks such as *Clayton Christenson Institute* (Arnett, 2015), advocacy groups, such as *ConnCAN* (Doyle & Han, 2012), or policy groups, such as the *Center for American Progress* (Crowe, 2011) and the *Pioneer Institute* (Candal, 2014). These articles positioned nGSEs as not only refreshing, but as a change needed to improve the quality of teachers entering schools. Furthermore, they shared the twin assumptions that "if ever there were a system in need of reinvention, it would be teacher education" (Kronholz, 2012) and that "for schools to get better, early-career teachers with strong skills are going to have to become a whole lot less exceptional" (Schorr, 2013). Taken together, this group of articles argued that university-based teacher education programs, and the teachers they prepare, are not up to the task of promoting quality teaching in K-12 schools.

Touted as a "swell of disruptive innovation" (Gastic, 2014, p. 91), nGSEs were perceived as a new and "better" way to engage in teacher preparation. Lauded as key successes of nGSE were: unprecedented attention to recruitment (Arnett, 2015; Candal, 2014); new accountability measures for the relationship between teacher practices and student outcomes (Doyle & Han, 2012; Gastic, 2014; Schorr, 2013), and; the emphasis on practice-based approaches to learning to teach, rather than the purported theory-heavy curriculum in university-based teacher education (Candal, 2014; Hammerness et al., 2020; Kronholz, 2012; Schorr, 2013).

In terms of recruitment of teacher candidates, Gastic (2014) argued in a chapter of *Teacher Quality 2.0: Toward a New Era in Education Reform* (Hess & McShane, 2014) that "the demand for effective teachers far exceeds the capacity of the current human capital pipeline" (p. 91). Gastic (2014) later pointed out that teachers today tend to achieve less academically in terms of class ranking and SAT scores. This argument paints a dismal picture of university teacher education: not enough people want to become teachers, and those who do tend to achieve less academically than people in other academic fields. Along these lines, Arnett's (2015) case study commented to those considering starting a graduate school of education: "Getting elite talent...could be a challenge. Focus on finding people who are willing and eager to challenge convention and embrace self-imposed measures of setting up and maintaining the program" (p. 21). Similarly, in a white paper, Candal (2014) pointed out that Match Teacher Residency program (later, Sposato GSE) was explicitly looking for teacher candidates whose philosophy matched theirs and who were willing to put in "large amounts of hard work" (p.5). Finally, both Candal (2014) and Kronholz (2012), whose article was published in a nonpartisan online journal, made the point that good teachers are made, not born. Taken together, these articles suggested that nGSEs were working to select philosophically-aligned and deeply committed candidates.

A second aspect of the perceived success of nGSEs extolled in this group of articles was the presumed unrivaled attention to accountability for student achievement. For example, Relay GSE was acclaimed for "break[ing] the mold" (Kronholz, 2012) and for being a "leading symbol of a burgeoning revolution in how America is learning to teach" (Schorr, 2013), in particular because of the "feedback loop" feature of its pedagogy (Kronholz, 2012; Schorr, 2013). This has to do with the claim made by Relay GSE that students cannot earn their master's degree unless they demonstrate "measurable growth in the classroom" (Doyle & Han, 2014, p. 14). In other words, teacher candidates at Relay are granted master's degree's only when they have proven, according to Relay's measures, that they have positively impacted on student achievement. In a public impact report, Doyle and Han (2014) claimed that Relay's list of approved measures for student achievement included "teacher-constructed" or "teacher-acquired" (p. 107) materials, a claim that has been challenged (Zeichner, 2016) and to which I refer later.

A third feature of nGSEs promoted in this group of articles from wide-ranging publications was their presumed attention to the "daily realities" of teaching rather than the theory perceived to be emphasized in university-based teacher preparation (Schorr, 2013). Kronholz (2012) noted that Relay's candidates' lessons where "highly scripted," and Schorr (2013), who published an essay in a university-based magazine, claimed that Relay "departs sharply form the American norm" with its "decidedly practical" approach of videotaping a lesson and later analyzing it. Candal (2014) similarly deemed Match Teacher Residency as "unique in that it provides a narrowly focused form of teacher education with the intent of producing teachers…for [high-performing] urban schools…many of which take a 'no-excuses' approach to teaching" (Candal, 2014).

These articles from varied and diverse publications together painted a picture of teacher training at nGSEs as technical, rather theoretically-based, with a focus on preparing teachers to enact specific practices or moves. Finally, some of these articles promoted particular nGSEs as *the* solution to perceived problems in teacher education. For instance, High Tech High Graduate School of Education (HTH GSE), which has been credentialing teachers since 2004, has been positioned as a new innovation not only in teacher preparation, but also for K-12 education.

Caillier and Riordan, members of HTH faculty and authors of the sole article in this section published in an academic journal (*Journal of Teacher Education*), argued that teacher preparation should be embedded in schools as an "explicit reform agenda" (Caillier & Riordan, 2009, p. 495).

Critiquing nGSEs as a Threat to Democratic Education

The second group of articles were all written by teacher education researchers and were published in peer-reviewed academic journals or policy publications. These analyses were primarily based on publicly available materials, such as nGSE websites. These scholars generally focused on one of three primary critiques: new schools of education are built on the faulty narrative that university teacher education is a failure; many nGSEs emphasize scripted practice in the preparation of teachers, which is perceived as a turn away from justice- and democracy-oriented teacher preparation, and; there is either an absence or a false representation of research to support the kind of success independent graduate programs and their advocates claim.

The first critique of nGSEs and other independent teacher preparation programs is that they rely on the false, but "prevailing narrative" (Souto-Manning, 2019, p. 1) that teacher education needs improvement, and that nGSEs and the like are the solution (Cochran-Smith et al, 2018; Kretchmar & Zeichner, 2016; Souto-Manning, 2019). In a conceptual article, Souto-Manning cogently (2019) argued: "The discursive construction of university-based teacher education as being broken has paradigmatically positioned university-based teacher education as the sum of its (perceived and real) deficits, while downplaying its history and contributions" (p. 2). Importantly, many teacher education scholars who critique teacher preparation at nGSEs do not deny that teacher education needs improvement (i.e., Anderson, 2019; Kretchmar & Zeichner, 2016; Souto-Manning, 2019). Rather what they collectively take issue with are the public and persistent attacks on university-based teacher education made by policy institutions, think tanks, advocacy groups, charter management organizations or other charter-affiliated organizations and the U.S government. These critics have argued that this narrative of failure, combined with the overemphasis on market-based reform efforts to improve teacher preparation has made room for venture capitalists, namely but not exclusively the New Schools Venture Fund (NSVF) and the Bill and Melinda Gates Foundation, to enter the space of teacher education, hence promoting the privatization of teacher education (Anderson, 2019; Hursh, 2017; Kretchmar, 2014; Mungal, 2015, 2016, 2019; Souto-Manning, 2019; Zeichner, 2015, and Zeichner & Peña-Sandoval, 2015).

In fact, according to Mungal's (2015) empirical analysis, free market ideologies have infiltrated teacher preparation and are here to stay: "Prompted in part by *A Nation at Risk,* as well as a shift toward a free market economy-what was supposed to be a temporary solution to a teacher shortage in the 1980s would become a permanent aspect of teacher preparation by 2012, with the arrival of Relay GSE" (p. 6). Mungal (2016) also argued that in places like New York City, this change in the field has made way for a "parallel education structure" (Mungal, 2016) -- teacher preparation programs located in education schools and teacher preparation programs that serve charter schools. Along similar lines, Kretchmar, a Teach for America (TFA) grad turned university professor, cautioned that behind education reform initiatives such as TFA, a privatization agenda in public education "loom[s] large…the connections between Teach for America and other groups supporting market-based initiatives is striking, and its impact is significant" (p. 651). In a speech published in *Policy, Futures in Education,* Hursh (2017) argued that there is currently a "corporate reform agenda" in that major corporations, primarily but not exclusively the Bill Gates Foundation, are colluding with other powerful groups to shift or redesign public education to a privatized institution.

Anderson's (2019) sociological analysis of the rise in venture philanthropy in teacher education posited that the newly formed interest of private organizations, namely NSVF, in public education has roots in racial capitalism. Citing Robertson (1983), who argued that racism and capitalism "co-evolved," Anderson braided together several justice-oriented arguments against the rise of nGSEs:

> When, for example, developers can acquire closed school buildings on the cheap, corporations can claim tax breaks via charter school investments in 'low-income communities,' hedge funds can profit from schools' hiring of inexperienced, transient, nonunion teachers and wield outside political influence in policy making, and voucher programs can shunt public funds to unproven private practice providers- practices that are all permissible only because they reap reward at the expense of poor Black and Brown children- justice is most certainly not the driving motivation. (p.3)

Central to Anderson's argument was the belief that university-based teacher educators have colluded- intentionally or not- with those interested in proliferating "entrepreneurial outfits" (Anderson, 2019, p.9) such as Relay, Match, TFA and Alder GSE.

Finally, both Anderson (2019) and Zeichner and Peña-Sandoval (2015) argued that the NSVF has set its sights on the scaling up of independent teacher preparation programs, especially those aimed at serving urban charter schools throughout the country. These teacher education scholars see entrepreneurial organizations like the New Schools Venture Fund as a privatized infiltration into what should be inherently kept as a public responsibility: K-12 schools and teacher education schools. Doing so, they argued, is a threat to democracy because schools sit at the heart of our societal well-being, and therefore should not be subject to the influence of private corporations, whose agenda might not align with that of the public it intends to serve.

The second critique of nGSEs and other independent teacher preparation programs is the narrow focus of curriculum at many nGSEs, which was described as an over-emphasis on scripted practice in the preparation of teachers and a simultaneous turn away from justice-oriented teacher preparation (Ben Porath, 2015; Nagrotsky, 2019; Philip, 2019; Philip et al., 2019; Stitzlein & West, 2014; Smith, 2015, and Zeichner, 2016b). Independent graduate schools of education like nGSEs tend to privilege a practice-oriented approach to teacher preparation in response to the demand for- and at times singular attention to- achievement-by-standardized testing that currently dominants K-12 public education. The heavy emphasis on preparing young people to do well on standardized tests leaves little room for teacher candidates to interrogate the sociopolitical nature of schools and schooling and its impact on historically marginalized young people (Ben Porath, 2014; Stitzlein & West, 2014; Nagrotsky, 2019, and; Smith, 2015). This is particularly important to pay attention to because many nGSEs are preparing teachers for urban public or urban charter schools, which are made up of students who bring vast and various assets and funds of knowledge from different cultures, heritages, ethnicities and backgrounds to classroom spaces and school settings.

For example, in a conceptual article, Stitzlein and West (2014) argued that “Relay and Match [Sposato GSE] have a fixed definition of success, one largely tied to test scores and demonstrated ‘academic achievement’” (p. 8). In their analysis of program materials at both of these nGSEs, these researchers found no references to democracy in K-12 schools, educational philosophies, or schooling and society. In response, Smith (2015), a former student at Sposato GSE, corroborated this finding, problematizing Sposato’s ‘no excuses’ approach: “At Match, the network of rules constructs a system that prizes silence and rigorously controls students' bodies" (p. 3). Similarly, Miller's case study (2017), conducted for the larger research project of which this study is a part, found that Sposato GSE's heavy focus on a "technical, moves-based epistemology of teaching" allowed for a successful realization of its mission of "creating jaw-droppingly effective rookie teachers," but that this is came at a cost; these rookies were "social[ized]…into a gradualist and technically rational vision of equity and justice consistent with the goals of 'No Excuses' schools" (p. 2).

Nagrotsky (2019), a TFA graduate who is currently a teacher education professor, analyzed institutional documents, available video artifacts, and other publicly available information and found that Relay's curriculum heavily relied on "automaticity and standardization," (p. 24) lacked critical reflection and lacked attention to structural racism (Nagrotsky, 2019). Interestingly, Chatman (2019), Director of Curriculum at Relay GSE, substantiated this argument in her dissertation, which examined the extent to which early career special education teachers in urban settings (recent Relay GSE grads) felt prepared for and used culturally responsive teaching practices in their classrooms as teachers of record. Chatman (2019) found that "overall…their classroom practice reflected a surface understanding of…culturally responsive teaching" and that this "limited their ability to make explicit connections between classroom practice and culturally responsive teaching theory" (p.59).

In conceptual and empirical journal articles, other teacher education scholars took direct aim at particular nGSEs for their prescriptive measures of teaching that seemed to take up social justice and cultural relevancy in name only (Anderson, 2019; Philip, 2019; Philip et al., 2019; Stitzlein & West, 2014; Smith, 2015; Zeichner, 2016). For instance, Philip et al. (2019) argued that because teaching is intellectual and improvisational work, organizing teacher education around a set of core practices risks peripheralizing equity and justice. Philip et al. (2019) also argued that an emphasis on a narrow set of teaching practices "trivializes" the work of teachers, who are engaged in the ongoing work of contributing to the formulation of a democratic society (Philip et al., 2019).

Finally, some teacher educators offered alternatives to the focus on practice-based teacher preparation currently pervading nGSEs. For example, Philip (2019) called for the adaption of "principled improvisation" in teacher preparation programs, a construct aimed at helping candidates develop interactional, responsive, and creative ways to raise the critical consciousness of their students. Along somewhat different lines, in a conceptual article, Zeichner (2016b) called for "Teacher Prep 3.0," which he referred to as programs whose focus is on "bring[ing] together knowledge and expertise from the university, schools, and local community in more democratic ways, and the focus is on working with and for communities rather than saving students from them" (p. 154).

The third critique of nGSEs made by teacher education scholars was that those who promote nGSEs and other independent teacher preparation programs have made under-researched claims about the purported success of these programs (Zeichner, 2015; Zeichner & Conklin, 2016). While many teacher educators questioned the unsubstantiated claims that nGSEs are "bold" and "innovative" (Anderson, 2019; Zeichner, 2016; Zeichner & Peña-Sandoval, 2016), there were two conceptual articles that directly analyzed the misrepresentation of research to support non-university education providers and undermine the work of colleges and universities (Zeichner, 2016; Zeichner & Conklin, 2016). Using the constructs of "echo chamber" and "knowledge ventriloquism" (Robertson, 2012), Zeichner and Conklin (2016) examined print and news media claims that university teacher preparation programs are failing and also their promoting of non-university programs. These scholars argued that there is a "limited or biased use of research" in policy making, which is perpetuated by the "media's reproductions of this narrative of failure" (Zeichner & Conklin, 2016, p. 4). Using four examples, this study illustrated that "a network of publicly subsidized and interrelated think tanks, advocacy, groups, and philanthropists" (Zeichner & Conklin, 2016, p. 5) misused research in order to influence teacher education policies to deregulate teacher education and make way for more independent teacher preparation programs.

In a peer-reviewed policy brief written for the *National Education Policy Center*, Zeichner (2016) called for state and federal policymakers to discontinue implementing policies and providing funding streams that privilege independent teacher preparation programs until there is "substantive credible evidence" that these programs actually are as "bold" and "innovative" as they claim. This is particularly critical because "to date, these new alternatives focus almost exclusively on preparing teachers to teach 'other people's children' in schools within high-poverty communities- not on public school teachers in advantaged communities" (Zeichner, 2016, p.3). This raises questions about the extent to which these programs either work to make schools more equitable places or contribute to persistent systemic inequities in schooling.

A final point to make about this group of articles that critique nGSEs and independent graduate schools of education is that despite skepticism, there remains hope that there is a way to simultaneously reconcile the missteps of university-based teacher education and to interrupt the inequities perpetuated by nGSEs and other independent teacher preparation programs. For instance, Kretchmar & Zeichner (2016), along with Souto-Manning (2019) called for a needed transformation to teacher education, which includes and asset-, equity-, and justice-oriented approach to preparing teachers (Souto-Manning, 2019) that "develop[s] new ways to prepare teachers to work with and for communities to educate students with aims that go far beyond increased test scores and to see this work as connected to broader struggles to address poverty" (Kretchmar & Zeichner, 2016, p. 430).

Relevance for this case study

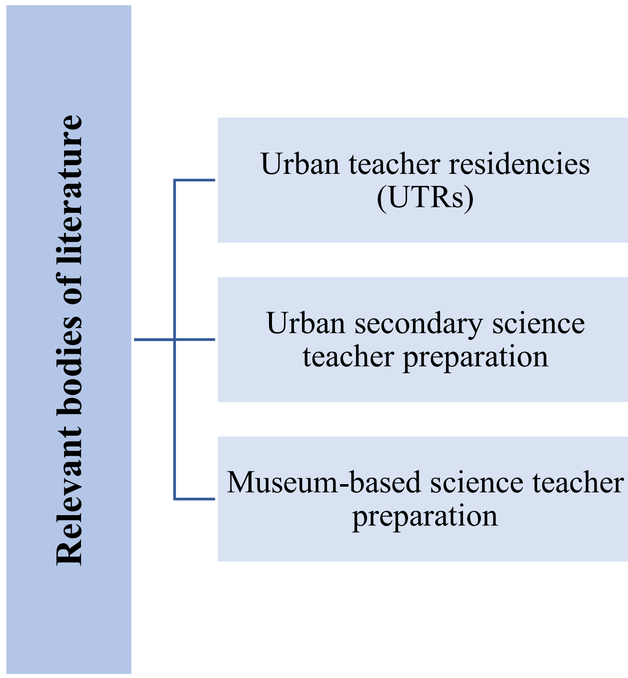
As I have shown, there is a need for rigorous empirical research that seeks to understand teacher preparation at nGSEs. As Zeichner and Peña-Sandoval (2015) rightly pointed out, "saying over and over again that these programs are innovative, groundbreaking, and bold does not make it true in the absence of solid research evidence" (p. 28). Therefore, rather than either touting nGSEs as *the* innovative solution to all of teacher education's problems *or* critiquing them based on publicly available materials, this study contributes to the small body of independent, empirical research that seeks to understand how teacher preparation is conceptualized and carried out at nGSEs.

Three Bodies of Related Empirical Research

In addition to the eclectic body of research and commentary on nGSEs reviewed above, there are three bodies of empirical research related to this dissertation. These are: research on urban teacher residencies (UTRs), research on urban secondary science teacher preparation, and research on museum-based teacher preparation. (See Figure 3.)

Figure 3

Bodies of literature relevant to AMNH MAT case study



To analyze this research, I used Cochran-Smith and Villegas' (2014) analytical framework for reviewing teacher preparation research as "historically situated social practice," or Research as Social Practice (RASP), to guide and organize my analysis. This framework assumes that researchers engage in particular social practices within larger social, historical, and political contexts. Cochran-Smith and Villegas (2014) suggested that the RASP framework is "especially appropriate in emerging fields such as teacher preparation, which are made up of multiple territories, many of which are contested, and which borrow from many other disciplines" (p.5). The RASP framework focuses on the following social practices: 1) the construction of problems and the framing of research questions; 2) underlying assumptions; 3) researcher identity and intended purposes and audiences; 4) research designs, theoretical frameworks and the way evidence is used; and 5) trends in findings and assumed implications.

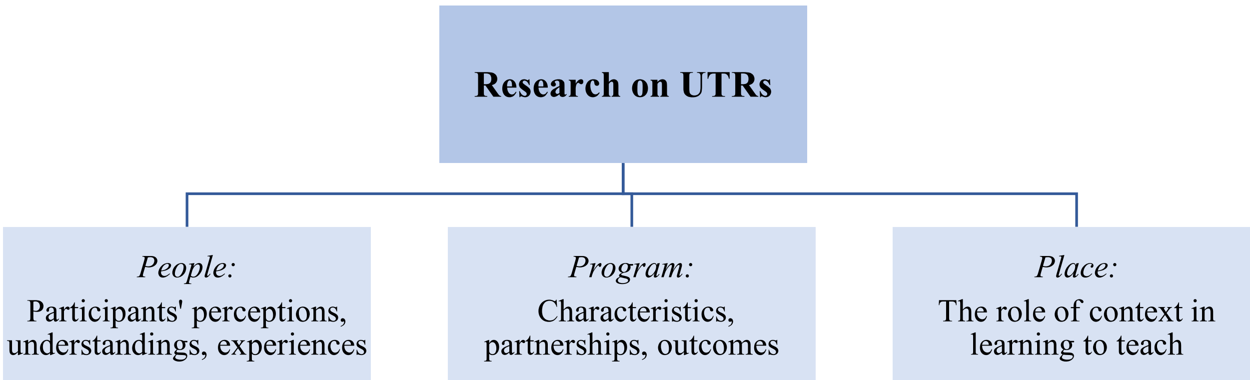
Informed by the RASP framework, I used the research questions of the studies to categorize each body of literature into three groups as a first level of sorting out the research. Next, within these three groups, I analyzed the studies by first describing the problems, assumptions and logics that shaped them. Next, I synthesized the purposes and research questions posed, and explained the research designs used. Finally, I described trends in findings along with assumed implications of each group of studies.

Research on Urban Teacher Residencies

The first body of empirical research relevant to this case study is the literature on urban teacher residencies (UTRs). The residency model is an approach used by six of the 12 currently operating nGSEs, including the AMNH MAT. Interestingly, both nGSEs in general and the urban teacher residency model in particular have been touted as "innovative" approaches to preparing teachers for urban schools and yet the empirical research on both phenomena is sparse to date. Figure 4 represents the major groupings within this body of research.

Figure 4

Major groupings within the research on urban teacher residencies (UTRs)



Urban teacher residencies (UTRs) are modelled on the medical education practice of pairing new practitioners (or residents) on site in hospitals working alongside seasoned staff. They have been referred to as “pockets of vitality” (Gatlin, 2009, p. 470) in teacher education, with many researchers suggesting that UTRs show great promise, in part because they prioritize the context of the urban classroom in teacher preparation (Beck, 2016; Berry, Montgomery, & Snyder, 2008; Hammerness et al., 2016; Papay, West, Fullerton, & Kane, 2012; Reynolds et al., 2016; Roegman, Pratt, Goodwin, & Akin, 2017, and; Zeichner, 2010). UTRs were originally described as having the following characteristics: a nonprofit organization partnership with a school district or university; preparation for the lowest performing schools and highest shortage areas; candidate recruitment that is targeted; a cohort who learns to teach over the course of at least a year and with mentors; a residency where candidates work full-time in mentor teachers’ classroom for an entire school year; a stipend received during candidates’ time in the program in exchange for a commitment to teaching in high-needs schools for a set number of years, and; receipt of a master's degree as well as mentoring and induction support (Silva et al., 2014).

The current peer-reviewed, empirical research on UTRs can be organized into three groups. The first and strikingly largest group of studies, "people," includes studies that examined UTR participants' perceptions, understandings, and experiences. Participants included teacher residents, recent program graduates, mentors, and in two cases, teacher educators. The second group, "programs," includes studies that focused on UTR program characteristics, partnerships, and outcomes. Finally, the third and smallest group, "places," includes three studies that focused on the role of context in teacher candidates' learning at UTRs. It was surprising to discover that few studies directly examined participants' understandings of, and knowledge about, the urban contexts for which they were preparing to teach, especially given that the explicit purpose of UTRs is to prepare teacher candidates for urban schools.

People: Participants' Perceptions, Understandings and Experiences

The first group of studies on UTRs examined the perceptions and experiences of the residents (e.g., Garza & Werner, 2014; Gatti & Catalano, 2015, and; Anderson-Levitt et al., 2017) and the mentors, faculty liaisons, and teacher educators (Gardiner, 2011; Goodwin, Roegman, & Reagan, 2016; Kolman, Roegman, & Lin Goodwin, 2016; Roegman, Reagan, Goodwin, & Yu, 2016, and; Garza et al., 2018). Most researchers based their studies on two premises that framed "the problem" of teacher education. First, researchers who focused on the perceptions and experiences of UTR residents generally were concerned with a lack of high-quality urban preparation programs, which results in teachers entering urban schools underprepared. These researchers believed that this concern was connected to another: urban schools in the U.S. face a continuous teacher recruitment and retention problem (Anderson-

Levitt et al., 2017; Chen et al., 2016; Garza & Werner, 2014; Gatti & Catalano, 2015; Klein et al., 2016; Reagan et al., 2015; Reagan et al., 2016; Strom et al., 2018; Vernikoff et al., 2018, and; Williamson & Hodder, 2015). Second, the group of researchers who focused on perceptions and experiences of UTR mentors and faculty liaisons generally agreed with the national call for more clinically-rich teacher preparation, honing in on a need for a deeper understanding of mentors and mentoring (Gardiner, 2011; Gardiner & Salmon, 2014; Gardiner & Lorch, 2015; Garza et al., 2018; Goodwin et al., 2016; Kolman et al., 2017, and; Roegman et al. 2016).

Anderson-Levitt et al. (2017), Gardiner and Salmon (2014) and Gardiner and Lorch (2015) all assumed that UTRs fostered coherence between field-based learning and on-campus learning. Klein et al. (2016), on the other hand, argued that UTRs were third spaces that "cross customary role boundaries" (p.244) between universities and schools, inviting the co-construction of curricula among faculty, candidates, mentor teachers, and community members. The difference here is subtle, but while the former points to UTRs as a bridge that connects knowledge from one location (university) to another location (schools), the latter suggests that UTRs have the potential to be a unique space with new knowledge sources and new possibilities for preparing urban educators.

Finally, many studies assumed that teaching is a complex process that unfolds over time (e.g., Gardiner, 2011; Roegman et al., 2016; Strom et al., 2018) and that clinically-rich practice ought to be a key feature of teacher preparation. This was especially true for studies that examined how participants experienced educational rounds (Reagan et al., 2015; Williamson & Hodder, 2015) and mentoring (Gardiner, 2011; Garza et al. 2018; Goodwin, Roegman, & Reagan, 2016; Kolman, et al., 2016, and; Roegman et al., 2016).

Most often, researchers asked questions about how residents experienced particular aspects of UTRs, including educational rounds (Reagan et al., 2015; Williamson & Hodder, 2015), inquiry (Klein et al., 2016), and teaching for social justice (Chen et al., 2016; Reagan et al., 2016). Gatti and Catalano (2015) used critical metaphor analysis to unpack how one UTR grad experienced teaching in a neoliberal context. Researchers who examined UTR mentors' perceptions, experiences, and practices asked how mentors defined and understood the process of mentoring overall (Goodwin et al., 2016), how mentors perceived the impact of yearlong placement (Gardiner, 2011), how mentors self-assessed their work (Roegman et al., 2016), and how they described the impact of their own practices and approaches (Garza et al., 2018). Gardiner and Salmon (2014) and Gardiner and Lorch (2015) studied the impact of faculty liaisons on the school-university partnership, a role unique to their UTR and designed to work more closely with mentor teachers and residents in schools.

Throughout this group of research, the following data sources, mostly qualitative, were frequently used: multiple interviews with stakeholders occurring over a period of time, usually a year; observations of classrooms, lesson debriefs, meetings; analysis of admissions and candidate coursework essays and reflections, and program documents; surveys (Gardiner & Salmon, 2014; Goodwin et al., 2016), and in one case, a questionnaire (Williamson & Hodder, 2015).

The majority of the studies were framed in terms of sociocultural learning theory and sociological perspectives (e.g., Anderson-Levitt et al., 2017; Gardiner, 2011; Goodwin, Roegman, & Reagan, 2016; Reagan et al., 2015; Strom et al., 2018; Vernikoff et al., 2018; Williamson & Hodder, 2015). Additionally, there was a focus on theories of justice (e.g., Reagan et al., 2016) and social justice (e.g., Chen et al., 2016). These theoretical framings consider the cultural and social context in which people learn to teach as important for to understand on its own as well as to see it as part of prospective teachers' burgeoning identity as teachers. The researchers in this group often found that residents made connections between themselves, their coursework, and the context of their residencies, and were "agentic participants in constructing teacher practice" (Strom et al., 2018, p.22).

There are two important sets of findings in the research about UTR participants. The first set of findings has to do with residents' perceptions and experiences, and the second has to do with UTR mentors' perceptions and experiences. In terms of the first set of findings on UTR residents' perceptions and experiences, researchers found that residents sought to make connections between themselves, their coursework, and the context of their residencies. Specifically, residents' perceptions about their own identities as teachers hinged on how they made sense of two important connections: their personal connection to their UTR experiences and the extent to which they felt that there was a connection between their UTR coursework and their residency classrooms (e.g., Garza & Werner, 2014).

Along these lines, this research found that if residents experienced opportunities to work on the development of a "*personal* professional identity" (Anderson-Levitt et al., 2017, p. 380, original emphasis), which refers to how residents come to see themselves as teachers, early on in the program, they were more likely to experience coherence between their coursework and their work in schools. A common finding among the studies, in fact, was how important it was that teacher identity be a significant part of the curriculum early on. Klein et al. (2016), for example, found that residents experienced a shift in "teacher identity" through inquiry practices and by experiencing "third space" instructional rounds, which helped them develop the idea that knowledge is constructed and reconstructed over time through working with others and throughout the span of their careers. Reagan et al. (2015) found that residents' developed their own “beginning repertoire” (p. 66) of teaching practices, dispositions, and tools based on their experiences with educational rounds, a common practice in UTRs that involves frequent peer observation and feedback, which contributed to residents taking ownership of their own teaching practices (Reagan et al., 2015).

Another trend in the findings about UTR residents’ perceptions was that it was important for them to experience a connection between their coursework and fieldwork, a connection which they sometimes did not find. For example, Garza and Werner (2014) found that residents desired a deeper connection between the UTR curriculum and the urban classrooms in which they taught. Additionally, Gatti and Catalano (2015) found that a recent UTR grad whom they followed for one year tended to think about learning to teach as a journey, whereas the UTR program in which she studied framed teaching as a business. This “tightly scripted and highly surveilled” program “preclude[d] opportunities for creativity, exploration, and even failure” (Gatti & Catalano, 2015, p. 154), which demonstrated a clear disconnect between this resident’s teacher identity and how her UTR program worked to prepare its teachers.

Finally, there were two studies that focused on residents’ conceptualizations of teaching for social justice (Chen et al., 2016; Reagan et al., 2016). These studies found that while residents left the program with a deep commitment to and understanding of the larger social and political landscape in which their schools and students resided, they “need[ed] more support in teaching for social justice within and against this landscape in the day to day moments that directly impacts students” (Chen et al., 2016, p. 20). In other words, residents found it difficult to translate social justice beliefs and practices into their own daily teaching. This speaks to the difficulty of moving from “rhetoric and concept” to “action and impact” (Chen et al., 2016, p. 20), which is necessary if urban teachers are being prepared to disrupt persistent and pervasive inequities. Vernikoff et al. (2018) found that "emerging place-based pedagogical content knowledge," which referred knowledge of residents who attended urban schools themselves, can help all prospective teachers in UTRs to understand the constructs of racism and privilege and to see how young people navigate the possibilities and pitfalls of city life.

The second set of findings from this group of research has to do with the perceptions and experiences of UTR mentors. A trend in the findings across these studies was that mentors struggled in their roles in two main ways: creating spaces for open and critical dialogue with mentees (Goodwin et al., 2016; Roegman et al., 2016) and straddling their twin responsibilities of teaching their K-12 students and contributing to their mentee's preparation (Kolman et al., 2017). One implication of this research is that fostering an approach to mentoring where learning between mentor and mentee is reciprocal and co-constructed can reconfigure the mentor-resident relationship as more of a partnership (Kolman et al., 2017). This takes careful training and mentor teachers with an inclination towards co-constructed curricular practices. Unpacking the grant-funded role of faculty liaison at one university, Gardiner and colleagues (2014, 2015) found that the enhanced presence of teacher educators in schools pushed residents' growth by connecting their coursework to their fieldwork and by examining their own content knowledge. This group of researchers made a strong case for redesigning UTR preparation programs to include a faculty liaison—that is, teacher educators who are much more visible in schools, working directly with mentor teachers and residents (Gardiner et al., 2014; 2015).

Taken together as a set, the studies about the perceptions and experiences of UTR participants suggested that UTR residents benefitted from teacher education pedagogy and practices that involved opportunities for personal reflection and growth, particularly when this involved forming their identity as teachers. This research also revealed the predicament of the mentor-resident relationship: while residents craved more connection, mentors were struggling to help the residents, their mentees, with making these connections. This struggle was largely due to the mentors' tightrope walk that involved balancing the responsibilities of building relationships with and fostering the independence of their mentees on the one hand and grappling with the interwoven and always complex goals of preparing students for state-mandated standardized tests and enacting socially-just pedagogy on the other hand. Leveraging these two goals at the same time proved difficult for mentors, causing them to at times root their mentoring practices in procedural, technical, and instrumental operations of the daily goings-on of the classrooms (Goodwin et al., 2016).

Program: Characteristics, Partnerships, and Outcomes

The second group within the UTR studies all examined the "big picture" of UTRs as a model of urban teacher preparation, offering an overview of how UTRs functioned as a whole. Because the questions about UTR programming were different, there emerged three subgroups within this group of studies. The first subgroup dealt with UTRs characteristics, specifically: determining how UTRs matched up to federal qualifications for residencies (Wasburn-Moses, 2017), examining the findings of an implementation study looking at 30 teacher residencies (Silva et al., 2014), and comparing a UTR with a university-based program (Harju-Luukkainen, Wang, LaTorre, 2019). This subgroup of studies also analyzed program characteristics such as methods of teacher preparation (Beck, 2016), key aspects that influence student learning and success (Garza et al., 2013), and criteria for recruitment (Marshall & Scott, 2015). The second subgroup actually has only one study—Boggess's (2010) analysis of two district-residency partnerships. This study stands on its own because it is the only empirical study to date that examined the influence of the partnership structure in UTRs on how participants conceptualized teacher quality. Finally, the third subgroup analyzed UTR outcomes in terms of retention. What is interesting to notice is that the two studies in this group defined “retention” differently. While both defined “retention” as remaining in the profession (Papay et al., 2012; Roegman et al., 2017), one study saw also saw it as the extent to which residents *retained* the curriculum, inquiry, and social justice practices learned during their preparation (Roegman et al., 2017).

About half of the studies in this group followed the logic that there was a “teacher quality problem” in urban schools (Boggess, 2010; Garza et al., 2013; Silva et al., 2014; Marshall & Scott, 2015; and Harju-Luukkainen et al., 2019), which refers to a lack of proficient teachers in urban schools. Although they shared this assumption, these studies illuminated different aspects of this dilemma. For example, Boggess (2010) argued that there was a teacher quality gap between urban school districts and their surrounding suburbs. Harju-Luukkainen et al. (2019) agreed, pointing out that there was an “uneven distribution” (p. 248) of quality teachers in the United States writ large. Along somewhat different lines, Garza et al. (2013) argued that a lack of quality urban teachers was due to the fact that many educators are underprepared to teach culturally and linguistically diverse students. Harju-Luukkainen et al. (2019) further pointed out that most scholars agree that teaching in urban schools requires special skills, but just what those skills are is much less clear, making quality urban teaching difficult to define. Taken together, these researchers identified different root causes for the dearth of quality educators in urban schools.

The remaining studies in this group focused on slightly different issues in urban teacher preparation. Some researchers agreed that the connection between coursework and fieldwork needs to be made more explicit during preparation, and that UTRs have been designed to attend to this problem (Taylor et al., 2014; Wasburn-Moses, 2017). Others problematized the lack of empirical research on this model as an approach to teacher preparation (Beck, 2016).

Data sources and analysis for this group of studies included: content analysis of publicly available documents (Harju-Luukkainen et al., 2019; Wasburn-Moses, 2017), mixed-method design (Garza et al., 2013; Silva et al., 2014; Roegman et al., 2017); qualitative research design and analysis (Boggess, 2010), including two studies that used Bhabha's (1994) notion of "third space" as a framework (Taylor et al., 2014; Beck, 2016), and studies with quantitative design and procedures (Marshall & Scott, 2015; Papay et al., 2012).

It is difficult to determine trends in the findings and implications of these studies on UTR program characteristics, partnerships, and outcomes because the studies asked different kinds of questions about different program features of UTRs. Therefore, what follows is a discussion of findings organized by the three subgroups of studies outlined above. The first subgroup of studies aimed to understand UTR program characteristics. Wasburn-Moses (2017) located 37 UTRs nationally, most of which met federal guidelines for residencies. She found that mentoring structures were the least consistent and least clear features across UTRs (Wasburn-Moses, 2017). UTRs also varied in course offerings and amount of coursework. She cautioned that the title "Teacher Residency" ought to be used with more care or risk losing its meaning, or worse, integrity (Wasburn-Moses, 2017). In their comparison of a UTR and a university-based program, Harju-Luukkainen et al. (2019) found that the UTR focused more heavily on fieldwork and studies of teaching and subject education, while the university-based program placed a greater emphasis on education research. Like Wasburn-Moses (2017), Harju-Luukkainen and colleagues (2019) raised questions about UTR fieldwork experiences with mentors: "What are the teachers expected to learn during their practicum and how is this university making sure that learning during practicum is consistent in its quality and assuring that the learning outcome is equal across students?" (p.267). Silva and colleagues (2014) found that prospective teachers in teacher residency programs funded by federal Teacher Quality Partnership grants were not demographically different from those prepared in other programs, but they did tend to have different work and education experiences. They also found that teacher residency program graduates felt more supported and more prepared than their counterparts but had similar retention rates to other novice teachers (Silva et al., 2014).

Along different lines, Beck (2016) found that a UTR that employed "third space" ideology had great potential as an innovative teacher preparation structure that used "evidence-based decision making" (p. 58) but lacked coherence in terms of recruitment and admissions decisions between the university and the residency program itself. Also characterizing UTRs as "third spaces," Taylor et al. (2014) found that teacher educators had to manage multiple tensions, most of which involved building relationships with mentor teachers and residents. Examining their own UTR's outcomes, Garza et al. (2013) found that their teacher education curriculum was inconsistent in rigor and purpose and that the mentoring structure and recruitment process needed improvement.

As mentioned above, the second subgroup is one stand-alone study (Boggess, 2010). Boggess (2010) argued that two district-residency partnerships, the Academy for Urban School Leadership (AUSL) and Chicago Public Schools and the Boston Teacher Residency (BTR) and Boston Public Schools, and the private funding they each received, worked to "tailor," or custom-make, new teachers by socializing them with particular notions of teacher quality (Boggess, 2010). While AUSL and BTR held similar beliefs about the knowledge and skills needed to teach in urban classrooms, they varied on their beliefs about what counts as having high expectations for students (Boggess, 2010). In Chicago at AUSL, high expectations meant a heavy emphasis on student accountability and perseverance, whereas in Boston at BTR this meant having an activist disposition, particularly in terms of race awareness and teaching for social justice. Boggess's (2010) finding raises questions about how and to what extent political agendas should influence the ways teachers are "tailored" for particular urban schools.

The third subgroup of studies examined UTR outcomes. Both Papay et al. (2012) and Roegman et al. (2017) found that UTR graduates remained in the profession longer than their non-UTR counterparts. Papay et al. (2012) also found that UTR graduates were more racially and ethnically diverse than non-UTR graduates. Interestingly, using a fixed effects value added assessment approach, Papay et al. (2012) found that over time, students of UTR graduates outperformed the students of veteran teachers in standardized math scores. Along very different lines, Roegman et al. (2017), also examining outcomes, found that UTR graduates were successful at building relationships with students, creating meaningful, relevant, and justice-oriented curricula, viewing students through an asset-based perspective, and working with their colleagues.

There are three points that warrant commentary in this section. First, as the above paragraphs indicate, different researchers have different ideas about the kinds of outcomes that matter in determining the success of UTRs. Papay et al. (2012) analyzed effectiveness in terms of teacher retention, diversity of teachers, and the performance of students on standardized achievement tests, whereas Roegman et al. (2017) measured effectiveness in terms of the extent to which the teaching practices of UTR graduates reflected the mission, goals, and methods taught in the residency program. A key question that policymakers often ask is whether or not one model or approach of teacher preparation is better than another. These two studies show that it is difficult to determine the "success" or "superiority" of different models of teacher preparation because researchers have different operating assumptions about what counts as success, *and* they use different metrics to measure success.

A second point relates to the word of caution highlighted in the questions raised in Boggess's (2010) study: "If mayors and district leaders and private reform entrepreneurs can shape and tailor their teachers, whose definitions of teacher quality should hold sway?" (p.87). The current research on UTRs largely ignores its funders, whom, as Boggess (2010) showed, can be structurally and ideologically influential. This is important to pay attention to because many UTR graduates go on to teach the nation's most vulnerable children. Teachers' values and ideals shape the experiences and opportunities of young people in urban schools, so it is worth asking who is shaping the values and ideals of prospective urban teachers.

Finally, one common finding across these studies was that the role of mentor is crucial to UTRs and therefore needs careful cultivating. Garza et al. (2013), Taylor et al. (2014), Wasburn-Moses (2017), and Harju-Luukkainen et al. (2019) all found issues related to quality of mentor teachers in UTRs. This raises questions about the assumptions made about who and what constitutes quality mentoring, and how mentors broker relationships with faculty, with the residents, and between the residents and the students.

Place: The Role of Context in Learning to Teach

This group of studies of UTRs focused on how teacher candidates understood various aspects of the contexts for which they were learning to teach. All three studies in this group generally found it problematic that UTRs are rapidly growing, and yet there is little known about how they impact residents' learning for and in urban contexts (Hammerness & Craig, 2016; Roegman et al., 2016; and Williamson et al., 2016). The underlying assumption was that it is of paramount importance to understand the curriculum in UTRs (Roegman et al., 2016) and for the curriculum to incorporate urban schools and settings, the very places in which residents will both learn to teach and ultimately become teachers of record (Hammerness & Craig, 2016; Williamson et al., 2016). All three of these studies situated their research within sociocultural frameworks. Kolman et al. (2016) studied what and how residents learn within their school residency context. Hammerness and Craig (2016) and Williamson et al. (2016) asked questions about how the curriculum in UTRs reflects the context of the schools and communities where residents learn to teach and will become teachers of record.

Kolman et al.'s qualitative exploratory study (2016) of residents' learning within the context of their residency classrooms found that while residents valued opportunities to learn classroom practices that helped them understand the complexities of teaching, they found that their mentor teachers mostly modeled negative teaching practices and acted as gatekeepers who limited opportunities for residents. This study concluded that finding good schools and strong mentors is hard work, especially because mentors require training in understanding "how the context of high-need and low resources impact[s] not just the learning process of K-12 youth but also the learning to teach process for teacher candidates" (Kolman et al., 2016, p.190).

Hammerness and Craig (2016) and Williamson et al. (2016) focused on how the content of UTR curriculum attended to the complex context of urban settings. Interestingly, each study raised questions about how much and what kind of context-specific knowledge ought to become part of the UTR curriculum, but each came to different conclusions. Hammerness and Craig (2016) used mixed methods design and found that residents felt knowledgeable about historical issues and problems in urban schools but did not feel as prepared for the particularities of the New York City schools where they engaged in clinical practice and where they would go on to become teachers of record. On the other hand, Williamson et al.'s qualitative study (2016) found that residents developed "context conscious mind-sets" (p. 1182) for teaching in San Francisco schools in particular based on their understanding of key issues in schools and in the community as well as their understanding of the role their own backgrounds played in their interactions with students and families. At the same time, these residents also felt less confident about their ability to generalize this knowledge to schools and districts outside of this city (Williamson et al., 2016). Both studies revealed that preparing teachers for the context of schools in urban settings is complex. On the one hand, widening the curricular focus in UTRs to include pervasive issues in American urban schools left residents feeling less prepared to navigate the specific urban school and district in which they were preparing to teach (Hammerness & Craig, 2016). On the other hand, narrowing the focus of UTR coursework specifically to one city hampered the residents' confidence that they can teach in any urban setting (Williamson et al., 2016).

These three studies revealed that the entwined and layered components of the context of urban schools and communities are central to UTR teacher preparation, and yet it is difficult to determine exactly how to approach this complexity in the coursework. In addition, these studies revealed that it is not enough to assume that if residents spend a long period of time in a particular school with the same mentor teachers, then they will learn what they need to know about teaching in urban schools generally. Furthermore, the research indicates that careful attention must be paid to how resident learning is facilitated not only during coursework, but also while working alongside classroom mentor teachers within the residency placement.

Relevance for this case study

Overall, this analysis of UTR literature revealed two issues. First, there are issues with mentors and/or mentoring across UTRs, such as a disconnect between mentor practices and UTR coursework and the struggle mentors have in trying to balance their responsibilities as teacher educators and role models, on the one hand, and K-12 teachers, on the other. The research on UTR mentoring has raised critical questions about the role and responsibilities of mentors that need to be examined in further research, namely: Do UTRs put too much stock in mentors to do the work of preparing residents to teach for urban school contexts? This question was taken up in this case study because I found the AMNH MAT's unique "senior specialist" role particularly valuable in preparing residents for teaching in urban schools. Senior specialists were faculty who act as teacher educators, advisors, coaches, and mentors, helping the residents negotiate what they are learning in their coursework at the museum with their work as residency teachers in New York City schools.

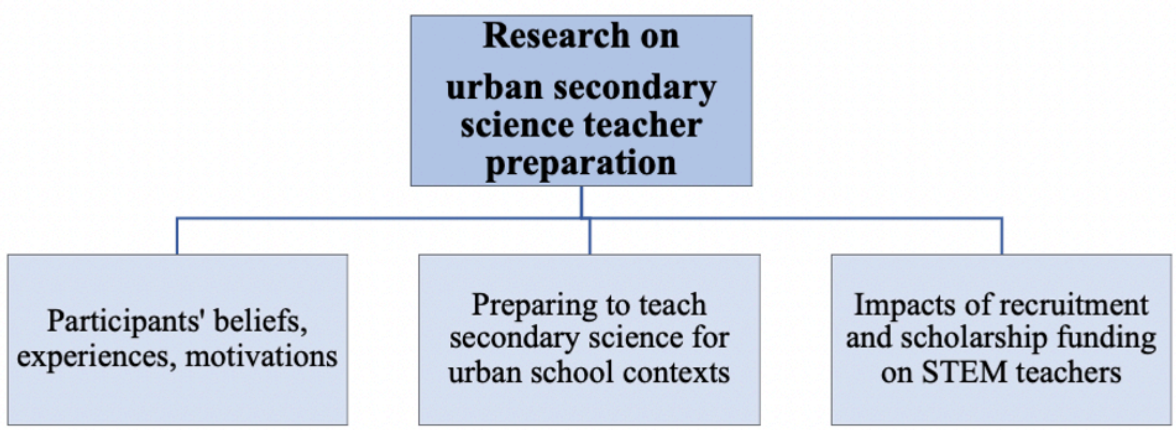
A second issue that this body of literature on UTRs revealed is that there is a dearth of research examining how and to what extent UTRs actually prepare residents for the context of urban schools, including not only the physical geography of the school, but also the heritages, cultures, norms, and life experiences of the faculty and students who make up school communities. Part of supporting prospective urban schoolteachers is helping them to understand and honor the various perspectives of students and to use these perspectives as frameworks for deeper class discussion and analysis. Beck (2016) rightly argued that "UTRs are responsive to context; therefore, more needs to be learned about how UTR programs operate in …different urban environments" (p.52). This case study responded to this, as it is an analysis of how and to what extent the only museum-based UTR in the world analyzed prepared its residents for the work of teaching in urban schools.

Research on Teacher Preparation for Urban Secondary Science

The second body of literature that informed the analysis in this dissertation is the research on urban, secondary (middle and high school) science teacher preparation. This research is relevant because, as I have described in a previous section, the AMNH MAT program prepared its residents to be Grade 7-12 earth science teachers for high needs schools in New York State. I organized these studies into three main groups according to the research questions posed (See Figure 5).

Figure 5

Major groupings within the literature on urban secondary science teacher preparation



The first group of research includes studies on the beliefs, views and experiences of teacher candidates, the beliefs, practices, and successes of first-year or early career science teachers, and the motivations of mentor teachers. These studies are grouped together because collectively, their central purpose is to understand the ways in which participants in urban secondary science teacher preparation programs shape and are shaped by their experiences in the learning to teach process. The second group of studies is comprised of research that focuses specifically on the context of teaching in urban schools, including teaching for diversity in general and teaching for emergent bilinguals/English language learners in particular. The third group of studies examined the impacts of scholarship funding on prospective science, technology, engineering, and mathematics (STEM) teachers in terms of their motivations and career paths. Despite the similarity of research questions, there was a subtle difference between the participants in the studies on the impacts of recruitment and scholarship funding and the participants in the first two groups of studies: scholars or fellows could have different motivations for learning to teach than other teacher candidates, since the former were recruited and funded to become teachers and the later sought out teaching as a profession in the first place. It is also useful to look these studies as a set because the AMNH MAT, which received National Science Foundation funding, also purposefully recruited its residents based on their prior science knowledge and their research.

Participants' Beliefs, Experiences and Motivations

The first group of studies about urban secondary science teacher preparation examined the beliefs, experiences, and motivations of participants. Researchers in this group generally outlined three main problems in urban science teaching. The first issue was that there are not enough STEM teachers who enter into and remain in urban schools (McDonald, 2017; Marco-Bujosa, McNeill & Friedman, 2020; Ng & Thomas, 2007, and; Osisioma & Moscovici, 2008). Though many agreed on this fact, researchers framed this problem differently. For instance, Marco-Bujosa et al. (2020) pointed to the larger issue that urban schools in general lose about 20% of their teachers each year, while Osisioma & Moscovici (2008) indicated that retention is an issue in part because there are fewer students pursuing math and science at the university level. Ng &Thomas (2007) homed in on the fact that while alternate route teacher preparation, out of necessity, is being relied on by more and more urban schools, suburban schools continue to enjoy a large pool of candidates from university-based teacher preparation for math and science teaching positions.

A second problem identified by the researchers of urban secondary science teacher preparation was that science teacher candidates need a greater understanding of and exposure to the diversity of most urban schools and classrooms (Flores, Claeys, Gist, Clark & Villarreal, 2015; Marco-Bujosa, 2020; Mark, Id-Deen & Thomas, 2019; Marri, Perin, Crocco, Riccio, Rivet & Chase, 2011, and; Mensah et al., 2018). Mensah et al. (2018) illustrated the "demographic imperative" (p.128) that exists in urban public schools: there is an increasing number of students of color and a majority white, female teaching force. Combined with the fact that most of these candidates are also primarily or only English speaking, Mark et al. (2019) argued that they also need to understand how they themselves are ethnically, socially and culturally positioned. What makes the demographic disparities even more problematic, is the fact that most teacher preparation programs do not offer a multicultural framework for teaching secondary science (Mensah, et al, 2018). Along related lines, Marco-Bujosa et al. (2020) argued that teacher preparation programs ought to be preparing science teachers to be social justice educators.

Flores et al. (2015) and Marri et al. (2011) argued that it is difficult for emergent bilingual students to acquire science knowledge. Flores et al. (2015) faulted teacher preparation programs, arguing that many secondary teachers feel underprepared in general to teach English language learners, which in turn negatively impacts their teaching. Marri et al. (2011) added nuance to this argument, pointing out that the high incidence of reading and writing issues in secondary classrooms thwarts the development of content knowledge and critical thinking, especially for ethnically and linguistically minoritized backgrounds (Marri et al., 2011), which could have “far-reaching consequences” (p.326), such as dropout rates, earning capacity as adults, for the lifespan of these vulnerable students.

A third research problem posed by these studies was that the science instruction in urban schools seems to privilege “school facts” or “school science” (Marco-Bujosa et al., 2020, p. 4) over inquiry-based science, informal science learning opportunities, and the application of science to the everyday lives of students. Furthermore, several studies indicated that a “pedagogy of poverty,” which has been generally characterized by rote learning and teacher-centered activities (Haberman, 1991) is prevalent in urban science classrooms. Researchers who identified this problem pointed out that this approach promotes “compliance and content knowledge over application and relevance” (Marco-Bujosa et al., 2020, p.28), excluding funds of knowledge (Brown, 2019; Moll, 1992) that students themselves bring to the classroom.

The studies about secondary science teacher education asked research questions that examined the views and experiences of pre-service science teachers, first year or novice teachers, and mentors. In general, these studies were interested in how participants in urban secondary science teacher preparation programs incorporated and enacted identities as teachers of social justice in their clinical experiences (Marco-Bujosa et al., 2020; Mark et al., 2019; Mensah et al., 2018). Other researchers asked questions about what made the first year of teaching successful in an urban context (Ng & Thomas, 2007), especially in terms of negotiating preservice teacher learnings and constructing instructional practices (Strom, 2015; Strom et al., 2018). Finally, researchers posed questions about what contributed to mentors’ motivation for participating in urban teacher preparation programs (Garza et al., 2018) and about which coteaching practices a preservice teacher carried over into their own teaching (Wassell & LaVan, 2009).

Most studies drew on sociocultural learning theory and constructivist frameworks, both of which are designed to unpack the ways in which people, learning, and environment interact. Some studies in this group also grounded their research in multicultural science teacher education (Mensah et al., 2015) and conceptualizations of social justice (Marco-Bujosa, 2020). Finally, some researchers drew on critical discourse analysis (Mark et al., 2019) and content-driven literacy (Marri et al., 2011) were employed to unpack programmatic structures such as rubrics and coursework.

All of the studies that used qualitative methods of research were interested in the perspectives of the participants in urban secondary science teacher preparation. Overall, a few studies used case study design (Jeanpierre, 2007; McDonald, 2017; Strom, Dailey, & Mills, 2018, and; Wassell & LaVan, 2009), which included methods of research such as: observations; semi-structured interviews; field notes from observing classrooms, from debriefing sessions, and from discussions among teacher candidate cohort groups; analysis of teacher journals, and; memo writing. Some studies primarily analyzed data such as responses and written reflections, lesson and unit plans, and class discussions (Mensah et al., 2018; Osisioma & Miscovici, 2008). The remaining studies included qualitative research design methods such as interviews with prospective teachers, teacher educators or program directors, observations both in teacher preparation programs and in urban classrooms, and document analysis (Marco-Bujosa et al., 2020; Mark et al., 2018, and; Strom, 2015).

Finally, a few studies employed a mixed-methods design. In addition to interviews and focus groups, for example, Flores et al.'s (2015) data collection included survey responses of teacher candidates both at the beginning and at the end of their time in the program, and analysis of archival program records to determine the extent to prospective math and science teachers' efficacy to teach English language learners was fostered. Another study relied on four different years of mentor surveys, studying the open-ended responses provided by the mentors, to determine their motivations for participation in an urban teacher residency (Garza et al., 2018).

The findings of the studies in this group overwhelmingly pointed to a need for urban science teacher preparation programs to pay more attention to culturally relevant approaches and practices, specifically in terms of what prospective teachers would actually experience in schools once they became teachers of record. For instance, both Mark et al. (2019) and Marco-Bujosa et al. (2020) found that although pre-service teachers were generally critical-minded and had an orientation towards social justice, they encountered structures in their schools that restricted their ability and confidence to be agents of societal change. Examples of these restrictive structures included: norms that emphasize student compliance, a standardized curriculum, and contradictory district policies (Marco-Bujosa et al., 2020). Additionally, Strom, Dailey, & Mills (2018) found that beginning teachers had to negotiate relationships with students while at the same time negotiating administrative demands, a lack of resources, and spatial issues (such as teaching physics in a non-science room) (Strom et al., 2018). On another note, both Jeanpierre (2007) and Mensah et al. (2018) found that while prospective urban science teachers believed in their students and worked to foster student voice, they struggled to identify examples of culturally relevant curriculum or transformative approaches when asked.

Flores et al. (2015) and Marri et al. (2019) examined the incorporation of literacy teaching in science classes. Flores et al. (2015) suggested a framework for preparing culturally efficacious mathematics and science teachers that involves an "iterative cycle: (a) awakening cultural consciousness, (b) acquiring cultural competence, (c) developing cultural proficiency, (d) actualizing cultural and critical responsivity, and (e) realizing cultural efficacy" (Flores et al., 2015, p. 26). Marri et al. (2011) found that using a content-driven literacy approach "can convince preservice teachers of the significance of literacy to teaching their disciplines and can provide them with strategies they find effective in enhancing their own students' performance in acquiring content knowledge" (Marri et al., 2011, p. 343).

Studies that focused on the motivations and experiences of mentors in urban secondary science teacher preparation programs revealed that new urban secondary science teachers felt a sense of preparedness because of the practices learned from their mentors and because of the relationships they developed. Wassell and LaVan (2009) found that "cogenerative dialogue," or critical conversations about classroom occurrences, and the co-teaching that occurred between mentors and their prospective teachers proved useful structures on which to build their own teaching practices and dialogues with students. Garza et al. (2018) found that mentors had a "selfless desire to help aspiring teachers" (p. 233), but they did not always address ways to improve their own practice for the future.

Rodriguez (2015) suggests that teacher preparation programs create a conundrum for novice teachers. His words serve well to sum up the findings of this group of studies on the beliefs, experiences, and motivations of participants in urban secondary science teacher preparation: "We prepare them to become culturally sensitive and social constructivist teachers, but teacher graduates often find themselves in contradictory contexts in which they attempt to implement what they learned with limited resources" (p. 453). The findings of these studies suggest important directions for the improvement of urban secondary science teacher preparation programs. The studies suggest that there needs to be more attention to helping prospective teachers develop the tools, strategies, and approaches needed to not only to engage in culturally relevant classroom practices and to create curriculum that is committed to social justice. But programs also need to prepare their teachers to push against systems of oppression that they may encounter in their respective school and district contexts.

Preparing to Teach Secondary Science for Urban School Contexts

The second group of studies within the larger category of research on urban secondary science teacher preparation generally asked research questions about how teacher preparation programs prepare prospective secondary science teachers for the particular context of urban schools. In general, these researchers tended to conceptualize science education as a civil rights issue (Barton 2002; Tate 2001). In fact, in their conceptual piece about urban science teacher preparation, Ash and Wiggan (2018) captured the general assumption held by this group of studies: “Using science as a catalyst for teaching about diversity has the potential to unravel misconceptions about race and ethnicity by systematically addressing fundamental aspects of our shared humanity, as well as [to] evoke critical questions about the social and historical discourse of diversity in education” (p. 111).

The studies in this group problematized the lack of quality science teachers in urban schools as an injustice to young people (Ash & Wiggan, 2018; Jablon, 2012, and; Tobin, 2006). Researchers argued that there was an issue with teacher effectiveness in general (Furman, Barton, & Muir, 2012) and also with teacher preparedness for serving youth in poverty and minoritized youth in particular (Furman et al., 2012; Garza, Duchaine & Reynosa, 2013; Heineke, Smetana & Carlson Sanei, 2019). Ash and Wiggan (2018) suggested that part of the problem with “low-quality instruction” (p. 95) in urban secondary science classrooms had to do with a gap in the research; particularly in the area of how science can help facilitate meaningful conversations about human diversity. Tobin, Roth and Zimmerman (2001) asserted that factors such as inadequate funding, teacher shortages, lack of resources, and high proportions of students living in conditions of poverty contributed to the difficulty of retaining quality science teaching in urban schools.

Taking a different perspective, Rivera Maulucci (2013) pointed out that one main problem with becoming a quality urban science teacher is that this job itself is “fraught with emotional ambivalence” (p. 453). Prospective teachers experience systemic injustices which might anger them and make them feel powerless when confronted with navigating their own positionalities and identities as burgeoning social justice educators. According to Rivera Maulucci (2013), part of being a quality urban science teacher involves working to understand the impact of systemic oppression on urban students and then learning to create productive spaces of learning for promoting agency within young people to disrupt these systems (p. 456).

Finally, Jablon (2012) took aim at science education research itself, arguing that many science education studies are not useful for practicing urban science educators, who every day face the “emergency nature of the situation” (p. 222). He argued that this was the case because they are mostly conducted by science teacher educators who have not themselves spent much time as urban science teachers.

In terms of research questions, this group of studies was primarily concerned with understanding the extent to which teacher preparation programs were meeting the needs of STEM teachers in general (Garza et al., 2013). Particularly, studies asked questions about how colleges of education could better prepare teachers of social justice (Furman et al., 2012; Rivera Maulucci, 2013). Other studies asked questions about ways to better develop pedagogical strategies for teaching emergent bilingual students in urban secondary science classrooms (Heineke et al., 2019; Naiditch & Selinker, 2017). Ash and Wiggan (2018) framed their literature review around questions about the role of science teaching and science teacher preparation in teaching diversity in urban schools.

The research designs in this group of studies were overwhelmingly qualitative case studies intended to examine transformative action and social justice in the teacher preparation curriculum and to inform practices for teaching emergent bilingual students (Furman et al., 2012; Heineke et al., 2019; Naiditch & Selinker, 2017; Rivera Maulucci, 2013, and; Tobin et al., 2001). Garza et al. (2013) used mixed methods design by conducting online surveys three times over the course of two years to determine which aspects of a teacher preparation program contributed to the development of its aspiring teachers.

The findings from this group of studies suggested several areas where urban secondary science teacher preparation could improve. The first area for improvement involves restructuring programming to include ways for prospective urban secondary teachers to see themselves as teachers of literacy, science, and culture. For instance, Naiditch and Selinker (2017) noted that "the problem is that content area teachers, novice and experienced, do not generally see themselves as language teachers" (p. 444). Rivera Maulucci (2013) argued that urban science teachers need to develop a "positional identity" that is critical of their current school environment and that also assists in their development of their own personal vision of good teaching (p. 475).

The research in this category also pointed to the lack of fusion of informal science learning into the formal science classroom. Heineke et al.'s (2019) findings suggested that "teacher educators should go beyond adding a stand-alone, university-based course and instead reconceptualize holistic programs with authentic field experiences to apprentice teachers into inclusive teaching of emergent bilinguals in science classrooms" (p.9 5). Researchers pointed to informal science environments such as museums, aquariums, and zoos as rich, low-risk opportunities for emergent bilingual students to learn the English language and science at the same time.

A final improvement to urban science teacher preparation suggested by the research findings of the studies in this group was the need to tighten the relationship between coursework and fieldwork. For example, Furman et al. (2012) found that prospective teachers ought to be "allowed to propose innovations" (p. 170). In other words, prospective teachers need opportunities to try out their "crazy ideas" in a setting of "distributed expertise" (Furman et al., 2012, p. 170) such as in a mentor's classroom, in order to gain confidence and to see possibility in their own learning as well as in the learning of their students. Tobin (2006) and Garza et al. (2013) both argued for greater attention to the connection between what candidates learn from their mentors and what these novices learn in their coursework. Tobin's (2001; 2006) concept of "cogenerative dialogue," which primarily occurs between mentors and prospective teachers, is a way to expand the agency of all the participants (of the learning to teach process) and to improve the quality of learning environments.

Impact of Recruitment and Scholarship Funding on STEM Teachers

The third group of studies within the larger category of research on urban secondary science teacher preparation had to do with the impact of recruitment and scholarship opportunities on prospective STEM teachers. Most of the participants in these studies had received National Science Foundation (NSF) funding in general or Noyce scholarship funding in particular. Taken as a given by most of these researchers was the fact that there is a shortage of math and science teachers in school districts "with a large proportion of students from low-income or poor households" (Ganchorre & Tomanek, 2012, p. 88).

The research problem that these studies tended to address was the lack of attention in science teacher preparation to teaching diverse populations (Ganchorre & Tomanek, 2012; Liou et al., 2010), especially in terms of teaching English language learners in the science classroom (Bayne et al., 2018). Equally as problematic for these researchers was the concern that the deficit-based perspectives that permeate urban schools could thwart preservice and in-service teacher success (Christodoulou et al, 2009; Bischoff et al., 2014). Expounding on this point, Ganchorre and Tomanek (2012) assumed that "teacher training opportunities to develop positive perspectives about students from diverse backgrounds can enhance prospective science and mathematics teachers' success in teaching students from a wide range of backgrounds and experiences" (p. 89).

Most of the studies in this group asked research questions that were intended to uncover the influence of the Noyce Program on scholarship recipients' in terms of initial commitments to education (Liou et al., 2010), the effect of the field experience component within the teacher preparation program (Bischoff et al., 2014), and the growth of Noyce scholars compared with prospective math and science teachers in other teacher preparation programs (Bayne et al., 2018; Saxman et al., 2010). One study in this group was interested in understanding Noyce scholars' motivations to teach in under-resourced districts (Ganchorre & Tomanek, 2012). Another was interested in how the orientations and experiences of prospective teachers related to their actions in the classroom (Christodoulou et al., 2009).

About half of the studies were qualitative, and the rest were either quantitative or used a mixed-methods design. In terms of the qualitative studies, the conceptual frameworks used to look at the data were generally concerned with notions of beliefs, experiences, and motivations of the scholars or fellows. One interesting pattern in these qualitative studies is that none of them used observation data as part of their research design. Instead, documents such as journal entries (Christodoulou et al., 2009), questionnaires and personal statements (Ganchorre & Tomanek, 2012), and reflective essays (Bischoff et al., 2014) were central data sources. Ganchorre & Tomanek (2012) also employed interviews and focus group discussions.

The quantitative studies used varied data source. For instance, to learn about 555 past and current Noyce scholars, Liou and colleagues (2010) utilized a large-scale survey with multiple components, ranging from topics such as "decision to become a teacher" to others such as "program character and experience." Saxmen et al. (2010) used standardized assessments, open-ended assessments, and classroom performance observations write-ups to document the growth of the fellows as they proceeded through the program. Finally, Bayne et al. (2018) used mixed-methods design by surveying Noyce scholars, examining data such as GPA, gender, and academic achievement as well as by conducting focus groups and analyzing videotaped lessons to compare Noyce scholars' academic outcomes with their counterparts from another science teacher preparation program.

A trend in the findings of these studies is that an initial disposition toward teaching for social justice mattered in the success and confidence of prospective urban science teachers. To this end, implications of the studies showed that scholarship programming designed for teacher preparation in STEM should provide ample opportunities for prospective teachers to build on their identities as agents of change during their preparation. According to Bischoff et al. (2014), "we know from the literature that successful high-need urban science teachers appear to have high levels of self-efficacy toward what they can accomplish as science teachers in high-need urban schools and that they embrace the cultures of the schools' pupils" (p. 47). Similarly, Ganchorre and Tomanek (2012) found that recruiting STEM teachers who have "dispositions of care and compassion can be starting points to assist teacher educators in promoting [Noyce] Scholars' success working with diverse students, regardless of Scholars' backgrounds and experiences" (p. 105). Regardless of whether or not scholars themselves identified as attending a high needs school, all of them felt that they could contribute to the life chances of the young people with whom they worked. Liou et al. (2010) concluded that scholarship program recruitment and preparation should foster commitment to high needs schools.

Finally, studies that compared Noyce scholars with prospective STEM teachers from other programs without funding found that overall, Noyce scholars were better prepared and felt that they had an advantage over their counterparts (Bayne et al., 2018). Comparing two teacher preparation programs in New York City, one with funding and one without, Saxmen et al. (2010) found that Noyce scholars outperformed their peers in terms of standardized testing as well as their ability to engage and assess students.

In conclusion, a main finding in this group of studies was that the social justice orientations of prospective urban STEM teachers matters a great deal in terms of how they see themselves as beginning teachers and, more importantly, in terms of the kind of work they believe they can accomplish with urban youngsters. While the implications of this body of research are most directly applicable to NSF or Noyce-funded teacher preparation programs, or to other funding structures like this, the message is clear for all urban secondary science teacher preparation programs: fostering an identity as teachers of social justice impacts the pedagogies and practices of prospective urban science teachers.

Relevance for this case study

Together, the studies in this group suggest that urban science teacher education needs to be revised to include greater attention to preparing science teachers for understanding the context of urban school contexts and communities. This finding echoes that of the literature on UTRs, which revealed a dearth of research on understanding how and to what extent UTR pedagogies, practices, and programming incorporate the cultures, communities, and contexts of urban schools.

This body of literature also pointed to a need for prospective urban teachers of secondary science to explore their own positionalities, to learn how to embrace the knowledge and assets of their students, and to learn how to be change agents in the sociopolitical arena of urban public schools. For instance, Marco-Bujosa et al.'s (2020) study yielded two important insights into how teacher preparation programs can better prepare and support future science teachers for the political work of urban teaching: 1) they can include political clarity and ways to help prospective teachers understand teacher activism and 2) they can provide induction support that is centered on continued reflection and collective action. Mensah et al. (2018) argued for a specific change in science teacher education: multicultural education and culturally relevant teaching approaches to be infused in science methods courses as a means of closing educational gaps when working with teachers who service diverse populations.

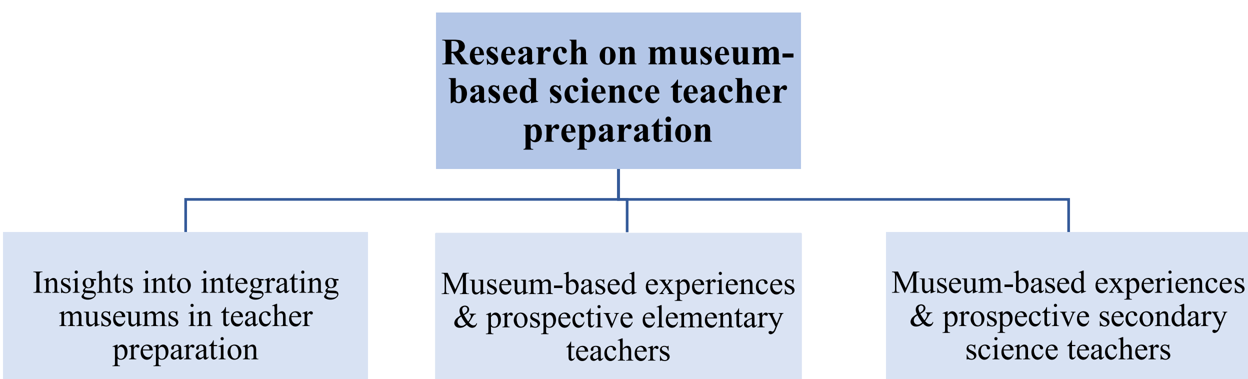
The insight of this body of research on urban secondary science teacher preparation was helpful in understanding the AMNH MAT's laser-focus on preparing residents for the work of teaching earth science in grades 7-12 New York urban and high-needs classrooms. My case study of the AMNH MAT addressed some of the questions raised here in Chapter 6. where I outline my analysis of the programming, pedagogies, and practices of the MAT program that are useful and that might also require more emphasis in terms of its preparation of candidates specifically for urban schools.

Research on Museum-Based Science Teacher Preparation

The third body of literature that informed this dissertation is museum-based science teacher preparation. Among other places such as zoos and aquariums, museums are considered informal science learning institutions, which Adams and Gupta (2017) defined as "places that convey complex science ideas and phenomenon through non-traditional and engaging ways" (p.121). Interestingly, some of the researchers in this category were founders, leaders, or early contributors to the AMNH MAT program, and therefore some of the assumptions of this research are very much in line with the assumptions of the museum's MAT program. This body of literature can be organized into three groups. (See Figure 6).

Figure 6

Major groupings within the literature on museum-based science teacher preparation



The first group consists of studies that analyzed the value and sustainability of museum-university partnerships (Avraamidou, 2014a; Gupta et al., 2010; Macdonald et al., 2008). The second group is studies that analyzed museum-based experiences in elementary teacher preparation, particularly in terms of content knowledge gained (i.e., Kelly, 2000) or awareness of the value of informal science learning (i.e., Çil et al., 2016). The third group of studies examined museum-based course requirements on prospective secondary teachers of science at universities (i.e., Kreuzer & Dreesmann, 2017).

Insights into Integrating Museums in Teacher Preparation

The following three conceptual and descriptive studies are grouped together because they offer important insights about the value of infusing learning in informal science environments into science teacher preparation. Avraamidou's review of literature (2014a) argued that informal science learning ought to be included in elementary teacher preparation for two reasons: to help shape positive orientations towards science and science teaching and to support teacher candidates' development of "reform-minded science teaching identities" (p. 839), which referred to new policies that placed special emphasis on scientific inquiry in the curriculum (National Research Council, 2012). Avraamidou (2014a) argued that informal science environments are "well-positioned" to help prospective teachers of elementary science tackle reform recommendations because they are motivating and interesting, safe and non-threatening, and resource-rich and inquiry-based (p.840).

Gupta et al. (2010) examined the historical and cultural context of teachers, teacher educators, and museum educators in terms of the different goals of each group when it comes to preparing science teachers as well as their shared goal of providing enriching learning experiences for young people. These researchers argued that while museum-university partnerships hold great power to strengthen science teacher preparation, each institution has its own historical presence in society as well as its own set of cultural values and beliefs (Gupta et al., 2010), which means there is a need to address "the tensions related to maintaining an institution's identity while still serving the needs of the larger society" (p. 698).

Finally, in a descriptive article, Macdonald et al. (2008) explained the Teacher Renewal for Urban Science Teaching (TRUST), a National Science Foundation-funded partnership between the AMNH and Brooklyn and Lehman Colleges of the City University of New York. TRUST, launched in 2003, was a four-year program based on the assumption that metropolitan areas like New York City simultaneously have large scientific institutions and "science-impoverished classrooms" (Macdonald et al., 2008, p. 269). One goal of TRUST, just as with the current AMNH MAT, was to increase the number of certified earth science teachers in New York City schools. Overall, preliminary evaluation of TRUST revealed that it attained its objectives and "effectively respond[ed] to many of the recommendations made in national reports and the professional literature that call for science education reform," making TRUST "a model worthy of replication" (Macdonald et al., 2008, p. 278-279).

Museum-Based Experiences and Prospective Elementary Teachers

The second group of studies within the broad category of museum-based science teacher preparation has to do with the influence of museum experiences on prospective elementary science teachers, especially in terms of their becoming more confident in teaching science content and applying constructivist-oriented, inquiry-based approaches to their pedagogy and instruction. Many studies were concerned with how to improve the content and pedagogical knowledge of prospective elementary teachers (Clarke-Vivier & Bard, 2019; Dawborn-Gundlach et al., 2017; Jung & Tonso, 2006; Kelly, 2000, and Ramey-Gassert, 1997) while others focused on preparing prospective teachers to facilitate and incorporate informal science learning in the formal setting of the classroom (Çil et al., 2016; Harron et al., 2019; Kisiel, 2013; Morentin & Guisasola, 2015; Olson et al., 2001, and; Tasdemir et al., 2014).

The research problem constructed by these studies involved the tension between the push for reform in science education to deepen the content knowledge and the inquiry-based experiences of K-12 students, on one hand, and the didactic, "prevailing, transmissive pedagogy" (Dawborn-Gundlach et al., 2017, p. 215) that prospective elementary teachers were likely to have experienced during their own schooling, on the other hand. In other words, elementary teachers were being asked to engage in teaching activities unfamiliar to them in a content area they were also unsure of. Science instruction was also seen as irrelevant: Ramey-Gassert (1997) cited Wellington (1990) and argued that "science as it is presented in schools bears little resemblance to the natural world where science and technology are everywhere" (p. 433). Taken together, science curriculum and instruction was seen as disconnected from the lives of students.

These researchers assumed that informal science environments were places of promise for elementary teacher preparation, especially because curriculum can be reimagined in collaboration with museum educators and scientists (Clarke-Vivier & Bard, 2016; Dawborn-Gundlach et al., 2017; Morentin & Guisasola, 2015; Olson et al., 2001, and Tasdemir et al., 2014). It was also assumed that museums could provide "immersive experiences" (Dawborn-Gundlach et al., 2017, p.215) with scientists and museum educators who have "deep-seated science expertise" (Jung and Tonso, 2006, p.18). Jung & Tonso (2006) argued that science museums are places where deep, authentic and creative learning can be cultivated in elementary students. Museums were also thought to be low-stakes places of learning because they are generally not attached to grades or standardized assessments (Ramey-Gassert, 1997; Tasdemir et al., 2014).

Finally, while there is little argument that informal science institutions are places of possibility for young learners as well as prospective and practicing teachers, the researchers in this category also believed that museums were often overlooked by elementary teachers (Ramey-Gassert, 1997) due to time constraints, lack of exposure, and logistical obstacles (Çil, et al., 2016; Kisiel, 2013; Morentin & Guisasola, 2015, and; Olson et al., 2001). Taken together, the general purpose of this group of studies, then, was to examine the integration of museum-based experiences in elementary teacher preparation methods courses.

These studies examined the impact of out-of-school learning experiences for prospective teachers, including experiencing science community learning activities, facilitating and organizing virtual and in-person field trips, and organizing events at museums for K-12 students. Some articles also analyzed the importance of university-museum partnerships and the impact of science methods courses that included geoscience “immersion experiences” (Dawborn-Gundlach et al., 2017, p.215). To conduct these analyses, about half of these researchers conducted mixed-methods empirical research. For instance, Kelly (2000) conducted interviews, analyzed course assignments, and used pre- and post-tests to determine content knowledge and pedagogy as well as supplemental questionnaires on attitudes towards teaching science, confidence in teaching ability, and understanding of pedagogical knowledge and teaching strategies from nine science methods courses over four years. Other studies used pre- and post- testing to, for instance, to understand how pre-service teachers used virtual reality experiences when teaching science (Harron et al., 2019) and to determine whether or not prospective teachers’ awareness of community science resources changed after engaging in museum-based learning (Kisiel, 2013).

Other researchers used mixed-methods approaches differently. In addition to interviews and observations, Jung and Tonso (2006) observed and distributed surveys to discover what prospective teachers learned about teaching science. Dawborn-Gundlach et al. (2017), interested in the impact of a new museum-university course in their preparation program, conducted surveys, held focus groups and interviews, and observed 9 teacher candidates from two universities and Museum Victoria in Australia. Other researchers employed similar methods, including statistical analysis (Kisiel, 2013), surveys (Tasdemir et al., 2014), and coding of responses on pre- and post- testing (Kisiel, 2013; Harron et al., 2019, and; Morentin & Guisasola, 2015), primarily aimed at understanding pre-service teachers' view and understandings of their experiences with learning and teaching in museums. Other studies used qualitative methods such as focus groups, interviews, and coding of open-ended questionnaires or self-reflections (Çil, et al., 2016; Olson et al., 2001) to determine the impact of science learning experiences on prospective teachers. Clarke-Vivier & Bard (2016) and Morentin & Guisasola (2015) took a descriptive approach, explaining the collaboration of partnerships between their respective universities and with local museums.

Ramey-Gassert's (1997) oft-quoted review, which analyzed the literature on science learning in informal science education programs, offers a summary of the findings of this group of studies:

> There is a vast amount of fertile ground to be broken as staff of informal science centers, [professional development school] teachers and students, science educations, and university faculty discuss possibilities for change. Partnerships between schools and community resources can also increase students' and teachers' motivation to learn and teach science and provide means for engaging hard-to-reach students using relevant, realistic museum materials and settings. (p. 448)

Tasdemir et al. (2014) agreed, adding that out-of-school experiences with science are especially important for "disadvantaged students," who might not get experiences to explore and engage with science elsewhere. This call for meaningful partnerships between museums and universities has held sway in both subsequent research efforts and in teacher education programming (Macdonald et al., 2008; Saxman et al., 2010), making this an important message for museum educators and science teacher educators.

The remaining studies in general all found that prospective elementary teachers had much to gain by the incorporation of museums in their learning to teach process. Specifically, Kelly (2000) found that after prospective elementary teachers were encouraged to both learn and teach in an informal science environment, they were encouraged and "liked the learning centres because [they] were able to plan, prepare, and present their centres to elementary students" (p. 767). Similarly, Clarke-Vivier & Bard (2016) found that when prospective elementary teachers taught several different groups of elementary students in a one-day Earth Day experience at a local museum, this provided a diverse, authentic experience to increase their knowledge and to foster the idea that museums are great places for science learning and a "valuable part of local educational ecosystems" (p. 310).

Arguing that "the laboratory of geoscience is in the field" (p. 217), Dawborn-Gundlach et al. (2017) reimaged the curriculum of prospective elementary teachers at 2 universities in Melbourne, Australia by including a course called *Reconceptualising Rocks*. After spending two days in the field and in the museum collecting and observing specimens and engaging in enriching and exploratory activities, teacher candidates reported that they found the trips valuable because they learned to communicate science ideas and practices. Jung & Tonso (2006) found that teacher candidates characterized science museum settings as positive places to learn in a non-threatening environment. These prospective teachers also felt that they gained scientific knowledge, learned additional teaching strategies, and built their confidence to teach science (Jung & Tonso, 2006). Çil et al. (2016) found that half of the teacher candidates they studied realized their lack of science content knowledge after engaging in teaching and learning experiences at Mugla Museum in Turkey. In a large urban university in California, Kisiel (2013) analyzed the influence on prospective elementary teachers when they were required to participate in three community learning experiences, such as an open house at a science center or an aquarium lecture series. Teacher candidates who participated in this community-based learning assignment generally came to see the utility and possibility of such institutions in the teaching of science.

Overall, this group of studies made the argument that informal science learning opportunities during elementary teacher preparation can improve prospective teachers' confidence in teaching science, can deepen their content knowledge, and can help them conceptualize ways to teach science that involve the community around them (Kisiel, 2013), particularly trips to museums (Morentin & Guisasola, 2015). Not only are museums "nonevaluative, stimulating places to explore knowledge about the world that science and technology have generated (Ramey-Gassert, 1997, p. 448), but they are places where teachers and their young students can interact with science and with scientists in ways that are exploratory, personal, and authentic.

Finally, this group of studies called for the examination of museum-university partnerships to be "long-term" and "ecological" (Clarke-Vivier & Bard, 2016, p. 313), and an opportunity to reinvigorate earth science programming for prospective elementary teachers (Dawborn-Gundlach, 2017). Kisiel (2013) argued that, "Direct engagement at these community sites…provided a meaningful experience needed as part of a conceptual change" (p.85). In other words, future elementary science teachers transformed their perspectives on teaching science when they had experiences in institutions outside of the university, making them more inclined to incorporate the vast science resources of the community (Kisiel, 2013).

Museum-Based Experiences and Prospective Secondary Science Teachers

This group of studies on museum-based science teacher preparation focused on how and to what extent prospective secondary science teachers were influenced by museum-based experiences during their preparation. All of these studies posed research questions about teacher candidates' experiences with science museums or natural history museums in their respective methods courses. These studies also collectively constructed their research problem similarly to the elementary-level studies in terms of the following assumptions: out-of-school learning settings are important and well-respected educational resources (Kreuzer & Dreesmann, 2017) that are often too peripheral in the learning to teach science experience (Chin & Tuan, 2000; Chin, 2004) and; the traditional, lecture-based approach to teaching science doesn't work for science teacher candidates, who report having weak subject matter knowledge (Hsu, 2016). These studies also generally believed that teachers are life-long learners who provide challenging opportunities for their students to learn science (Adams & Gupta, 2017; Chin & Tuan, 2000; Chin, 2004, and; Gupta et al., 2016).

The studies in this group also generally raised two issues for beginning teachers of secondary science: (1) the first year of teaching is very difficult (Hsu, 2016), especially because many secondary science teachers are required to teach content outside of their expertise, and (2) new secondary science teachers are asked to incorporate out-of-school, informal experiences into their formal classroom settings without having much- or any- training to do so (Kreuzer & Dreesmann, 2017). In general, the purpose of these studies was to investigate prospective secondary science teachers' experiences with and reflections on learning and teaching in museums. Kreuzer and Dreesmann (2017) were also interested in evaluating optional coursework for prospective biology teachers to familiarize them with out-of-school settings, especially exhibits and collections at two different natural history museums. Gupta et al. (2016) and Adams and Gupta (2017) were particularly interested in how prospective teachers leveraged the affordances of the AMNH to develop an identity "of not just schoolteacher, but a teacher of science, one that crosses boundaries of teaching in both formal and informal spaces" (p. 178).

In terms of the research designs of the studies in this group, mixed-methods design and qualitative methods were used. For the mixed-methods studies, pre- and post-tests, questionnaires, and analysis of course assignments were used to analyze the influence of museum-based experiences on pre-service teachers' perceptions of teaching science and to determine whether or not content knowledge improved (Chin & Tuan, 2000; Chin, 2004, and; Kreuzer & Dreesmann, 2017.) These studies also conducted interviews and observations, collected documents and written work to understand how candidates were developing lessons and what they learned from that experience (Chin & Tuan, 2000; Chin, 2004; Hsu, 2016, and; Kreuzer & Dreesmann, 2017). Gupta et al. (2016) and Adams and Gupta (2017) used qualitative methods such as observations, semi-structured conversations, online posts and field notes to examine how AMNH MAT residents gained identity and agency as teachers of science.

Taken together, the findings of the studies in this group generally revealed that when prospective teachers of secondary science have exposure to learning in science museums, their content and pedagogical knowledge is improved, they see the value of informal science institutions, and they begin to form identities as teachers of science. This is partly true because museums are disconnected from the high-stakes accountability measures generally present in schools. But credit for teacher candidate success is also given to the curation of the exhibits, the lectures and tours by the museum educators and scientists, and the educational resources of museums.

For instance, Hsu (2016) studied a group of 21 prospective teachers from a university in south-central United States as they designed and implemented a lesson for "Science Circus Days" at a nearby museum. This study found that "teaching in an informal setting naturally motivated the preservice teachers to conduct rigorous preparations before implementing their lesson plans" (Hsu, 2016, p. 1220). These candidates also reported that they felt their content knowledge improved due to extensive preparations for presenting to many students throughout this multi-day experience. Kreuzer and Dreesmann (2017) found that teacher candidates were curious about and engaged in the science learned at museums, and they wanted to teach their students this content as well. Overall, these prospective secondary science teachers "gained background knowledge about museums and the use of their collections and felt more confident using these institutions to teach science in the future" (Kreuzer & Dreesmann, 2017, p.669). Finally, Chin and Tuan (2000) and Chin (2004) found that through developing a lesson plan that incorporated learning at the National Museum of Science in Taiwan, prospective teachers gained content and pedagogical knowledge because they focused on core concepts related to the exhibits chosen for developing the lesson plan, and were able to elaborate on their lesson by integrating educational resources from the museum that were unfamiliar to them before this experience (Chin & Tuan, 2000; Chin, 2004).

Gupta et al. (2016) and Adams and Gupta (2017) found that AMNH MAT residents gained confidence the more they interacted with young people and museum patrons during their residency experiences. Gupta et al. (2016) linked residents' burgeoning teacher identity with the AMNH MAT's requirement that they interact with patrons as they work on carts throughout the halls of the museum: “As the residents are successful with visitor interactions, they are seen as a certain kind of a person by their peers and by visitors, a person who knows how to teach science. Over time, they begin to see themselves as successful teachers of science, and this mediates changes in their identities” (p. 182).

Relevance for This Case Study

This body of literature generally revealed that incorporating museum-based learning experiences in elementary and secondary science teacher preparation increased the content and pedagogical knowledge of prospective teachers, demystified the preparation and organization necessary to incorporate informal science learning in formal school settings, and overall contributed positively to conceptualizing ways to teach science that are authentic and that promote curiosity and creativity in both prospective teachers and K-12 students. Gupta et al. (2010) raised concerns about massive institutions such as museums and universities partnering without first exploring their respective histories, missions, and cultures. Macdonald et al. (2008) made the case that museums and universities have the power to impact critical shortages in science teaching, especially if they work together and take a “problem-centered rather than an institution-centered approach” (p. 278). In a way, this dissertation examined the role that the mission of the AMNH played in the formation and sustaining of the MAT program. This analysis contributes to the current literature on museum-based science teacher preparation because it considers the assumptions of MAT program leaders, faculty, and residents in light of the larger institution’s central values and links these values with program conceptualization and enactment.

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This dissertation examines the AMNH MAT as it sits at the intersection of four phenomena: nGSEs, UTRs, urban secondary science teacher preparation, and museum-based science teacher preparation. In particular, the AMNH MAT is situated in the two larger contexts of nGSEs and urban teacher preparation. All three of the bodies of literature analyzed above informed my case study analysis in important ways. Because this dissertation is an examination of the way in which AMNH MAT prepared science teachers are prepared for urban schools, it is noteworthy that the research examined for this review revealed a need for prospective teachers of secondary science to deeply understand the complexities and possibilities of urban school contexts in general, and in particular to understand that being teachers of science provides ample opportunities to be agents of change and to foster agency within young people.

Both the research on UTRs and the research on urban secondary science teacher preparation pointed to the need for a greater understanding of the role of mentors and mentoring in urban teacher preparation programs, where mentors are heavily involved in the learning to teach process. Greater empirical insight is needed to understand how teacher educators, mentors, and prospective teachers make meaning of urban school contexts and the opportunities students from diverse backgrounds bring to the curriculum. This case study of teacher preparation at the AMNH MAT sheds light on the unique role of "senior specialist," who are PhD level science teacher educators acting as brokers for the residents, helping to bridge the science content and pedagogical knowledge learned at the museum with the practical learning in the classroom through extensive on-site advising and coaching. As I point out in Chapter 5, the senior specialist role in many was crucial to deepening the connections and learning of the MAT residents.

The literature on museum-based science teacher preparation revealed the multiple benefits of informal science environments not only on the learning to teach process, but also for K-12 students and teachers. This dissertation offers a fresh perspective on urban science teacher preparation because it analyzes how teacher preparation at the AMNH MAT is uniquely conceptualized and carried out at the nexus of a sharp emphasis on informal science learning and a singular focus on preparation for urban secondary science classrooms.

Finally, this dissertation contributes to all three bodies of literature because it uncovers the extent to which AMNH MAT programming and the faculty who organize and facilitate it do the work of preparing teachers for the students and schools of urban communities in service of museum goals and ideals. Particularly, this study analyzes how prospective teachers and program graduates are socialized into teaching specifically for the context of urban schools and secondary classrooms.

CHAPTER THREE

Research Design and Methods

In this chapter, I present the research design and methods for this descriptive and interpretive qualitative case study. Thus far, I have made explicit the goals of this study and the goals of the larger study of which it is a part. Maxwell (2005) points out that "goals serve two main functions in your research…to guide…other design decisions to ensure that [the] study is *worth* doing…[and] they are essential to *justifying* your study." The goals of this study justify that qualitative research design and methods are the most appropriate because, at its essence, this is a study about how people perceive and engage with a particular construct, learning to teach, in a particular teacher preparation environment—that is, a world-renowned museum and New York City secondary schools. According to Erickson (1986), "interpretive research maintains that causal explanation in the domain of human social life cannot rest simply upon observed similarities between prior and subsequent behaviors…Rather, explanation of cause in human action must include identification of the meaning-interpretation of the actor" (p. 127). Similarly, Miles, Huberman and Saldaña (2014) point out that qualitative data are "fundamentally well suited for locating the *meanings* people place on the events, processes, and structures to their lives and for connecting these meanings to the *social world* around them" (p. 5-6, original emphasis). Taking Erickson and Miles and colleagues together suggests that interpretive, qualitative research is the approach best suited for this study.

Specifically, applying qualitative case study design is useful because, according to Becker (1998), case study research is intended to create

> a rich dialogue with the evidence, an activity that encompasses pondering the possibilities gained from deep familiarity with some aspect of the world,

systematizing those ideas in relation to kinds of information one might gather, checking the ideas in light of that information, dealing with the inevitable discrepancies between what was expected and what was found by rethinking the possibilities of getting more data, and so on. (p. 66)

Finally, Erickson (1986) points out that "the primary concern of interpretive research is particularizability, rather than generalizability" (p. 130). Stake (2006) corroborates this claim, adding also that the power of case study research is in "its attention to the local situation, not in how it represents other cases in general" (p. 8). Along these same lines, this descriptive and interpretive case study has been carefully and specifically designed to offer a rich, contextual understanding of the "real life context" (Yin, 2018) of the project of learning to teach at the AMNH MAT based on multiple perspectives and experiences.

Case Study Research

As explained earlier, this dissertation is part of a larger study of teacher preparation at nGSEs. In line with the other three cases of teacher preparation at nGSE sites, this dissertation is a descriptive and interpretive qualitative case study (Stake, 2006; Yin, 2018). When deciding on case study as a design approach to research, it is important to have a clear definition of "case study" itself, because, as Stake (2006) points out, "Here and there, researchers will call anything they please a case study" (p. 8). Similarly, Schwandt and Gates (2017) argue that beyond the general understanding that a case study is "in-depth" and centers "real-life contexts," "it is a fool's errand to pursue what is (or should be) truly called 'case study'" (p. 604) because there are so many interpretations and ways of conducting research in this manner.

First there is the concept of "case" that requires clarification. Schwandt and Gates (2017) recast Ragin's (1992) argument that "cases" are either "empirical units," which are "more or less already 'out there,' and can be considered *found,* or they are "theoretical constructs," serving the interests of the researcher, and can be considered *made* (p. 601). Tracing the lineage of different paths and uses of case study design, Schwandt and Gates (2017) ultimately argue that "cases are always both simultaneously found and made. Collectively viewed, all case study research exists to address the dialectic that lies at the heart of understanding— an ongoing investigation of the empirical to refine the theoretical and the theoretical to better understand and explain the empirical" (p. 619). In this way, teacher preparation at the AMNH MAT was *found* as a discoverable phenomenon to assist the goal of the larger study. However, this "case" is also made in the sense that my analysis of AMNH MAT teacher preparation is an ongoing negotiation between "theoretical presuppositions" (Erickson, 1986, p. 120), data generated, research methods selected and my positionality as a researcher.

Next, in order to properly apply case study design, it is important to pay attention to how "case study" has been theorized. Yin (2018) indicates that "the distinctive need for case studies arises out of the desire to understand complex social phenomena. Case studies allow you to focus in-depth on a 'case' and to retain a holistic and real-world perspective" (p.5). According to Stake (2006), "qualitative understanding of cases requires experiencing the activity of the case as it occurs in its contexts and in its particular situation. The situation is expected to shape the activity, as well as the experiencing and the interpretation of the activity" (p. 2). Taken together, case studies are both tools of discovery (Yin, 2018) and entry points into what might be discovered (Stake, 2006). This dissertation is guided by the research questions and theoretical frameworks discussed above. However, the analysis was also open to new, unanticipated discoveries, which is part of the work of a case study researcher.

To help bound the conception of case study, Yin (2018) also offers a twofold definition. First, he outlines the *scope* of a case study, which he defines as investigating "a contemporary phenomenon (the 'case') in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident" (Yin, 2018, p. 15). Second, Yin (2018) adds that there are three particular *features* of a case study: (1) many "variables of interest," which require, (2) "prior development of theoretical propositions to guide design," and (3) "multiple sources of evidence, with data needing to converge in a triangulating fashion" (p. 15). Or, to put it succinctly, as Stake (2006) does, "a case study is both a process of inquiry about the case and a product of that inquiry." (p. 8) An important take away here is that case study design involves a clear plan for empirical work, which includes "theoretical proposition" as well as an understanding that what is observed and learned in the process also guides analysis.

These definitions suggest that case study is a useful research design for unpacking how the "case" of this study, teacher preparation at an nGSE, shapes and is shaped by the participants of the MAT program and the environments in which they operate—the museum itself, the partner schools, and the research sites. In other words, in order to understand and to honor how nGSE leaders, faculty and candidates make sense of and take part in the learning to teach process, it is imperative to study this phenomenon in what Yin (2003) referred to as its "real-life context" (p.1).

Finally, this case study can be considered as what Stake (1988) referred to as "intrinsic" because, as mentioned previously, preparing teachers in a world-renowned museum-based urban teacher residency is a one-of-a-kind experience. Therefore, studying this phenomenon is the "main and enduring interest" (Stake, 2006, p. 8) of this dissertation. Aside from its uniqueness, however, studying teacher preparation at the museum is also meant to be an "instrumental" (Stake, 1995) case study, because its purpose is to go beyond this single case analysis. As I have explained, this is the fourth case study in a larger project working to understand and interpret how teacher preparation is conceptualized and enacted within the domain of nGSEs. Therefore, the single case study analysis of teacher preparation at the AMNH MAT plays an important role in the cross-case analysis of the multiple case studies conducted for the larger project.

Case Study Site

Established in 2011, the Master of Arts in Teaching Earth Science Teacher Residency program at the American Museum of Natural History (AMNH MAT), at the time of this study, prepared about one third of New York state's earth science teachers. According to Maritza Macdonald, program co-founder, a main goal of this program was to "address…the shortage of middle and high school Earth Science teachers and embod[y]…AMNH's mission of research, education, and the dissemination of knowledge about the natural world" (quoted in Hammerness et al., 2020, p. 2). As noted by AMNH MAT program leader and co-founder, Ro Kinzler, and her colleagues (2012), the AMNH MAT was the only teacher education program in the United States wherein a museum, rather than a university or other higher education organization, granted a master's degree in teaching. What also made this program unique, according to Zirakparvar (2015), a museum scientist who formerly taught in the AMNH MAT program, is that it was the "first museum-based UTR" (p. 63). Since its inception, the AMNH MAT has been sustained by prestigious grants from the National Science Foundation Robert Noyce Teacher Scholarship Program, including its Discovery Research for Pre K-12 funding, federal funding in the form of Teacher Quality Partnership grant, and Race to the Top funding through New York State. At the same time, the museum itself has matched external grant funding for the MAT program.

The AMNH MAT program accepted 15 residents a year, all of whom received a fellowship for the $44,750 tuition plus a $30,000 living stipend, a laptop, books, and certification fees. Some unique features of the program included a 10-month mentored residency in New York City schools, two summer residencies in the museum that involve teaching youth of the city and the patrons of the museum as well as field-based investigations, science content courses and pedagogy courses co-taught by PhD-level science educators and museum scientists and curators, and extensive induction mentoring (Institutional Document #5, *CAEP Accreditation Document*). Until 2019, program acceptance and funding were contingent on candidates' commitment to teaching in high-needs schools in New York State for four years (now three) upon graduation, during which time graduates from 4 of 8 cohorts also received a $10,000 annual salary supplement (MAT Program admissions email, January 22, 2020). Seven cohorts totaling 109 graduates had completed the MAT program as of May 2020, a figure that, in some years, constituted as many as half of the earth science teachers prepared in New York State. The program's museum location and organizational structure, its full funding of teacher candidates through public and private grants, the premium it placed on science content knowledge, and the fact that it prepared its candidates for the particular teaching context of secondary earth science in urban and "high-needs" schools makes it an information-rich case for analysis (Stake, 2006).

Importantly, our research team secured a written agreement from the leaders of the AMNH MAT to be included as a research site for the larger nGSE study and for being examined as a single case study. In order to protect the interests of the "vulnerable participants in the setting" (Erickson, 1986, p. 142), we also secured informed consent from all teacher educators observed and participants interviewed. In the following section, I offer a detailed overview of who and what were involved in my data generation. I also describe how I conducted my investigation of how participants make sense of teacher preparation at the AMNH MAT, including aspects of the program designed specifically for understanding urban school contexts.

Data Generation

Saldaña (2014) reminds researchers that: “Data is a gift, so be thankful for it when it’s given to you and treat it with respect” (p. 979). Bearing this in mind, this dissertation pays careful attention to multiple sources of data, especially in terms of what they expectedly and unexpectedly reveal. Aligned with Yin’s (2018) aforementioned premise that one important feature of a case study is data triangulation, data for this study includes institutional and program documents, observations of multiple aspects of the program, and interviews with museum leaders and MAT leaders and co-founders, faculty, current candidates, and program graduates. Like the three other case studies that are part of the larger nGSE project, the qualitative data analysis software program Dedoose is being used to store and maintain the “data corpus” (Miles, Huberman, & Saldaña, 2014, p. 48) under password protection.

Data generation for the AMNH MAT case study occurred over the course of nine months, from May 2019 to January 2020. As detailed below, the larger study collected publicly available program material, media sources, and promotional materials regarding the program beginning in 2018 and continuing through the present (2022). Data sources for this case study were consistent with the data sources generated for the other three case studies from the larger study, which allowed for cross-case analysis of all four case studies, a culminating goal of the larger nGSE study. The research design for this case study was generally the same as the design for the other three case studies in that we interviewed approximately the same number of program leaders, faculty, candidates, and graduates and also observed courses and field experiences and gathered both proprietary and public program documents and materials.

However, what is unique about this case study—and also unique about the other three case studies—is that decisions about which learning contexts to observe, which materials to gather, and which participants to interview were decided upon based on collaboration between the MAT program directors and the nGSE research team. This is an important point to elaborate here. Before data generation began, our research team met with program leaders several times. We explained that our purpose was to understand teacher preparation at nGSEs in general, and also to specifically examine how the AMNH MAT conceptualized and enacted the project of learning to teach. Based on our research interests and on our intention to understand each case study site from the point of view of the participants at the site, AMNH MAT program leaders told us which courses and experiences were most important in their programs and thus should be observed, which faculty should be interviewed, and which institutional and program documents should be analyzed. For example, at the request of the AMNH MAT program leaders, we agreed to interview all candidates and program graduates who volunteered rather than limiting the pool to a certain number of hand-picking interviewees by the program leaders or by our research team. In essence, then, the main arguments of this dissertation are based on data sources that were considered by program leaders to be the most salient and important, program leader and faculty perspectives, and the perspectives and experiences of the pool of residents and program graduates who volunteered to be interviewed. This is the data corpus that contributed to an emic understanding of the project of learning to teach at the museum MAT. Figure 7 outlines the type and amount of each source of data.

Figure 7

Data Sources

	Source			
Type of data	*Institutional documents*	*Program documents*	*Observations*	*Interviews*
Description	Accreditation documents Grant proposals Internal and external program evaluations and research	Artifacts from observations Materials from observed courses Materials from unobserved courses Main program documents Key tools and assessments	Science content courses Science education and pedagogy courses Museum residencies Research practicum presentations School residency Monthly mentoring and induction meet-ups	Candidates from AMNH cohort 7 and cohort 8 Program Graduates from Cohorts 1-6 Teacher Educators Scientist Senior specialists Program leaders Museum leaders
Total number of data sources	27	401	15	25

One major purpose for gathering program materials and institutional data was to understand how AMNH MAT program leaders and faculty conceptualized teacher preparation. Examples of these institutional documents include grant proposals, accreditation materials, evaluation reports of the program, published research on the program, including some authored by AMNH scientists and teacher educators connected to the program, and other key institutional information (e.g., guidebooks, handbooks, and course schedules). Additionally, in order to understand how teacher preparation was enacted at the museum MAT, I was granted full access to the AMNH MAT's online learning platform, a Moodle that housed all current coursework, including syllabi, assignments, discussion boards, readings, and lecture PowerPoints. Over 400 program documents were gathered from the Moodle. These data were essentially coursework materials from the MAT program's seventh and eighth cohorts (occurring in the 2018-2019 and 2019-2020 academic years, respectively). Other program documents included key tools and assessments used throughout coursework and fieldwork, such as rubrics and tools for classroom observation and practice as well as artifacts collected during observations.[2]

It is also important to note that for this case study and for the cross-case analysis of the larger project, our research team regularly monitored AMNH MAT's website for programmatic changes in policy, procedures, and design. In fact, since 2018 and up to the conclusion of this data generation, all institutional shifts to the AMNH MAT in terms of arrangements, structures, and programming were recorded. Additionally, news and media outlets were regularly monitored for references to the AMNH MAT, and all relevant articles have been gathered and recorded.

As Yin (2018) points out, "the most important use of documentation is to corroborate and augment evidence from other sources" (p. 115). Therefore, to conduct a thorough analysis of teacher preparation at the AMNH MAT, more than 40 hours of observations occurred over five visits to the museum and two visits to school residency sites, some occurring over the course of two days. Yin (2018) also notes that one way "to increase the reliability of observational evidence is to have more than a single observer making an observation" (p. 123). While most of the observations were conducted by me, a few of observations were conducted by other

[2] Throughout this dissertation, I cite documents as either program documents or institutional documents. I also add the documents' assigned number for data organizing and collecting and its title- e.g., *CAEP Accreditation Document, Syllabus,* etc.)

researchers on the nGSE project, thus strengthening the reliability of the data collected for this case study.

Because the MAT program is 15-months long, it was possible to observe courses and residency work from both the seventh and eighth cohorts of residents, with some of these events overlapping and occurring at the same time. During each observation, my presence was acknowledged, but I did not directly participate. I took handwritten or typed notes of each observation based (depending on location and accessibility to lap top) on an observation tool I developed and modified for each site visit.[3] Appendix A is the observation protocol used for site visits, which included course observations and observations of monthly meet-ups, workshops, and residency classrooms. This tool has two pages: the first page identifies the key focus areas and key participants, the second is the template for recording handwritten notes. With course observations, I was interested in understanding the roles that the scientists and the teacher educators played in course instruction as well as their pedagogy and practice, especially in terms of the kinds of activities that occurred in the classroom and the questions posed by both the teacher educators and the candidates. I was also interested in the knowledge sources prioritized and the underlying assumptions about practice needed for teaching science in urban school contexts. For the monthly meetings about induction and partnerships, observations focused on, for instance, the attitudes, values, and beliefs about K-12 students, families and the community expressed by senior specialists, mentor teachers, and residents. For the secondary classroom observations, I was concerned with noticing teaching practices privileged, types of assessments discussed or practiced, knowledge sources prioritized, and ways that the backgrounds, experiences, cultures and heritages of the students were honored.

[3] Throughout this dissertation, I refer to all observations by their assigned number for data organization and categorizing and a brief descriptor – e.g., title of course or experience.

Observations included: seven courses; three "monthly meet-ups," which were meetings that centered on mentoring and induction; three classroom lessons taught by residents and subsequent debriefs with one senior specialist at a partner residency school; and one workshop. Specifically, examples of courses observed included: an earth science content course that focused on climate change, weather, and the solar system; a methods course on curriculum and teaching secondary science; and a course that focused on teaching science in the urban context. In addition, observations of three monthly meet ups occurred: one was with current teacher residents and their school mentors, and two were induction support meetings for program graduates who were in their first and second years of teaching. These meetings were facilitated by the designer of AMNH MAT mentoring and induction programming. Appendix B describes the content of each observation of courses and meetings.

I also observed the museum summer residencies, including one in which residents interacted with museum patrons while working on "touch carts" throughout the museum and the Summer Science Institute, where groups of residents prepared and taught youth who attended the museum's summer programming. In addition, I observed three-hour lessons taught by residents, which were followed by three different debriefing sessions: one with students, one with peers, and one with faculty. Additionally, three sets of observations occurred at one school residency with three AMNH teacher candidates teaching in their respective residency classrooms and the debriefs that followed between the senior specialist and the teacher candidate. Finally, during the second summer of the 15-month program, candidates engaged in a science fieldwork residency at Black Rock Forest in the Hudson Valley, and then presented their research findings to museum scientists, curators, fellows, and educators. I observed candidates from the seventh cohort presenting this research.

Observations were based on several important assumptions: both expected and unexpected actions occur and are important to note; all learning is situational, relational, and contingent upon who is present, for how long, where the event takes place; and there is inevitable discrepancy between what is planned for and what actually happens. Therefore, and as evidenced by my observation tool, my observations were not rigid or focused on pre-determined ideas. In addition, I collected all materials used during observations, including handouts and rubrics. Within twenty-four hours after each visit, I typed up any handwritten observation notes and wrote a reflective memo that documented my thoughts, questions, and ideas as they related to the larger picture of teacher preparation at the AMNH MAT that was emerging. As Erickson (1986) points out, "a fundamental principle" of qualitative fieldwork is the "subsequent reflection and write-up" which "needs to be completed before returning to the field setting to do further observation" (p. 144). Figure 8 lists key focus areas of observations as well as how these are connected to the research questions.

Figure 8

Examples of key focus areas of observations

Observation Site	Key Focus Areas	Research Questions Addressed
Science content and science pedagogy courses Museum residencies Monthly meet-ups	• knowledge sources privileged • ways practice is discussed and understood • teacher educator instructional methods, strategies and activities • attitudes, values, beliefs about K-12 students & families and urban schools • types of assessments discussed or practiced	**Question 1** When an urban science teacher preparation program is embedded within a museum, how is teacher preparation conceptualized and enacted?
Science content and science pedagogy courses School residency	• knowledge sources privileged • ways practice is discussed and understood • whether and how features of the context of urban schools are taken up • whether and how a critical examination of race or culture occurred	**Question 2** How are the candidates specifically prepared to teach for the complex context of urban schools?

Given that the overall purpose of this case study is to understand how teacher preparation was conceptualized and enacted at the AMNH MAT according to the perspectives of the participants, it was imperative to interview multiple stakeholders. To this end, 25 in-depth, semi-structured interviews were conducted with the following groupings of AMNH MAT participants: current teacher residents from the eighth cohort, program graduates the first seven cohorts, teacher educators and scientists, senior specialists, museum leaders, and program co-founders and leaders.[4] Faculty and program leader interviews transpired at the museum, while teacher candidate, program graduate and museum leader interviews were conducted over Zoom. Each interview was approximately one-hour in length, with some lasting about 45 minutes and others stretching to approximately an hour and a half. All interviews were recorded along with handwritten notes and a reflective memo after each interview. The purpose of this was to reflect on patterns I was noticing or themes that were emerging, and to record any surprising or unexpected information. In general, I was interested AMNH MAT participants' beliefs about the knowledge, skills, and practices necessary for learning to teach for urban school contexts, and the extent to which these beliefs converged or diverged. One limitation to note here is that in total, five residents and six program graduates volunteered. Given that at the time of recruitment for participating in this study, there were over 90 program graduates and 15 residents, this is a relatively small pool. However, in keeping in line with the larger study, which is aimed at getting a sense of the experiences and perceptions of many participants, these interviews were part of a corpus many different kinds of data. Collectively, then, these interviews, along with interviews with AMNH faculty, served as part of the practice of triangulating data in order to gain a clear picture of the case of teacher preparation in this program.

In consultation with the PI of the larger research project, I designed an interview protocol based on the goals of the larger nGSE study and the theoretical underpinnings and research questions of this case study. Protocols differed slightly depending on the type of participant. (See Appendices C, D, and E.) I conducted two in-person follow-up interviews with teacher educators

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[4] Throughout this dissertation, I use the following designations for interviewees: Museum Leaders, which refers to AMNH administrators; Program Leaders, which includes co-founders, (some of whom were also teacher educators), research directors, and administrators of the MAT program; Program Faculty, which refers to teacher educators, senior specialists, and leaders/facilitators of support programming; Program Faculty/Scientist, which refers a museum scientist who co-taught one of the courses in the MAT program; Program Graduate, which refers to member of Cohorts 1-7 of the MAT program (2012-2019), and; Resident, which refers to a (then) current MAT resident (Cohort 8, 2019-2020).

as a way to complete the respective interviews. Also, during the course of interviewing and observing, the idea for a focus group of three senior specialists organically developed. Based on my observations and interviews up to that point, I designed a protocol particularly for this focus group interview (see Appendix F). Yin (2018) points out that "case study interviews will resemble guided conversations rather than structured queries" (p. 118). Keeping this in mind, I approached each interview with the idea that the conversation would be fluid, rather than rigid question-and-answer sessions.

Because one aim of this case study is to understand how and to what extent the AMNH MAT prepares its candidates to teach in urban contexts, my approach in general was to ask current teacher candidates and program graduates about their coursework and residency experiences overall as well as how well prepared they felt to teach in urban and/or high-needs schools in particular. In order to understand the pedagogies and practices of teacher educators, I asked various questions about their beliefs, about the purpose of education and teacher education, and about their understanding of good science teaching in particular. In addition, program leaders were interviewed to get a better understanding of how the program's arrangements, structures, and curriculum worked together to fulfill the AMNH MAT's mission. Figure 9 outlines examples of interview questions and how these questions connect to the research questions of this dissertation (see Appendices C-E for full protocol). For a complete list of interviewees, see Appendix G.

Figure 9

Examples of interview questions posed to AMNH MAT participants

Interview Protocol	Interview Questions	Research Questions Addressed
Candidate/ Program Graduate (Appendix C)	Which strategies, activities, and practices learned in the MAT program have been the most useful to you in your own practice? Do you believe that these tools are generalizable, to any school setting, or are the tailored particularly for the urban/ "high needs" schools for which you are preparing to teach? What strategies and practices have you been taught or introduced to in your coursework at the museum?	**Question 2** How are the candidates specifically prepared to teach for the complex context of urban schools? **Question 3** How do the candidates and program graduates experience and make sense of the program?
Teacher educator/ Senior Specialist (Appendix D)	What activities/instructional strategies do you think are the most essential for the candidates to know and be able to do? Are there specific strategies, methods, or practices that residents ought to learn in order to be able to teach in urban or "high needs" settings?	**Question 1** When an urban science teacher preparation program is embedded within a museum, how is teacher preparation conceptualized and enacted? **Question 2** How are the candidates specifically prepared to teach for the complex context of urban schools?

Data Analysis

In terms of the larger study, in order to conduct cross-case analysis and in line with Miles, Huberman and Saldaña's (2014) method for creating codes, the research team developed "main codes" and several smaller "subcodes" that represented key ideas related to the larger study’s focus on the phenomenon of teacher preparation at nGSEs from both programmatic and institutional perspectives. For instance, under the main code “learning to teach,” there were subcodes such as, “teacher education pedagogy,” “assessment of candidate,” and “context.” For the main code “mission, values, and institutional logic,” there were subcodes such as “history” and “values/ideals/beliefs.” These codes and the initial round of open coding completed for the larger study, which were developed specifically for cross-case analysis, provided ideas and possibilities for the within-case analysis of the MAT program at the AMNH, which is the focus of this dissertation. Data for this case study, however, was separately coded, sometimes drawing on the coding of the larger study, but more often relying on the powerful ideas and concepts from this dissertation’s selected theoretical frameworks and research questions. This is in keeping with the idea that the AMNH MAT program as intrinsic case of the phenomenon of teacher preparation at nGSEs.

MacLure (2013) asserts that, "We are obliged to acknowledge that data have their ways of making themselves intelligible to us" (p.660). The salient point here is that analysis is based on assemblage of the “data corpus” (Erickson, 1986, p. 146) according to the decisions researchers make about how to think about the data (theoretical assumptions), how to look at it (research questions), what data are meaningful, useful, or necessary (data collection), and how to make sense of it (data analysis). Erickson (1986) suggests that the job of interpretive researchers is “to make use of the ordinary skills of observation and reflection in especially systematic and deliberate ways” (p. 157). Along somewhat similar lines, Yin (2018) asserts that, “a rigorous style of empirical thinking, sufficient presentation of evidence, and careful consideration of alternatives” (p. 165) are key tenets of data analysis and imperative to mitigating bias. Taking both ideas together, I used systematic data analysis procedures, working from the assumption that there were multiple possibilities for how data could be interpreted and analyzed.

For the within-case study of the MAT program at AMNH, data analysis occurred in multiple phases. First, as noted, written reflective memos were generated after each round of data generation as a means of recording initial impressions about the teacher preparation experience at AMNH MAT or about the understandings and assumptions of the participants. Another purpose of these memos was to record ideas and questions, including noticing any patterns that seemed to be emerging. These memos served as a preliminary, informal level of analysis of data and indicated important directions for formal analysis. I wrote these memos after each visit, after each interview, and after each observation. At times I also recorded my thoughts in voice memo. It is also important to point out that there was some time between data generation and analytical memoing and the time I began the period of formal analysis. During this time, I continuously examined data, pondering and noting what at the time might be considered emerging themes and possible codes. It should also be noted that during this time, this initial analysis contributed to ongoing scholarship of the larger project (Olivo, 2021; Olivo & Jewett Smith, 2021).

Although data analysis was ongoing throughout the case study, I engaged in a period of formal data analysis once all data sources were generated, following the general process Erickson (1986) calls *analytic induction*. The first layer of formal analysis, which began after data generation was complete, involved organizing and preparing the data. There are two things to point out regarding the data collection and generation phase of this study. As data were generated during my visits to the museum, all data were inventoried in Google drive, organized by visit data and by type of data source (interviews, observations, documents, etc.). Documents that were downloaded from the AMNH MAT Moodle as part of our access agreement with the program, which included *all* the course materials from *all* the 2017-2018 and 2018-2019 courses on the platform, were organized as "Documents" and by course or by "Key Tools & Assessments." I also made two folders for courses- "Observed Courses" and "Unobserved Courses." Once all data sources were gathered and generated, and once my visits to the museum and interviews were complete as well as a few visits and several interviews by the program PI and other team members, I created a data inventory to organize the 900 + documents. I also conducted a first round of data organizing, weeding out the documents that I would not use for analysis because they were redundant or superfluous. These included mostly documents downloaded from the Moodle that were from unobserved courses. Although it should be stated that I did in fact use data from a few courses I did not observe (e.g., *EDU 610: Content Area Literacy with Applications to Multilingual Contexts* and EDU630: *Developmental Variations: Development, Assessment, and Instruction with a Special Needs Focus*). This initial process cut down the data sources to 522. All of this data is also housed in Dedoose.

As a way to begin to engage in formal data analysis in 2021, I reread all memos, all publications and presentations written by AMNH MAT faculty, and all published materials from our larger research project on nGSEs in general, and all the additional notes and memos I had written since 2019. Informed by the theoretical frameworks already discussed and by the research questions described earlier, I generated a first round of what Erickson (1986) refers to as "assertions" (p. 146), or propositions about the case of teacher preparation at the MAT program at AMNH, largely through analytic induction. I then synthesized my ideas and created two preliminary, tentative assertions. Each assertion had three sub-arguments. Once these assertions were established, I reread the data corpus and categorized it in three main categories: 1) Conceptualizing teacher preparation, 2) Enacting teacher preparation, and 3) Teacher preparation for urban schools. I did this without consulting my assertions, as a way to check my own assumptions and to remain faithful to Stake's (1995) notion of "interpretation as method" (p. 40), wherein "there is no particular moment when data analysis begins. Analysis is a matter of giving meaning to first impressions as well as to final compilations" (p. 71). The idea throughout this process was to determine the key data needed to explore my research questions. Another goal of this process was *not* simply to look for ways to substantiate my tentative assertions and sub-assertions, but *rather* to look at data as either confirming *or disconfirming* my initial thinking.

Throughout this categorization process, there were a few documents that I placed into more than one category. The main example of this is the *AMNH MAT Observation Rubric Tool*. This tool was co-constructed by MAT faculty in response to the need for a centralized understanding and conceptualization of "good science teaching" that could be effectively and consistently communicated throughout the program in coursework and fieldwork. MAT faculty spent considerable time collaborating to revise this document to be reflective of their beliefs about effective science teaching. In this way, this document is a prime example of how the program conceptualized the project of learning to teach. This document is also an excellent example of what Wenger (1998) referred to as *reification* because it is the embodiment of how this program envisioned "good science teaching." That is, it is a codified set of ideas, activities, and approaches that residents were expected not only to know, but to practice. Therefore, this document was also an example of how the program enacted teacher preparation. Ultimately, this document was analyzed at length in Chapter 5, where I take up how the program enacted the project of learning to teach.

It is also worth noting that the process of data categorizing and organizing was also a process of actively endeavoring not to make assumptions about what might count as "urban teacher preparation" specifically. For instance, there are components of the program intended to prepare the students for "diverse" learners- mostly for special education students or for emergent bilinguals or multilinguals. I did not place material related to this necessarily into the "Teacher preparation for urban schools" category, even though it is true statistically that urban schools tend to have higher populations of students with special needs or who are emergent bilinguals or multilinguals than many other schools. However, *all* schools have these populations of students, even if they are small in number, therefore making attention to these issues more like standard procedure in teacher preparation programs of all kinds, not only in programs that prepare urban teachers.

Once all data was categorized, I engaged in a next level of analysis. I first revised my initial assertions to better reflect the data after my first full reading of the data corpus during the categorization and organization period. Next, I entered into what was my third reading of the data (after initial reading and after first round of categorizing). Rereading specific portions of the corpus of data allowed for confirmation or revision of preliminary assertions. According to Erickson (1986), this analytic technique is accomplished "by reviewing the data corpus repeatedly to test the validity of the assertions that were generated, seeking disconfirming evidence as well as confirming evidence" (p. 146). This layer of analysis accounts for the assumption that "all local meanings and values are not self-evident in the data" and that it is the job of researchers to engage in discovery of the "subtle shadings of distinctions in social organization and meaning" (Erickson, 1986, p. 147). This process of confirming and disconfirming inductive assertions took place over several rounds, and required me to investigate more data, primarily program documents.

I analyzed all data by category, working to identify codes and sub-codes that adequately represented it. Miles and Huberman (1994) argue that "*codes* are labels that assign symbolic meaning to the descriptive or inferential information compiled during a study…and can take the form of a straightforward, descriptive label or a more evocative and complex one" (p. 47). Using this logic, I created "descriptive labels," or codes, based on my initial assertions. These labels helped me locate and collate information relevant to my initial assertions and key linkages.
As I read, I kept the following questions in mind: Is this data source in the correct category? Is this quotation significant enough to mark for later? Does this data confirm or disconfirm my assertions? Which data sources are related to each other data sources? What needs to be added to my current assertions? What needs to be taken away?

Beginning with "Conceptualizing teacher preparation," I read through all the data once, developing codes and sub-codes that represented themes and trends. I read through those data at least two more times and noted data excerpts that represented the major themes and trends in each category. This is what Erickson (1986) refers to as *key linkages.* In essence, this analytic technique required me to look for "patterns of generalization within the case at hand" (Erickson, 1986, p.148). The idea was to discover and test linkages that are comprehensive and can be seen in many places throughout the data. I also confirmed or disconfirmed whether and to what extent my assertions matched these linkages because "the strongest assertions are the ones that have the most strings attached to them, across the widest possible range of data" (Erickson, 1986, p. 148). These key linkages ultimately served as codes and sub-codes. Once I had data excerpts, I then read through them several times to ensure accuracy of codes and sub-codes. I completed this same process for the next two categories as well: "Enacting teacher preparation" and "Teacher preparation for urban schools."

Once I engaged in this formalized data analysis, I realized that the interviews with program graduate and residents, which captured how these key participants were experiencing and making sense of learning to teach at the AMNH MAT, ought to be in their own category for two reasons. First, the data here was rich, often contributing to the saturation of themes and trends in other forms of data—documents, observations, or faculty interviews. The second reason I made the candidate/graduate data its own category was because these interviews attended to the third research question of this dissertation. Parsing out the data this way allowed me to thoroughly answer this question. Therefore, I ultimately had a fourth data analysis category, "Program Graduate & Resident Experiences," which I analyzed and coded in the same way I did the other three.

A final point to make here is that throughout this process of reading, analyzing and developing codes and sub-codes for each data set, I revised my assertions several times. Because this process of data analysis took several weeks, I completed weekly progress memos, to track my own thinking. Each memo included revised assertions, based on new insights gleaned from the analytical procedure described above. Figure 10 represents the final list of codes and sub-codes I developed once this process was complete. These codes and sub-codes both informed and were informed by the theoretical frameworks chosen for this case study, and therefore were used as the blueprint for the finalized arguments of this dissertation. Included in this chart are the primary data sources used for each category of data.

Figure 10

List of codes used during formal data analysis process

List of codes		Data sources
Primary codes	***Sub-codes***	

Conceptualizing teacher preparation	• Beliefs about the nature of science teaching and learning
	  ○ Deep science content knowledge is required for good science teaching.
	  ○ One of the key places we learn about the science around us is in informal science environments, such as museums, zoos, and aquariums.
	  ○ Developing a science identity is necessary for science teachers and learners.
	  ○ Learning science is not a matter of learning facts; science is a process.
	• Beliefs about the nature of good teaching
	  ○ There are a set of research-based practices that are key for teaching science
	  ○ High leverage science practices and ambitious science teaching strategies are effectives ways to teach science
	  ○ Good science teaching also involves culturally sustaining practices.
	• Beliefs about the nature of learners
	  ○ All learners have knowledge and experience related to the scientific world.
	  ○ All learners are capable of learning complex science ideas.
	  ○ All learners can develop a science identity.
	  ○ All learners can become science literate members of society.
		Institutional documents
		
		Museum leader interviews
		
		Program leader interviews
		
		Teacher educator interviews

Enacting teacher preparation	• Community of scientists (SCI)
	  ○ Museum as a resource; using museum resources
	  ○ Opportunities in coursework to deepen science content knowledge
		Observations
		
		Institutional documents

	o Opportunities in coursework to deepen science research practices • Community of good science teachers (GST) o Research-based lesson and unit planning o Opportunities to practice specific teaching strategies during coursework o Opportunities for instructor feedback on practice teaching o Acknowledgement of a set of dispositions of good science teaching o Opportunities for self-reflection • Community of NYC teachers, students, and schools (NYC) o Understanding and reaching diverse learners o Opportunities to teach New York City students o Opportunities to receive feedback on teaching NYC students o Understanding and application of a set of key dispositions needed for teaching	Coursework materials Program documents Teacher educator interviews
Teacher preparation for urban schools	• Cultural Conflicts • Recent uptick in attention to CRP o Faculty perceptions of cultural awareness o Beliefs about efforts to teaching cultural practices o Residents' perception of program's efforts to prepare for multiple and varied cultures in urban schools o Dispositions Tool • Meritocracy Myth o Faculty beliefs about and challenges with addressing privilege o Faculty working toward addressing race • Rejection of Colorblindness • Recruiting for diversity o EDU650: Foundations of Education in the Urban Context • Low expectations o Evaluation reveals residents struggle to differentiate	Institutional documents Program documents Program leader interviews Teacher educator interviews Resident and program graduate interviews

	◦ Attending to diversity ◦ Residency as best experience for learning context ◦ Coursework engaging residents in having high expectations while differentiating ◦ High expectations for all, regardless of background • Deficit mind-sets ◦ Creator & facilitator of Induction/Monthly Meet Ups/Dispositions Tool ◦ Understanding different backgrounds ◦ Graduate's perception of learning to debunk deficit mindsets in program ◦ Coursework designed for diverse learners • Context-neutral mind-sets and practices ◦ Faculty perception of why learning NYC context is important ◦ Graduates' uneven experience with learning context ◦ Induction ◦ Connection to NYCDOE ◦ Faculty perceptions of how to teach different cultural aspects of context ◦ Residents' and grads perception of learning NYC context ◦ Planetary Bootcamp/ Summer Science Institute	
Resident and program graduate experiences	• Perceived strengths in program experience ◦ Science teaching practices ▪ edTPA preparation ▪ Regents-oriented knowledge ▪ NGSS science inquiry practices ▪ Practice-orientation in science ed courses ◦ Museum faculty, affordances, and structures ▪ Resources of museum, museum itself	Resident interviews (Cohort 8) Program graduate interviews (Cohorts 2-7)

	▪ Museum faculty's care and commitment ▪ Mentoring, feedback and support ▪ Cohort model ▪ Induction • Experiences that prepared candidates for urban school contexts o Residency o Selected coursework • Experiences that were not useful o Science courses o Science research practicum o More emphasis on urban contexts	

Once the codes listed in Figure 11 were identified in the data, I examined how the patterns compared and contrasted in order to build what Miles et al. (2014) call "higher-level explanations" (p. 112). These "higher-level explanations," once tested against the latest version of my assertions and sub-assertions allowed me to finalize my arguments and draw conclusions from the data. Elliott (2018) suggests that coding is a "decision-making process;" thus, across all layers, my analysis of case study data was guided by key ideas from the two sets of theoretical frameworks used for this case study. For example, guided by Lave and Wenger (1991), my analysis confirmed that there were multiple communities of practice into which AMMH MAT residents are socialized during the process of becoming urban secondary teachers of science. Also, to remain faithful to the goals of the larger nGSE study, data analysis yielded a rich and detailed understanding of the main practices and principles that define teacher preparation at the museum MAT.

Researcher Positionality

As Stake (2006) points out, we all enter every experience with our own frameworks of cultural experiences. I have been an urban public school teacher and teacher educator for most of my career. Much of what I know about the world of teaching and learning I have learned by trying to look through the eyes of people with vastly different experiences from my own, and much of that learning has taken place inside the walls of my classrooms. Given this experience, I brought to this case study deep concerns about whether and how new teachers are prepared for urban schools, which Craig (2014) has argued involves the formidable task of navigating through the "fine-grained nuances of the complex educational crisis underway in U.S. public schools" (p. 111).

In my experience, the "fine-grained nuances" that Craig (2014) describes were multiple, complex, inconsistent, and persistent. One issue that plagued me, and that ultimately brought me into doctoral studies, was the multitude of ways teachers were being prepared to enter into urban public schools. Some were prepared through fast-track entry programs like Teach for America, while others experienced year-long residencies alongside their coursework. Although most of the teachers I worked with as a teacher and teacher educator were prepared by university-based programs, I realized that this too was inconsistent, particularly with regard to the knowledge sources prioritized in coursework, the length of time and emphasis placed on fieldwork, and the attention to the local contexts of the schools for which teachers were being prepared. As a teacher, I have long believed that it is the responsibility of all teachers to create spaces of curiosity and opportunity for students. Therefore, I wondered how teachers might be better prepared with the confidence of content knowledge, with strategies for developing their own identities as teachers, and with the understanding of learning as situational, cultural, and contextual.

With full regard for these concerns, I designed this case study in a way that reflects attention to the many problems that urban teachers, particularly science teachers, face. From the beginning, I was committed to conducting an even-handed investigation, since the aim of the larger study was not to judge or evaluate teacher preparation at any given program, but rather to was to present a fair account of how teacher preparation was conceptualized and enacted from the perspectives of participants. This was the explicit purpose of not only the larger nGSE project, but also this case study and the other three case studies that were conducted as part of the larger project. To that end, this case study was conducted "with great care and methodological awareness, while minimizing pitfalls and aiming for high-quality results" (Yin, 2018, p. 233). What manifested, as these next chapters three chapters reveal, is a depiction of teacher preparation at a unique museum-based urban teacher residency, which was both incredibly coherent and which raised important questions about the nature, intent and impact of the decisions programs make about what to cohere around.

CHAPTER FOUR

'Science is King': Conceptualizing the Project of Learning to Teach

The MAT program in Earth Science at the American Museum of Natural History is a unique, museum-based urban teacher residency program. One co-founder and program leader described the program's goal this way: "We want to change the science conversation in schools" (Interview #7, Program Leader). This goal was organizationally aligned with the mission of the museum, which was to "discover, interpret, and disseminate— through scientific research and education—knowledge about human cultures, the natural world, and the universe" (AMNH, "Mission Statement" para. 1). The MAT program worked to "disseminate" a science curiosity in the faculty, students, and communities served by New York's high-needs schools, which were primarily in New York City. Echoed throughout multiple interviews with program co-founders, leaders, and teacher educators was a catch phrase of the museum's— "science is king," or sometimes "content is king." This chapter reveals that this phrase aptly captures how teacher preparation was conceptualized at the museum; as I observed throughout the period of data collection for this case study, a deep reverence for science was just about everywhere I looked.

Chapters 4 and 5 of this dissertation are closely aligned, together illustrating that teacher preparation across many aspects of the AMNH MAT program coalesced around key beliefs about teaching science. Across the two chapters, I make the argument that the founders and leaders of the AMNH MAT program intended to change the science conversation in schools through tight coherence between the program's conceptualization and enactment of the project of learning to teach science. As I demonstrate below, this high level of program coherence was predicated on the assumption that prospective teachers needed to have deep science content knowledge coupled with knowledge of how to enact research-based teaching practices in order to engage all learners. In Chapter 4, I argue that teacher preparation at the AMNH MAT was *conceptually* coherent in that three sets of beliefs about science, teaching, and learning were evident across many aspects of the program. In Chapter 5, I demonstrate that the MAT program incorporated those beliefs into a *structurally* coherent enactment of the project of learning to teach, highlighted by placing residents at the nexus of three interrelated communities of practice.

Chapter 4 has two major parts. The first provides background information and an overview of the museum MAT program in Earth Science, including the program's origin and its positioning as an nGSE, the program's mission, coursework and residency programming, and how all of these worked together to address the goal of changing the conversation about science in the schools. The second major part of the chapter focuses directly on how the project of learning to teach was conceptualized at the AMNH MAT program. This section includes an analysis of three sets of interrelated beliefs about the nature of science teaching and learning, the nature of good teaching in general, and the nature of leaners.

Background and Overview of the AMNH MAT Program

To lay the foundation for my analysis of the three sets of beliefs that supported the AMNH MAT's conceptualization of learning to teach, I begin this chapter with a descriptive overview of four key aspects of the program. These include: (1) the origins of the program, particularly how the museum MAT was situated amongst other nGSEs and other urban teacher residencies (UTRs); (2) its "highly specialized and restricted" mission (Cochran-Smith et al., 2022); (3) its programming, including the coursework and the arrangement of residencies; and (4) its approach to candidate recruitment and selectivity.

Origin

The justification for AMNH's decision to create a teacher preparation program is best outlined in its original proposal to New York State for approval of the MAT program:

> The decision to focus on Earth science was based on the critical shortage of certified Earth science teachers in New York State and, in particular, New York City. During the 2008–09 school year, 39% of New York City Earth science teachers were not certified to teach in that area (NYSED, 2008). The current shortage of certified teachers prevents many schools from offering any Earth science courses, thus diminishing students' opportunities to study this subject, prepare for the New York State Regents Examination in Earth Science, graduate with a Regents degree, or prepare for higher education opportunities or careers in this field. More generally, the shortage of effective science teachers negatively impacts student achievement in science, technology, engineering, and mathematics (STEM); research has consistently shown that improving the quality of teaching is critical to efforts to improve STEM education and achievement (NSB, 2007), which is critical to workforce developments and this state's and nation's future competitiveness. (Institutional Document #26, *New York State Proposal Narrative*)

As this statement suggests, since 2012, the AMNH MAT has prepared earth science teachers for grades 7-12 in what New York State has deemed "high needs" schools (AMNH, "MAT Program Overview," n.d.b., para. 1). The MAT program is housed within the Richard Gilder Graduate School, which was established by the AMNH in 2006 to grant the PhD degree in Comparative Biology. As I pointed out in Chapter 3, teacher candidates in the MAT program, referred to as residents, were fully funded for the 15-month program that included two semester-long teaching residencies in two different New York City schools, one museum teaching residency, and one museum research residency. In fact, Chapter 3 also details the fully-funded fellowship, tuition remission, and living stipend residents received upon signing a three-four year commitment to teaching in New York's high-needs, urban schools after graduation.

Like other nGSEs that have been investigated in the larger study of which this case is a part, the AMNH, a stand-alone organization, founded the MAT program in part of a larger education reform movement in the late 1990s and early 2000s, particularly regarding "improving teacher quality" and ameliorating critical shortages of teachers (Cochran-Smith, 2021a). One AMNH MAT program leader and co-founder explained that New York State's decision to distribute *Race to the Top* funding to institutions other than higher education, was

> the moment when we felt the opportunity was there. We had the track record of doing tons and tons of professional development for teachers. We had partnership activity that was around certifying new teachers and we thought we should take the plunge. And the only reason was truly because of the need for earth science teachers. (Interview #1, Program Leader)

As Cochran-Smith et al. (2021b) pointed out, the AMNH's decision was consistent with the origins of other nGSEs: "the founders and leaders of all four nGSEs [we studied] had broad aspirations about disrupting and remaking the educational enterprise of teacher preparation in the United States" (p. 103).

Also, just as is the case of many nGSEs, since its inception, the AMNH NAT, has been sustained by a combination of public, private, and government grant funding (Cochran-Smith et al., 2021b), federal funding and its own internal support (Olivo & Jewett Smith, 2021)- a point I elaborate in Chapter 3. The AMNH MAT program is accredited as a higher education institution by the New York State Board of Regents, which is recognized by the U.S. Department of

Education as an institutional accreditation agency in New York. Additionally, the AMNH MAT is one of only three nGSE teacher preparation programs (in addition to Relay GSE and TEACH-NOW GSE) that is nationally accredited by the Council for the Accreditation of Educator Preparation (CAEP), one of two national professional accreditors in teacher education.

Like other nGSEs, the museum's MAT program represented an intentional break from university-based teacher preparation (Cochran-Smith et al., 2021b). The museum has historically had many partnerships with local universities. The best example of this, described in some detail in Chapter 2, was the Teacher Renewal for Urban Science Teaching (TRUST), a National Science Foundation-funded partnership between the AMNH and Brooklyn and Lehman Colleges of the City University of New York. This teacher preparation initiative "included two types of participants, teachers seeking Earth science certification and teacher leaders/school administrators seeking to improve science instruction in their school" (Macdonald et al., 2008, p. 269). This program ran for four years predicated on the assumption that New York City was a place paradoxically rife with "science-rich institutions" and "science-impoverished schools" (Macdonald et al., 2008, p. 269). This program accomplished its goal of responding to calls for science education reform and increasing the number of certified earth science teachers in New York City schools. In an article about the MAT program, one co-founder referred to it as "a model worthy of replication" (Macdonald et al., 2008, p. 278-279). Therefore, it is not a surprise that on the heels of the TRUST-supported program's completion, the museum decided to develop its own teacher preparation programming. According to one museum leader, the decision to embark on "the exquisite academic complexity" of creating its own teacher preparation program, rather than to partner with a university to do so, was prompted by the fact that the museum had what program leaders claimed universities did not: the expertise of scientists and a great partnership between scientists and teacher educators (Interview # 5, Museum Leader).

Finally, like many of the 11 nGSEs that now exist, including Sposato GSE, Relay GSE, and the Reach Institute, the AMNH MAT was designed to prepare teachers specifically for the context of urban schools. It is also interesting to note that the AMNH MAT used the urban teacher residency model to prepare its teachers, as did High Tech High GSE, Alder GSE, Teachers College of San Joaquin, Sposato GSE, Relay GSE, and the Reach Institute (Cochran-Smith et al, 2021). As I indicated in Chapter 2, some have suggested that the UTR model is an "innovative" approach to preparing teachers (Berry et al., 2008; Gatlin, 2009, and; Guha et al., 2009). Like other nGSEs, the AMNH MAT took the residency approach, in this case in order to tackle the targeted problem of a lack of qualified science teachers in New York's high needs schools.

Despite similarities to other nGSEs, there are several features that make the AMNH MAT different. Perhaps the most notable difference between the AMNH program and the other nGSEs was its devotion to and belief in the value of science content knowledge for prospective teachers. In fact, as the title of this chapter shows, two program leaders alluded to this in separate interviews: "Science is king here" (Interview #1, Program Leader) and "Content is king" (Interview #6, Program Leader). I expound on this idea in the next section. While the other nGSEs had specific foci, none were as connected to a specific content area and grade level as the AMNH MAT.

Also, while many nGSEs have unique design components (Olivo, 2021), such as TEACH-NOW GSE's activity-based coursework delivered completely online (Carney, 2019, 2021) and High Tech High's model of embedding a graduate school within a set of K-12 schools

(Sanchez, 2019), the AMNH MAT featured several key design components that made it stand out among its peers. For instance, as I detail below, the museum MAT program offered three different types of residencies that occurred in four different settings: two semester-long, school-based residencies, which occurred in New York City and Yonkers schools; a museum teaching residency, which included three teaching experiences at the museum and; a museum research residency, which occurred at Black Rock Forest in Cornwall, New York (Program Document #2, 2018-2019 *Handbook for Students and Faculty on Academic and Conduct Policies and Procedures*).

Another distinguishing facet of AMNH MAT programming was the "senior specialist," a new role that was designed primarily to prioritize the practice of good science teaching. As I indicated in Chapter 2, some urban teacher residencies have designated faculty roles designed to provide a liaison between coursework and the residency experience for teacher candidates (Gardiner & Salmon, 2014; Gardiner & Lorch, 2015). In addition, our cross case analysis for the larger study found that one trend of nGSEs was that they created new roles that privileged practice, such as K-12 veteran teachers who served as the primary faculty for the program (Olivo, 2021). However, the role of the senior specialist created for the museum MAT was different because these faculty were doctorate-level teachers, advisors, and coaches, each of whom had several years teaching science in schools. As one MAT teacher educator pointed out based on her experience presenting at many conferences,

> [the senior specialist role] does not exist anywhere. And we have presented on this trying to spread the love to other teacher ed programs, but it's just a completely different mindset. No one shares responsibilities like that, those are different people's jobs. So many clinical supervisors…are our retired teachers (Interview #14, Program

Faculty).

Senior specialists taught courses in the MAT program, but their primary job was to advise, coach, and mentor the residents during their school residency experiences as well as during their coursework and when they were involved in other program experiences (Program Document #3, *2018-2019 Handbook*; Interview #14, Program Faculty; Program Document #2, *Observation Rubric Addendum Update for CAEP Accreditation*). Chapter 5 provides more detail about how this role is unique among other teacher preparation programs, which involves socializing residents into multiple communities of practice by brokering connections between the science content and pedagogy of their coursework and the practices they observed and enacted in school residencies. Finally, as elaborated upon in Chapter 5, the composition of the museum MAT faculty was also unique in that all courses were co-taught by science teacher educators and scientists.

Mission

The second key aspect of the MAT program was its mission, which, as noted above, was directly linked to the mission of the museum. The program's 2019 *Teacher Quality Grant* proposal pointed out that:

> The AMNH MAT-R[esidency] program is an institutional priority. The AMNH 2012 Strategic Plan emphasizes the Museum's vital role as an institution with unique resources, expertise, and capabilities to help address the nation's crisis in STEM education. AMNH is committed to sustaining the MAT-R[esidency] program through a combination of private philanthropy and federal and state support as long as the need for Earth science teachers persists. (Institutional Document #21)

While the MAT program is unique in that it is an “institutional priority” of the richly-historied AMNH, the program enacted its mission in a way that is consistent with the approach of other newly formed nGSEs. For instance, our cross case analysis for the larger study revealed that “teacher preparation at nGSEs was highly mission-driven and that missions were *highly specialized, restricted*, and *well-known to all participants”* (Cochran-Smith et al., 2022, emphasis in original) and tightly linked to outcomes (Cochran-Smith & Alexander, 2021).

To illustrate the MAT program’s “highly specialized” and “restricted” mission, consider this description, excerpted from the 2018-2019 MAT program’s *Handbook for Students and Faculty on Academic and Conduct Policies and Procedures:*

> The MAT Residency Program extends the American Museum of Natural History's mission of research, education, and dissemination of knowledge about the natural world and the universe into the field of teacher preparation. Working with partner schools and focused on educating all students, the Museum's MAT program integrates scientists, educators, collections, and technological resources into the curriculum and assessments for teachers and students in New York State. (Institutional Document #2)

We previously pointed out that science teacher preparation in the MAT program was a “natural outgrowth” of the museum’s specific mission and commitment to educating the public (Olivo & Jewett Smith, 2021). What made this nGSE’s mission “highly specialized” and “restricted” was its allegiance to the mission of the AMNH itself.

Certainly, the AMNH has a long history of educating the public, including and especially through its multi-layered and overlapping educational programs for the youth and teachers of New York City, including children and family programming, programming designed for teens, and professional development for practicing teachers, including *Seminars in Science* and *Urban*

Advantage. As one program leader noted, "the mission of the museum is...deeply educational…Part of the history of the museum is all about educating New York City, visitors, students, teachers. It's just central to the heart of this institution. And it's been a part of it since... it started...around 1860" (Interview #6, Program Leader). Imbued with the museum's long standing commitment to educating the public and creating a science literate society, the MAT program set out to accomplish the highly specialized goal of improving the current pedagogies and practices of grades 7-12 earth science teachers by producing more candidates who were qualified and certified by the state of New York and who were also highly competent and deeply knowledgeable about science, scientific research practices, teaching science in informal environments, and diverse learners and learning.

In addition to being highly specialized, the mission of the MAT was also linked to program outcomes, as evidenced especially in external program evaluations and ongoing, internal research about the program, which centered primarily on whether the program was accomplishing what it set out to do—that is, ameliorating the critical shortage of science teachers in New York's high needs schools. For instance, the AMNH MAT program conducted research that monitored: the percentage of students taught by MAT grads who lived in conditions of poverty and/or were minoritized (Institutional Document #25, *Summary of Research Findings, June 2019*); the New York State Earth Science Regents Exam scores of students taught by MAT grads compared to the scores of the students of other teachers (Institutional Document #23, *Exploring the Impact of a Museum-Based Teacher Program on Program Graduates' Science Teaching Practices and Their Students' Learning*); graduates' perceptions of program impact on their practice (Institutional Document # 13, *Key Impacts of the AMNH MAT Program: Evidence from the External Program Evaluation)*; and, the persistence of program graduates teaching in

New York's high needs schools beyond the required four years (Institutional Document #25, *Summary of Research Findings, June 2019*).

Finally, as is the case with other nGSEs, the mission of the AMNH MAT was well-known and clearly articulated by participants (Cochran-Smith et al., 2022). Consider the similarity in the following descriptions of the AMNH MAT's mission offered by two different faculty and program leaders:

- And I think the specific sort of purpose is to provide people with access to knowledge about science and to making informed decisions about all the issues that are happening in science today. And I think the museum feels that educators are central to that and that teachers are central to that and then there's also this very important equity argument around, deep concern about what's happening in New York City right now in terms of access and equity. (Interview #6, Program Leader)
- In the MAT Program, our vision is to improve science learning opportunities for all students in New York State. That was where we started...Our vision was that we would graduate teachers who could really improve the learning opportunities or learning outcomes for all students across the state in science and in particular in Earth science. (Interview #1, Program Leader, Co-Founder).

Clearly, the mission to contribute to a more science literate society by providing rigor, enthusiasm and, importantly, access to science for youth in New York's high needs schools resonated deeply with faculty. This rang true for the residents and program graduates as well:

- I would say the mission is that all students can be successful at science, and all should have the opportunities that they, like all of the resources they need to be successful in this program. Part of this program is getting those opportunities out there and like trying to make that more of an even playing field for, for all of the students in New York. (Interview #19, Resident)

- I thought that the vision was that in New York City there is a need for qualified earth science teachers…. especially in underprivileged or underserved communities...and so their purpose was to take so-called experts from the field...and train us to then take that knowledge and adapt it to the classroom. (Interview #22, Program graduate).

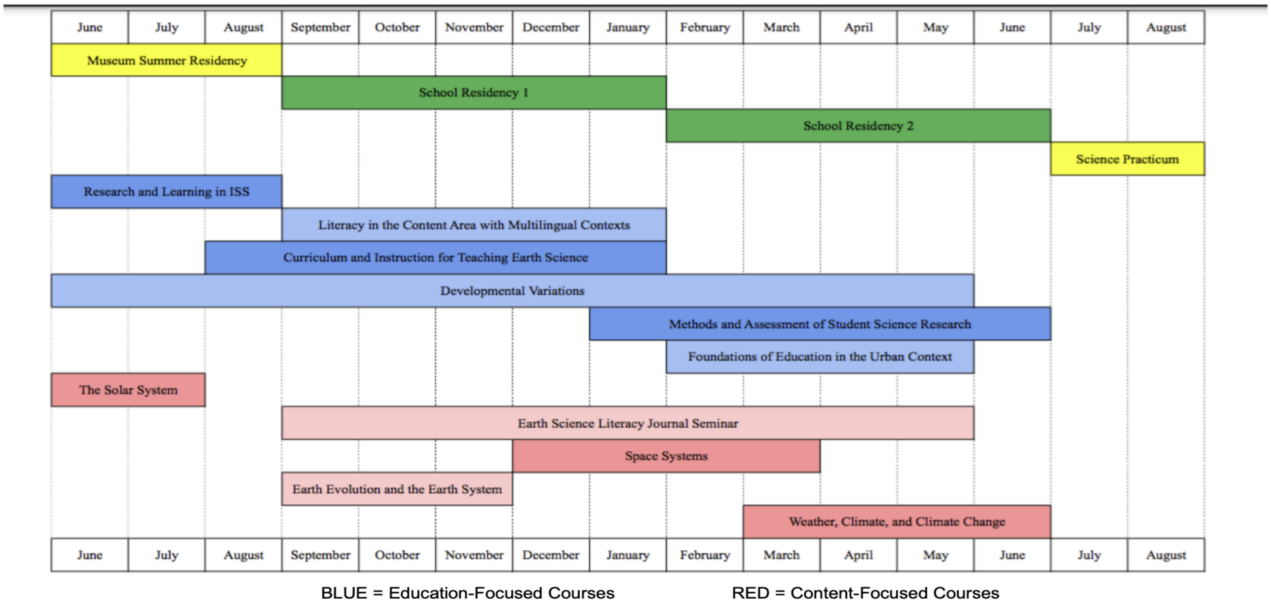
As was the case with AMNH MAT faculty, residents and program graduates had a clear understanding that the main goal of this teacher preparation program was to bring deeply committed, knowledgeable, and resourceful teachers of science into schools where that was not the current situation. The participants of the AMNH MAT also understood that this goal, while connected to improving teacher quality, had the greater aim of nurturing scientific competency and curiosity in New York City's youth.

Coursework and Residency Programming

A third key aspect of the MAT program was the design of the AMNH MAT's coursework and residencies, which was consistent with its original purpose of privileging science content knowledge and cultivating expert educators to become teachers of science. The MAT program's mission to bring quality science education to New York City schools was evident in the careful arrangement and scheduling of coursework and residencies. Figure 11, taken directly from the *2018-2019 AMNH MAT Handbook* (Program Document #3), provided an overview of the study calendar followed by the seventh and eighth cohorts (with slight variation), which were the groups that were underway during data collection for this study.

Figure 11

AMNH MAT 15-month course calendar (Program Document #3)



This calendar of coursework clearly demonstrates the MAT program's prioritization of education-focused coursework (in blue) and science-focused coursework (in red), especially in terms of the sequence of coursework. As the calendar shows, while the education courses occurred throughout the school year only, the science-focused courses were spread across the entire 15 months of the program. Additionally, the museum residencies (in yellow) were bookends of the program, happening in both the first and second summers of the program, while the school residencies (in green) happened during the academic year. It is also important to note that unlike typical university-based, semester-based courses, the MAT program offered courses within different time frames and for different reasons. For instance, the *Developmental Variations* course and the *Earth Science Literacy Seminar* were stretched over several months, each covering key pedagogical concepts and instructional strategies for science educators of diverse learners. These key courses involved instruction in explicit teaching practices, which were mentioned several times by residents as being central to their learning, as I show in later chapters.

Also, it is important to note that the sequencing of these courses changed over time, mostly based on feedback from residents about how they experienced them, especially in terms of their connection to the school residencies. For instance, the course titled *Foundations of Education in the Urban Context,* which was offered in the spring (February-May) originally, was later changed so that the first half of the course was offered in the summer prior to work in schools and the latter half was offered in spring, during the latter part of the second school residency. This was the case because former residents indicated that having it before their residency experiences would have been beneficial to helping them understand urban school contexts.

The AMNH MAT's four residencies, all of which are outlined in greater detail in the next three chapters, occurred back-to-back over the course of the 15-month program, beginning with the museum teaching residency in the first summer of the program, which had three parts. The first part of the museum teaching residency, which was referred to by everybody as "the carts," was an activity in which residents spent a week in pairs or groups rotating around approximately six carts located in the science and cultural halls, taking an inquiry-based approach to teaching patrons using the individual cart's artifacts and the dioramas as guides. The second part was observing and assisting teachers in the museum's Lang Institute, a three-week summer institute for New York City youth in grades 6-12 who were interested in science. During the third part of the museum teaching residency, which was the residents' first foray into classroom teaching, teams of residents taught a day-long lesson in the museum's Summer Science Institute.

In addition to the museum teaching residency, during the academic year, residents engaged in two school residencies at two different schools, one in the fall and one in the spring. Each school residency required candidates to spend four full days in their mentors' classrooms over the span of 5 months: the first school residency began in August and ended in December, while the second residency began in January and ended in May. During this time, residents were also required to observe teachers of English language learners and teachers of students with disabilities (Program Document #3, *2018-2019 AMNH MAT Handbook*). During the course of the two school residencies, residents were observed approximately 20 times, 10 times per residency, by the senior specialists, who coached and advised the residents lesson-by-lesson on their practice.

The final residency was the museum research residency was the capstone project of the program. Residents spent a week in the field- at Black Rock Forest- conducting original research, which culminated in presentations to MAT faculty as well as museum scientists and curators (Program Document #411, *EDU640 Syllabus*). One of the most important aims of coursework and residency work in the AMNH MAT program, as the above description indicates, was nurturing teachers' science identities. Developing one's "science identity," which I describe in a later section, can be thought of as how residents' come to see themselves as "the kind of person" (Gee, 2000) who engages in science practices and who encourages others to do the same.

Candidate Recruitment and Selectivity

The fourth key aspect of the AMNH MAT's teacher preparation program was the candidate recruitment and selection process, which revealed the program's commitment to preparing science educators who were deeply science-literate. According to one program leader and co-founder, "The '*who* teaches?' [question] is really important to us because we recognize that we always are trying to help people be confident in their expertise" (Interview # 1, Program Leader). A document prepared by program leaders for CAEP accreditation corroborated this belief, stating that "candidates enter the MAT program with strong content knowledge and are expected to continue building that knowledge throughout the 15-month program" (Institutional Document #6, *Standard 1 Summary Statement*).

In line with the AMNH MAT's carefully structured program of science and education study, its founders and faculty were painstaking in their efforts to recruit and select candidates with strong science backgrounds. According to the *2018-2019 AMNH MAT Handbook*, applicants were required to have:

> A Bachelor's Degree (30 credits) in Earth science or a related discipline (e.g., Geology, Meteorology, Oceanography, or Space Science) OR a Bachelor's with a minimum of 24 credits in Earth science (as above) plus 6 additional credits in Physics, Chemistry, Environmental Science, or Biology from an accredited college or university prior to matriculation in the Museum's program. (Program Document #3)

This stringent requirement concerning science background knowledge proved difficult to meet for the AMNH MAT, however, in part because the geoscience workforce had dwindled. In Chapter 6, I address ways the program attempted to attract more a more diverse pool of qualified candidates.

As indicated in interviews, the prospective teachers who entered the AMNH MAT program did indeed have rich educational and scientific backgrounds. For instance, some candidates already had advanced degrees when they entered the program (Interview #16, Resident), with many attending highly-regarded colleges and universities as undergraduates (Interview #25, Program Graduate). Unquestionably, prospective teachers entered the AMNH

MAT program with a deep passion for science, to be fostered and enriched in their time in the program, a point I turn to later in this chapter.

Changing the Science Conversation

As I have shown above, the museum MAT program was science- and resource-rich, deeply committed to enhancing the quality of science teaching in New York's high-needs schools. The institutional affordances of the museum explain *why* this program exists. But this dissertation is about *how* the AMNH MAT envisioned and enacted teacher preparation, which I argue was a highly coherent enterprise, beginning with its main goal, reflected in the title of this chapter, which was best articulated by one co-founder and program leader:

> We want to change the science conversation in schools. We want science to look different in schools that hire our teachers. Because now kids know a scientist. Their teacher says, 'I'm a scientist…Here's this work I did. Here's these rocks, here's these maps, here's these videos or images that show me doing this work.' The work of an earth scientist or a geologist or a meteorologist or oceanographer or a planetary scientist...I want the classrooms to feel different and I want the schools to sound different because of the presence of our teachers. I want science to have a different value in the school because they've hired one of our teachers. (Interview #7, Program Leader)

Essentially, these objectives, which were intended to "change the science conversation in schools," positioned AMNH MAT graduates as change agents. The logic of this was as follows: (1) program graduates would influence other teachers based on the knowledge graduates brought into schools, including science knowledge and knowledge of museum resources; (2) this would improve science teaching practices in earth science classrooms so that more school students would take earth science courses and more students would perform better on the New York State

Regents Examination in Earth Science; (3) this, in turn, would help to mitigate the nation's shortage of workers in geoscience fields and promote a more science-literate society in general. In short, the MAT residents were called upon to use their deep science knowledge in the service of good science teaching in order to improve student achievement outcomes and (ultimately) societal understandings of and inclinations toward earth science.

Program leaders believed that preparing teachers to accomplish the goals above was an extremely difficult, but doable, task, because, as one co-founder and program leader elucidated: "We do place a high premium on expertise here in the American Museum of Natural History. We admittedly have hubris, and it has to do with the quality of this place" (Interview # 7, Program Leader). She later pointed out that that this was a benefit because "individuals who have strong science experiences are going to be better prepared to help change the way science is talked about and science is learned, and science is thought about in schools" (Interview # 7, Program Leader). As the remaining sections of this chapter reveal, the AMNH MAT conceptualized teacher preparation in terms of a set of closely related beliefs, all of which worked in service of the above assumption that graduates were capable of enacting change in the schools. As one teacher educator in the program noted, MAT faculty believed that their program reflected their "hypothesis of what it take[s] to prepare teachers in way[s] so that they are effective" especially in terms of "the philosophy of preparation and the importance of deliberate practice" (Interview # 8, Program Faculty).

Evidence that the program itself was a working "hypothesis" about the preparation of science teachers was reflected in a mixed-methods external evaluation that the program commissioned. The evaluation found that:

the MAT graduates bolstered their schools and colleagues via the provision of

> information, resources, and support relevant to their experience at the Museum and expertise in the Museum. The data highlighted how the program structure benefited the new teachers beyond providing them with instructional skills, enriching their curriculum with extensive access to resources to connect with and engage students in high needs schools. (Institutional Document #13, *Key Impacts of the American Museum of Natural History MAT Program: Evidence from the External Evaluation Program*)

The point here was that the affordances of the informal museum setting were useful not only in deepening the knowledge and understanding of the MAT residents. Rather, a point of great pride for program leaders was that the residents learned how to translate and use the strategies and methods of informal museum-based learning in the more formal settings of urban secondary schools. Not only was the MAT program designed to equip its residents with the skills, materials, and knowledge needed to change the conversation about science, but it also focused on nurturing the dispositions necessary to do so. For instance, one program graduate asserted: "I felt empowered from the museum to affect change immediately" (Interview #24, Program Graduate). This program graduate went on to describe the leadership roles that she was almost immediately able to take on at her school, one of which was Science Department Head (Interview #24, Program Graduate). She attributed her ability to do so directly to the knowledge and skills she acquired at the museum MAT.

Conceptualizing the Project of Learning to Teach

The remainder of this chapter is devoted to how the AMNH MAT conceptualized teacher preparation as a mechanism to "change the science conversation in schools," which I ultimately argue they set out to accomplish through tight program coherence. In order to contextualize this, I begin with a brief overview of the construct "program coherence" as it applies to teacher education.

Program Coherence

Because Chapters 4 and 5 of this dissertation together argue that the AMNH MAT's approach to preparing science teachers was programmatically coherent, it is important to understand how the construct "program coherence" is generally understood in teacher preparation. Tatto (1996) suggested that coherence in teacher preparation depends on a shared understanding of good teaching that pervades a program. Hammerness (2006) referred to this as *conceptual coherence*. In addition, s*tructural coherence* has been described as the alignment of key ideas and practices across coursework and clinical work, which builds an integrated or sequential experience (Feiman-Nemser, 1990; Hammerness, 2006). Linda Darling-Hammond (2014) has argued that the "holy grail" of powerful teacher preparation programs involves coherence and integration such that: "coursework…is carefully sequenced, based on a strong theory of learning to teach; courses are designed to intersect with each other and are aggregated into a well-understood landscape of learning; and they are tightly interwoven with the advisement process and students' work in schools" (p. 550). Darling-Hammond (2014) further explicates that, "In such intensely coherent programs, core ideas are reiterated across courses and the theoretical frameworks animating courses and assignments are consistent across the program" creating a "seamless experience of learning to teach" (p. 550). It is important to note that Darling-Hammond's use of the term, "holy grail" is no accident here. In fact, Darling-Hammond and others have argued that the kind of "seamless experience" she calls for is not always (or even often) the case with teacher preparation programs. At times what is stated in program documents and by program leaders is not consistent with what actual observations and analysis of program requirements reveals. There are also multiple—and rather inconsistent— ideas about "good teaching" reflected across programs and across courses and in fieldwork. As Darling-Hammond argues, program coherence on its own has been shown to be hard to come by, and many teacher preparation programs have been described as offering a "fragmented" experience to candidates (Buchman & Floden, 1991; Hammerness, 2006).

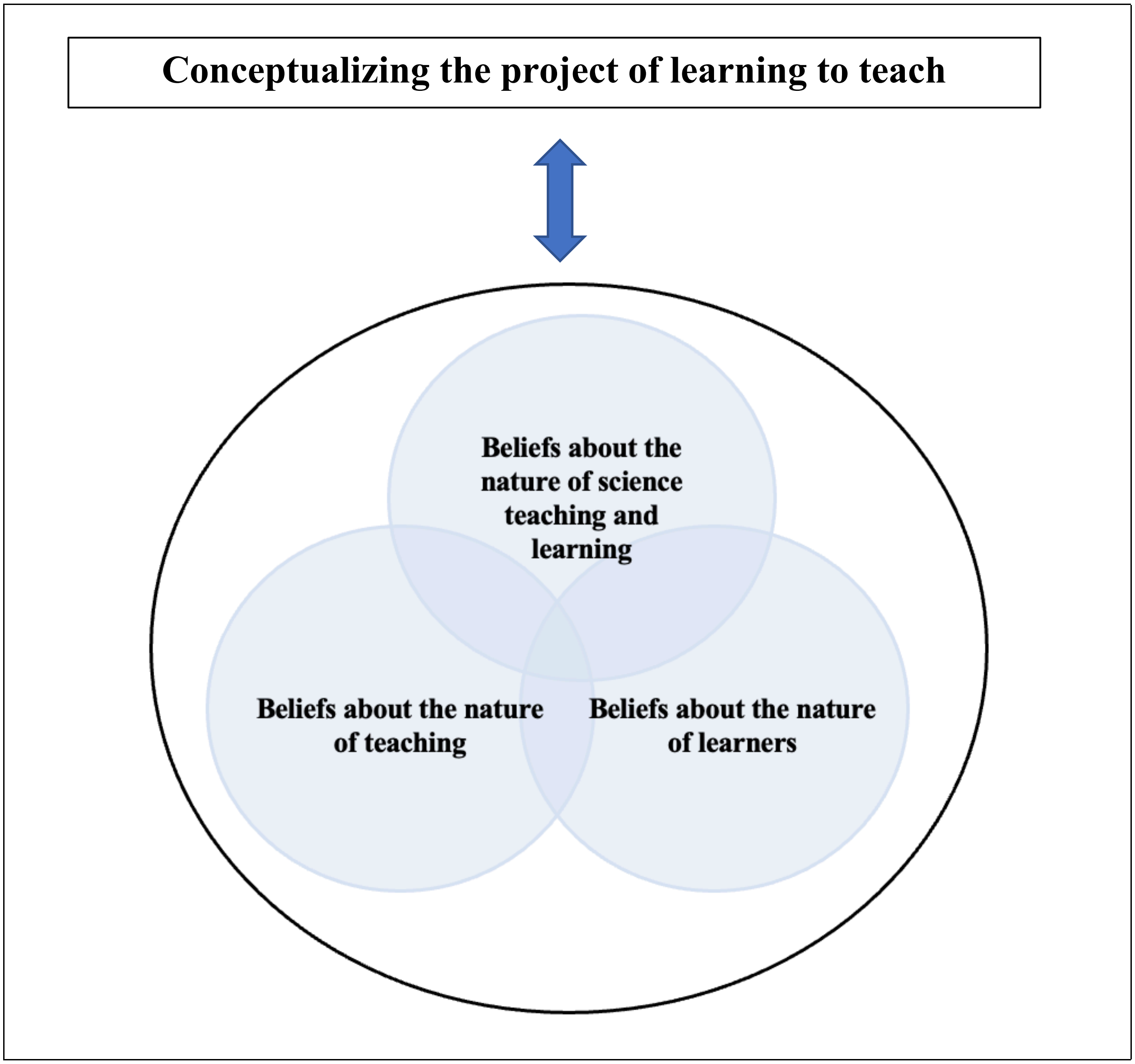
Although statements like those above suggest that program coherence is a highly desirable—and perhaps essential—aspect of teacher preparation, this concept has also been problematized. Conceptualizing teacher preparation in terms of a shared vision of good teaching and enacting that vision in programming and practice may engender consistency, but it also may perpetuate conformity. Thirty years ago, Buchmann & Floden (1991) suggested that one risk of program coherence is that graduates leave their programs with a "party line," or one centralized explanation of what good teaching is, rather than being empowered to critique various visions of good teaching or to consider from different perspectives the curricular, social and emotional, and instructional decisions they make. Furthermore, in the larger study of which this case study is part, we found through cross case analysis that many nGSEs exhibited high levels of program coherence, but they actually cohered around vastly different values, ideals, and beliefs about the nature of good teaching and the purpose of schooling (Cochran-Smith et al, 2021). We argued that whether or not program coherence makes for a "good" program depends on the match between the view of good teaching that animates a particular program and the view of good teaching that animates the viewpoints of those evaluating the program (Olivo, 2021). Because program coherence alone does not indicate the strength or effectiveness of a teacher preparation program, it is important to analyze *what* coherent teacher preparation programs actually cohere around, in particular the key beliefs that animate how a particular program conceptualizes teacher preparation.

Underlying Beliefs: Teacher Preparation at the AMNH MAT

Based on analysis of interview, observation, and documentary data, I argue here that the MAT program founders and leaders conceptualized the project of learning to teach in terms of a set of three overlapping beliefs that were reflected across aspects of the program. Figure 12 below represents these interrelated beliefs: beliefs about the nature of science teaching and learning, beliefs about the nature of good teaching, and beliefs about the nature of learners.

Figure 12

Three sets of interrelated beliefs of AMNH MAT's conceptions of learning to teach



Each set of beliefs, which reflected the program's desire to change the science conversation in schools, was related to the origins and mission of the program as well as to program coursework, fieldwork, and candidate recruitment/selection procedures. As I discussed in some detail in Chapter 2, according to Cochran-Smith and Lytle (1999), there are three co-existing ideas about the relationship between knowledge and practice that underlie various teacher learning initiatives; they label these knowledge-*for*-practice, knowledge-*in*-practice, and knowledge-*of*-practice. Here, I draw on Cochran-Smith and Lytle's (1999) knowledge-*for*-practice conception to argue that the leaders and founders of the AMNH MAT conceptualized the project of learning to teach primarily as teacher candidates' development of subject matter knowledge and research-based teaching practices. According to Cochran-Smith and Lytle (1999), the knowledge-*for*-practice "conception hinges on the idea that knowing more (e.g., more subject matter, more educational theory, more pedagogy, more instructional strategies) leads more or less directly to more effective practice" (Cochran-Smith & Lytle, 1999, p. 254). The idea here is that the knowledge necessary for improving the practice of teaching is knowledge that has been generated *by others,* such as professors, researchers, or experienced teachers, *for use* by teachers in classrooms.

In the case of the AMNH MAT, the *others* were "real practicing scientists" (Interview # 12, Program Faculty/Scientist) and teacher educators who were "experts in what they do" in the science classroom (Interview # 14, Program Faculty). This itself presents an interesting juxtaposition that is worth noting. On the one hand, by working firsthand with leading scientists in the field, the AMNH MAT residents had the opportunity to do what scientists do when they are involved in research and come "up against the edge of knowledge" and gain "a deep understanding [that] there isn't a right answer" in science (Interview # 12, Program Faculty/Scientist). In other words, the residents were exposed to the idea that science is a process of inquiry, often leading to more questions rather than to definitive answers. On the other hand, however, as a later section describes, the AMNH MAT program leaders and faculty framed good science teaching primarily as the ability to implement in the classroom a set of research-based teaching practices, consistent with those labeled "high-leverage practices" by some scholars

(Ball & Forzani, 2011; 2012) or those consistent with the idea of “ambitious science teaching” (Windschitl, Thompson & Braaten, 2018). This framing suggests that good teaching practice can be codified to a certain extent and taught to teacher candidates in terms of a particular set of approaches, strategies, and tools. To a degree, this meant that the AMNH MAT program reflected two different notions about practice. On one hand, the practice of “doing good science” was about inquiring and asking questions with no one right answer. On the other hand, the practice of “doing good teaching” was about implementing specific research-based (and thus “effective”) strategies. These two very different ideas about practice, fused together by the belief that particular knowledge sources work best *for* particular practices, worked together to instill ideas about what constitutes good science teaching at the AMNH MAT.

Despite the emphasis on the work of science as raising questions, the general understanding of the relationship between knowledge and practice that animated the MAT program was Cochran-Smith and Lytle’s (1999) knowledge-*for*-practice wherein there is a “heavy emphasis…on the need for teachers to learn additional and richer content information as well as new bundles of strategies and skills” (p. 258). Put another way, the AMNH MAT believed that scientists and PhD-level science teacher educators, both of whom were considered experts in their fields, held the *knowledge* necessary *for* prospective teachers to learn, understand and apply to particular classroom *practice*. The prevalence of the knowledge-*for*-practice conception was highlighted in the words of one co-founder and program leader, who described her belief in rigor:

> Rigor really has value and this institution definitely embraces that idea…Rigor is not just science, it's education, it's whatever endeavor you're doing…[while] obviously [being] mindful of the outcomes, mindful of the learners and the people we're impacting. But we

can't bring rigor to something if [we] don' t involve people with expertise from all the different angles that [we] need it. So you don't want someone teaching…earth science, if they don't know earth science. And you don't want someone teaching earth science if they don't know how to teach kids. (Interview # 7, Program Leader)

Part of what was emphasized in this quotation was the belief that becoming a good teacher of science involved learning from experts in the content of earth science as well as learning from experts in the practice of teaching. This was reflected in the program's co-teaching model, wherein each course was co-taught by a scientist and a science teacher educator, which I elaborate further in Chapter 5. In the rest of this chapter, however, I show more about how the AMNH MAT program assumed that deep science knowledge and knowledge of research-based teaching practices were necessary for the promotion of good teaching practice, reflecting a knowledge-*for*-practice stance on the relationship between knowledge and practice in teacher learning.

Beliefs about the Nature of Science Teaching and Learning

Central to the museum MAT's teacher learning initiative was a core set of beliefs about the critical role of science knowledge itself in the project of learning to teach. As one program leader pointed out,

> I think what's unique about the program is the learning opportunity in a site that is specifically focused on science, that has scientists sort of everywhere…that [the program] is in a science institution where there's multiple representations of science and science content, where…at the heart of the mission is communicating big ideas about science to the public. (Interview #6, Program Leader)

As suggested above, the phrase “science is king” (Interview #1, Program Leader; Interview #6, Program Leader) was commonly echoed by participants in the museum MAT. Expounding on this idea, one senior specialist noted that, “everybody's like an expert in what they do. And everybody is just smart, and they know their field” (Interview # 14, Program Faculty). The AMNH MAT had 11 program standards, outlined in *Master of Arts in Teaching Earth Science Residency 7-12 Program Standards*. Three of these were directly linked to the acquisition and continued development of science knowledge, which were considered important in the instruction of young people in science:

> The resident understands the central concepts of the discipline and can make the subject matter meaningful to students…The resident plans instruction based upon knowledge of subject matter, state and national standards, students and the community…The resident uses his or her personal science research experience to enhance instructional opportunities for his or her students. (Program Document # 1)

What the above excerpt highlights is the belief underlying the AMNH MAT program that deep science content knowledge drives good teaching practices. This idea reflected the knowledge *for* practice relationship discussed above because it was assumed to be “impossible for teachers at any level to teach students effectively and/or to meet the standards of the various subject matter professions without fundamental knowledge of the disciplines they teach” (Cochran-Smith & Lytle, 1999, p. 258). The MAT program’s commitment to building deep science knowledge for teaching and learning went beyond the general belief that prospective teachers required “fundamental knowledge” of science. In the sections that follow, I analyzed four specific beliefs underlying the general idea that good science teachers must be experts in their field.

Deep Science Content Knowledge. For the AMNH MAT, acquiring and deepening science content knowledge was assumed to be a life-long process for scientists and teachers of science alike, and it involved a commitment to instilling scientific curiosity and literacy in all young people. In fact, in two separate interviews, two program leaders, one of whom was a co-founder, echoed each other, solidifying the MAT's commitment to building science knowledge as the foundation of good science teaching:

- Science is king here. We're a science institution. I think we all know the museum is what it is because we do scientific research. And so we don't question the importance of that. However, we also know that to have an effective exhibition, to have an effective youth program, to have an effective experience for any audience, we need that similar level of expertise from our educators. (Interview #1, Program Leader)
- We need people who are really prepared to teach content and know content in an incredibly deep way. And that the best access that we can provide kids for science is teachers who have incredibly deep content. At the museum the people are always using this catch phrase, 'content is king at the museum.' But this is the heart of the museum is science research. And I think having a program that didn't take advantage of science faculty and science researchers would sort of not be a museum program. (Interview # 6, Program Leader)

This message that deepening teachers' science content knowledge directly contributed to effective teaching was clearly understood by the teacher candidates as well as program leaders, as one program graduate noted:

> the deeper your content knowledge, the more you're going to be able to… differentiate that material for whatever child you're, you're trying to reach...And yes, you could have like the greatest knowledge of all these strategies, and you could read all the literature of… best practices. But if you don't actually understand the science, all of that's…not going to work. (Interview # 23, Program Graduate)

In every aspect of the MAT program, there was a deep commitment to science. Half of the courses residents were required to take were master's level earth science courses (Program Document #3, *2018-2019 AMNH MAT Handbook*). Along these lines, one teacher educator noted that,

> We emphasize science learning in our Masters. So even though everyone comes in with enough credits to meet the requirements by New York State…Half of our program is about science…So that's just recognizing that even though we're recruiting people with what they need, we want them to have more, and we want to expose them to learning at higher levels. (Interview #7, Program Leader)

This strategy of deepening candidates' already strong science backgrounds was also reflected in the commentary of a resident who had previously earned a master's degree in geological sciences and who had spent time in the field working in the petroleum industry as well as in environmental sciences. When describing what he was learning in the MAT program, he said, "I've even learned a lot of science too…a lot…even like some geology…. I'm like surprised…that I'm still able to learn that stuff" (Interview # 16, Resident).

Informal Science Environments. The second sub-belief about the nature of science teaching and learning involved the museum itself. During the first of 16 observations of the teacher preparation at the AMNH, I observed a course titled *SCI 675: Weather, Climate, and*

Climate Change. During this class session, the residents were asked to spend time in the museum's Hall of Planet Earth, examining the paleoclimate wall, which was a multi-media exhibit that explored the question: "Why Study Past Climate?" They were asked to spend time in the hall, searching for new information and generating more questions to examine. As we were walking back to the classroom, the science educator for the course turned to me and said, "It's so cool that *this* is our classroom" (Observation #1, *Weather and Climate Change* course). This quip captures the true uniqueness of housing a teacher preparation program inside a museum. It also embodies the stance taken by everyone involved in the AMNH MAT: the affordances and resources of a world-renowned institution for informal science learning was also an extraordinarily meaningful and useful location for learning to teach science.

In addition to incorporating aspects and features of the museum's exhibits in actual coursework, one of the best examples of the way the AMNH MAT capitalized on informal science learning for the residents was the museum teaching residency, which occurred during the first summer of the program. As mentioned previously, the residents observed museum educators teaching New York City youth in the Lang Institute, they taught youth in the museum's Summer Science Institute, and they engaged museum patrons with the artifacts and items on carts throughout the museum, all of which corresponded with particular exhibits. Referring to the value of the experience with the carts, one program leader explained,

> all of the [AMNH] educators have experiences working with kids in the science institution using the materials or representations, the dioramas, the objects, and engaging learners in those materials. So, I think there's an argument on the part of the museum that, that's a special kind of teaching…I think the fact that the program starts with teach [ing at the museum in the summer] before the [residents] really do any other kind of teaching is

> a very unique feature that I really haven't seen in any other program that I've studied. (Interview #6, Program Leader)

Informal science teaching and learning were believed to be beneficial for the residents in terms of the way they themselves came to understand how to teach science in schools. One program faculty articulated this connection well:

> being housed in a museum, we have the influence of the museum, and we purposefully are using pieces of museum education and informal education within our MAT program…having our first summer here where they're learning …through the lens of like, how do people learn in a museum, what are the similarities from there that we can see in the classroom or what kills …that curiosity that exists at a museum when you go to the school? Why is learning about science not as fun and not as engaging as it was when you were in the museum? They engage in summer camps, they engage on the carts, they teach a week with high school students. (Interview #10, Program Faculty)

It was clear that the MAT faculty believed in the value of informal science learning in secondary schools, and this belief was clearly instantiated in the way residents came to conceptualize teaching science as well. For instance, one resident pointed out, "The museum is a tool…one of the classes asked us to prepare an investigation plan and take our kids to the museum….so I think that me teaching in the high needs school, that, that would be a great tool to engage kids" (Interview # 17, Resident). Additionally, another program graduate said, "the exposure to the museum…was relevant and helpful and we learned how to take field trips. We learned what that process looks like…I am surprised by how chaotic some field trips are for some educators and it's because they just never been familiarized with the process" (Interview # 24, Program Graduate). I elaborate on the impact this experienced had on residents in Chapter 6.

A final point to make about the MAT program's commitment to infusing informal science learning was that the AMNH-commissioned an analysis of program impact on graduates and students. This research revealed that residents believed that learning to use museum resources was an asset to their ability to translate what they were learning in the program to their teaching in classrooms. The report stated:

> The unique experience of participating in a teacher preparation program located at a museum shaped each of the case study participants as teachers. The MAT graduates' extended experience learning to use museum resources, both during the program and subsequently through induction, allowed the graduates to bridge the space between the Museum and the classroom. These graduates used the Museum and its resources as core components in their teaching. They maintained a connection to the Museum and shared that with students by bringing them to the Museum and by bringing Museum resources to them. (Institutional Document #23, Fallona et al., 2017)

Because learning to teach at the AMNH MAT involved many opportunities to explore and employ the affordances of the museum, residents were able to infuse their own conceptions of teaching science in schools with practices and resources often reserved for informal science settings.

Science Identity. A number of science education scholars describe the importance of how science identities are formed and developed (Avraamidou, 2014b) as well as the agency and constraints scientists of color face when developing a science identity (Carole & Johnson, 2007). As mentioned previously, James Gee (2000) defines "identity" in a general sense as "being recognized as a certain 'kind of person' in a given context" (p. 99). Building on prior research and extending this definition, "science identity" has to do with how and to what extent teachers and students think of themselves as the kind of people who engage in science or are passionate about science. As noted above, many of the residents who entered the MAT program already identified as scientists, or they arrived at least as people deeply invested in the value of understanding science, especially in today's world. In the context of the MAT program then, how the residents thought about themselves, and in turn how they perceived each other and were perceived by their colleagues and students in schools, reflected their science identity. According to a study conducted by AMNH faculty about their own program, the science identity of the residents was sharpened by the experiences they had learning to teach at the AMMH:

> The opportunities for aspiring teachers to use the affordances of [informal science learning] settings allows for a shaping of identity that blurs the lines of formal and informal learning and allows teachers to use the resources of such settings in varied ways to engage learners, garner respect for themselves from both adults and students, and develop a sense of self as a teacher of science that is strong. (Institutional Document #15, Gupta, Trowbridge & Macdonald, 2015).

The focus on developing an identity as a scientist and science teacher who seamlessly blended informal and formal science learning into classroom teaching was prevalent throughout the program. Two prominent examples are the two museum residencies. When the residents taught in the Summer Science Institute during their first summer residency, for instance, as part of their group-taught lessons, each of the candidates, one-by-one, where required to share a brief PowerPoint presentation depicting their work as scientists, especially in terms of their previous work as researchers (Observation #10, *Summer Science Institute, Teaching*). Positioning oneself as an expert in one's content area is not a typical requirement in most teacher preparation programs. At the AMNH MAT, however, embodying and exuding an identity as a scientist when teaching science was an important part of learning to be a science teacher.

This was also clear in the second summer residency, wherein the residents actually engaged in a week-long field research experience and presented their findings to AMNH scientists and faculty (Observation # 12, *Summer Science Practicum Research Presentations).* AMNH MAT faculty believed that part of becoming a science teacher was developing a “stance as a scientist” (Interview # 2, Program Leader) because, as one program leader indicated, the mindset of teachers deeply influences the mindset of the students:

> So when I think about what do I need teachers to have when they come into New York City classrooms, I need them to know the content, need them to know the process...I need them to understand what it means to be a scientist because if we're going to talk to kids about science, we need to have that…mindset…I want students to act like scientists…You can see why I express that the science practicum [Black Rock] is an important piece…I think it's a distillation of that idea of really giving them a strong science identity. So that when they walk into a classroom, they're a beacon to those kids that they can be scientists. They can do science. (Interview #2, Program Leader)

Finally, developing and enhancing a science identity was also understood by the residents as an important component to learning to teach. As one resident noted, the AMNH MAT worked to prepare inspirational teachers of science:

> And they're hoping that we're ready to go out into the world and like create scientists, or inspire scientists…So, a big thing that we talk about…is that it's almost like there's a certain kind of person that goes into science, and it depends on the teacher you had and…the representation that you felt…So we want to show kids that like anyone can be a

scientist…You don't have to wear a lab coat and look a certain way, and be…a white man…That's not what it has to be. You can be you, and love science. And that's cool...And it's also about the kids who don't eventually want to be scientists, making science fun for them, and that it has a purpose. (Interview #20, Resident)

The underlying belief that a strong science identity was necessary for strong science teachers was a key part the way program leaders and faculty conceptualized the project of learning to teach and was evident in all aspects of the program.

Science as Process. The final sub-belief about the nature of science teaching and learning that animated AMNH MAT's conceptualization of teacher preparation was the belief that teaching science means engaging students in a process, not presenting a set of vocabulary terms, concepts, or facts to be learned. This belief was related to the MAT program's deep roots in informal science learning as well as the influence of the AMNH scientists and curators. The importance of teaching science as a process was highlighted by one of the museum scientists who taught in the MAT program:

> I think there's sort of two ways that science gets taught. Science either gets taught as a litany of facts. You memorize the facts, you apply the equations, you know, it's sort of a rudimentary execution. And I think that a lot of science is taught that way when teachers aren't comfortable with the concept of science as a process. And, I think one of the things that this program is doing, is…we aren't teaching science that way to [the residents] …[We] also giv[e] them a framework for teaching science as science, as opposed to science as fact. If you think of science as a living, breathing thing, where we're constantly learning something new, no one's ever going to know everything they

> need to know. They might know everything they need to know for the Earth Science Regents exam, but that's not where it ends. (Interview #12, Program Faculty/Scientist)

This idea of science as process was further elucidated in a CAEP accreditation document: "Science literacy recognizes that science is more than just facts; it encompasses science knowledge, the practices scientists engage in to develop this knowledge, and the nature of the scientific enterprise, or science as a way of knowing" (Institutional Document # 6, *CAEP Standard 1 Summary Statement*).

The *Next Generation Science Standards* (NGSS) were central to the ways the MAT program required residents to structure their lessons and unit plans, which focused on teaching science as a process. However, the concept of science as a process went way beyond fulfilling the NGSS. This idea was woven into the fabric of all AMNH teacher learning initiatives, which is no small task, given that the museum "currently serves thousands of teachers a year in professional development programs" in addition to "being home to" the MAT program (Macpherson et al., 2020). An external program evaluation found that the MAT residents did indeed engage in student-centered science teaching practices:

> While these teachers are still novices, the practices they engage in are designed to help students do science. And in many ways, these kinds of teaching strategies—that emphasize putting students at the center of the classroom, that involve students in sense-making, that encourage students to do the work and practice scientists do—this kind of teaching differs from what is typically seen in many science classrooms. (Institutional Document #23, *Exploring the Impacts of a Museum-Based Teacher Preparation Program on Program Graduates' Science Teaching Practices and Their Student Learning*)

That the program pushed its residents to engage in inquiry-based, student-centered science teaching practices wherein science is viewed as a process was evident in residents' and program graduates' reports of their preparation as well. For instance, one resident shared that at the AMNH MAT focused on science as a process to be learned:

> they really push…less like teacher talking at kids, less like handing out stuff and just being like, do this, you know, do this reading and writing thing and like take notes and then pass it in…they want us to do less of that and more of…student driven…it's not about the test scores and all that stuff, it's more about just like, you know, growth mindset and…fun learning, right? (Interview # 16, Resident)

In sum, conceptualizing teacher preparation at the AMNH MAT involved the twin beliefs that in order to enact good teaching, prospective teachers must possess deep content knowledge and must work from the stance of a science identity.

Beliefs about the Nature of Good Teaching

While the emphasis on content knowledge was clear at the AMNH MAT, the program also focused on research-based teaching practices, which were also considered part of the knowledge base necessary for effective science teaching. However, this set of beliefs centered more tightly around the teaching practices grounded in research that the AMNH MAT believed were essential for learning to teach science. As I pointed out previously, Cochran-Smith and Lytle (1999) argued "that the heavy emphasis [in knowledge-*for*-practice relationships] is on the need for teachers to learn additional and richer content information as well as new bundles of strategies and skills" (p. 258). While the previous section illustrated the "richer content information" the AMNH MAT prioritized in teacher learning, this section describes the "new bundles of strategies and skills" this program taught to teacher candidates. In this section I suggest that the AMNH MAT was animated by the belief that in addition to ensuring deep content knowledge, preparing good science teachers was a matter of instilling in candidates a set of research-based practices to refine as they began their careers. Cochran-Smith and Lytle (1999) refer to this notion of practice as emphasizing "how, when, and what teachers do as they use the formal knowledge base in the daily work of the classroom" (p. 257). Just as was the case with the beliefs about the nature of science teaching and learning, this general belief about the nature of good teaching involved several other overlapping and interrelated sub-beliefs, which are described in the remainder of this section.

High-Leverage Practices. The AMNH MAT program taught teacher candidates research-based practices to use in the classroom, which were referred to several times in institutional documentation as "high-leverage practices," defined as research-informed "'best bets' about the skills vital to helping children learn, and to promoting equitable opportunities and outcomes" (Ball & Forzani, 2012, p. 13). These "best practices," according to Ball and Forzani (2012) also "can be taught and assessed" (p. 13). High-leverage practices were highlighted in one of the program's first grant proposals: "The AMNH MAT-R[esidency] program develops…high-leverage science teaching practices, such as open-ended questioning and stimulating discussions that reinforce developing scientific explanations (NGSS)" (Institutional Document # 23, *2014 TQP Grant Proposal Narrative*). In fact, one of the key areas cited as a priority in the proposal was "alignment and preparation with high leverage science practices" (Institutional Document #23). In another grant proposal, written four years after this one, the program again stated its commitment to high leverage practices, stating that it was pursuing grant funding to, among other things, "further develop Fellows' opportunities to learn high-leverage science teaching practices through coursework and clinical experiences" (Institutional Document #20, *2018 NOYCE Project Narrative*).

Deborah Ball and colleagues (Ball & Forzani, 2011) argued that a major concern in teacher preparation is that there is "no consensus about the set of instructional practices that are essential for beginners to be able to carry out." To move toward consensus, they conducted research that enlisted "the experience and imagination of a broad range of practitioners and researchers to create a comprehensive 'map' of the work of teaching" (Ball & Forzani, 2011, p. 11). They research-based practices that constitute this "map," or what they refer to as "high leverage practices." Some of these practices can be clearly seen in AMNH MAT conceptions of good science teaching. Figure 13 shows the consistency between the high leverage practices outlined by Ball and Forzani (2011; 2012) and the practices taught in the AMNH program, according to the *AMNH MAT Program Observation Rubric*.

Figure 13

High-leverage practices and AMNH beliefs about good teaching

High leverage practices (Ball & Forzani, 2011; 2012)	**Good teaching at AMNH** *(AMNH MAT Program Observation Rubric)*
eliciting and interpreting individual students' thinking	Surfaces and responds to students' ideas (Standard 3a)
posing questions about content	Uses questioning and discussion strategies (Standard 3c)
explaining core content	Using effective communication skills to demonstrate accurate content knowledge (Standard 1a)
recognizing particular common patterns of student thinking and development in subject-matter domain	Adapts content to students' level of understanding (Standard 1b)
Setting up and managing small group work	Develops and manages diverse and effective student groups (Standard 3d)

As this figure highlights, the MAT program was animated by the belief that there are specific practices that constitute good teaching; these were consistent with Ball and Forzani's "high leverage teaching practices."

Ambitious Science Teaching. Another key belief was that good science teaching reflected what Windschitl, Thompson & Braaten (2018) called ambitious science teaching. Their Ambitious Science Teaching (AST) framework was comprised of four practices: "1) planning for engagement with big science ideas, 2) eliciting students' ideas, 3) supporting ongoing changes in students' thinking, and 4) drawing together evidence-based explanations" (p. 4). The AMMH

MAT's emphasis on AST is reflected in a chapter written by AMNH faculty for *Preparing Science Teachers through Practice-Based Teacher Education* called "Preparing Teachers in a Non-university Site" (Macpherson, Howes, Hammerness, Gupta, Abowd, and Kinzler, 2020). In this chapter, AMNH faculty describe the museum's recent efforts to "explore…the AST framework as a way to help educators develop a shared conception of good teaching" (Macpherson et al., 2020, p. 154). Macpherson and her AMNH colleagues (2020) also state that "the AST framework, with its focus on student sensemaking, rigor, and equity, reflects central commitments and values of the MAT program for science teaching" (p. 155). They highlighted three key areas where this belief is instantiated in the program: the museum teaching residency, and two particular courses: *EDU 620: Curriculum and Instruction* and *SCI675: Weather, Climate, and Climate Change* (p. 156).

That the museum MAT reflected a belief in ambitious science teaching practices was also evident in in the following excerpt, taken from the *2019 TQP Grant Proposal*, in reference to what is offered in clinical residencies:

> Th [e residencies] include a focus on rigorous and equitable science teaching practices, such as those elaborated by Windschitl et al. (2018) termed 'Ambitious Science Teaching:' planning for engagement with big science ideas, eliciting students' ideas, supporting ongoing changes in student thinking, and drawing together evidence-based explanations, which residents rehearse in their clinical assignments during SCI652, EDU/SCI660, EDU620, and SCI670. Windschitl and his colleagues argue that these practices have been found to increase all students' participation in the classroom and in turn, represent concrete practices teachers can enact to foster an equitable Classroom. (Institutional Document #21)

Furthermore, when asked about the skills, knowledge, and dispositions needed for good teaching, one faculty member noted that her goals were to "have the residents understand current research on how people learn and what's effective science teaching and then put that into practice" (Interview # 10, Program Faculty). She further cited some examples of this, noting the "five E cycle and structure model" as well as things "like ambitious teaching…really getting students to think, to have mental models that they are making visible" (Interview #10, Program Faculty).

Finally, MAT residents referred to learning and practicing ambitious teaching practices during their coursework as particularly useful in learning to teach. One resident described "demos," which were opportunities during coursework to practice specific teaching strategies "as helpful…for the most part we're reading books about how to teach. Like *Ambitious Science Teaching*...those are helpful" (Interview #20, Resident). Another resident also referred to practicing ambitious science teaching in *EDU 620: Curriculum and Instruction*, as a positive experience:

> that class I think has been great, especially when they have us do the eliciting student ideas thing. Every class where we do a demo is helpful…just like the idea of doing that and like how am I supposed to act and what do I say when doing these things?...So just like having the guidance of…how you get ideas from students, this is how you pull ideas out of kids and... how you…use it later on. (Interview # 16, Resident)

High-leverage practices and ambitious science teaching were clearly articulated in institutional and program documents as well as by AMNH MAT participants as valuable, research-based practices that comprise good science teaching. One final component of the nature of good teaching taken up by the AMNH MAT was what they referred to as "high leverage culturally responsive science practices," which I turn to now.

Culturally Relevant/Responsive Practices. In addition to conceptualizing the project of learning to each in terms of high leverage practices and ambitious science teaching, the AMNH MAT was also animated by the belief that practice should be culturally relevant/responsive. As I pointed out previously, the concepts of “high-leverage teaching practices” and “ambitious science teaching” have empirical support (Ball & Forzani, 2011;2012; Windschitl et al., 2018). This is also the case with culturally responsive teaching practices. Gloria Ladson-Billings (1995) originally explained that *culturally relevant pedagogy* is made up of three tenets: “students must experience academic success, they must develop and maintain cultural competence, and they must develop a critical consciousness through which they challenge the status quo of the current social order” (p. 160). Building on this and other work, Geneva Gay (2002) theorized that *culturally responsive teaching* involves developing a curriculum that has a cultural diversity knowledge and delivering instruction that is culturally congruent with the young people it aims to teach. Finally, Paris (2012) posited that culturally sustaining pedagogy required a balance between sustaining the cultural and linguistic backgrounds of all students while simultaneously offering them access to “dominant cultural competence” (p. 95). It is important to note here that the AMNH MAT’s institutional documents, and some participants, referred to culturally relevant, culturally responsive, and culturally sustaining pedagogy somewhat interchangeably to refer to teaching practices designed to center the diverse cultures, heritages, and languages represented in New York City secondary science classrooms.

At the time data was generated for this case study, the MAT program exhibited a growing commitment to culturally responsive teaching practices, particularly when these practices worked in tandem with high-leverage science practices. This is a point I will return to – and expand upon- in Chapter 6. More recent institutional documents, especially those written several years after the inception of the AMNH MAT, used the term "high-leverage culturally responsive science teaching practices" to describe the kind of practices the program worked to instill into its prospective teachers.

This is best exemplified in the narratives of two grant proposals, the *2018 NOYCE Grant application* and *the 2019 TQP Grant application*. In the former document, the AMNH MAT requested funding for, among other things, ongoing research to "deepen…program practices for teaching Fellows about culturally responsive teaching practices to support them in complex school environments" (Institutional Document # 20). In the latter grant application, "high leverage culturally responsive science teaching practices" is defined as

> refer[ing] to specific strategies and concrete moves teachers can make in their classroom to implement CRT [culturally responsive teaching]. The MAT-R[esidency] program focuses on helping residents with the four key aspects of CRT identified by the NYSED: creating a welcoming and affirming environment; fostering high expectations and rigorous instruction; identifying inclusive curriculum and assessment; and engaging in ongoing professional learning and support. (Institutional Document #21)

Taken together, these two documents reveal that the AMNH MAT program was based on the belief that part of what it takes to be a good science teacher involves engaging in specific, research-based, culturally-responsive "concrete moves" to be used in residency classrooms and refined as program residents began their teaching careers. Alongside high-leverage practices and ambitious science teaching, the AMNH MAT strove to embed specific, New York State-sanctioned features of culturally responsive teaching into their notion of good science teaching.

Furthermore, when describing how the AMNH MAT worked to prepare residents for urban schools, one program leader and co-founder stated that her "constant focus" in the creation of the MAT program was on the "processes that teacher education institutions can put in place to be responsive...to the linguistic and cultural differences" of students because "if the students cannot understand you, it doesn't matter what you do" (Interview # 4, Program Leader). Another program leader and co-founder also expressed her belief that culturally responsive, or culturally relevant, teaching was key. An example she offered was that "culturally responsive education actually looks like selecting phenomenon, or examples, or metaphors that are resonant locally" (Interview #7, Program Leader). It was clear that these beliefs resonated with program residents, as one remarked that his experience with learning culturally relevant practices "really works" and was "kind of transformative" for him because "the part about making things culturally relevant, like I had no idea that that was a thing at all…until I got here" (Interview # 16, Resident). AMNH MAT participants valued the strategies and skills they learned to practice culturally relevant pedagogy, seeing them as ways to enhance the daily work of teaching science.

At the time data were generated for this study, the museum MAT had been working to better understand and employ "high leverage culturally responsive science teaching practices," which was an example of how it continuously centered science knowledge and research-based practices when considering how teacher preparation ought to be carried out. I return to this point in Chapter 6, where I address how the AMNH MAT incorporated preparation for teaching in urban contexts into its programming.

Beliefs about the Nature of Learners

A final set of beliefs that animated the AMNH MAT's conceptualization of teacher preparation involved the value the program placed on educating *all* students. According to one program leader and co-founder,

> in the MAT Program, our vision is to improve science learning opportunities for all students in New York State. That was where we started…And the word *all* was very intentional...our vision was that we would graduate teachers who could really improve the learning opportunities or learning outcomes for all students across the state in science and in particular in Earth science. (Interview #7, Program Leader)

Cochran-Smith and Lytle (1999) indicate that knowledge-*for*-practice initiatives attempt "to formalize what teachers need to know about their subjects as well as what they need to know in order to choose, construct, use, and evaluate representations of subject matter in ways that are teachable for diverse student populations" (p. 255). Just as with the MAT program's other beliefs undergirding teacher preparation, this knowledge-*for* practice conception of teacher learning can be seen in the MAT program's beliefs about the nature of learners, particularly because this belief was infused with the notion that what is needed to teach well is candidates' deep content knowledge in order to create appropriate and varied opportunities for learners of all kinds to engage in science. To accomplish this, the program prioritized ways residents could understand and engage diverse learners in its learning to teach process. Put another way, as one scientist who taught in the program did, the AMNH MAT worked to "really make sure that you give every child, or every student in the classroom, a mechanism to learn the way they learn" (Interview #12, Program Faculty/Scientist). The museum MAT's emphasis on teaching all learners was distinguished from, but consistent with, its commitment to culturally relevant teaching practices. The former centered on teachers' ability to tap into students' curiosity, the latter centers the cultures, languages, and heritages of young people.

This goal of reaching all students was made clear in many key institutional documents of the MAT program. For instance, according to a CAEP accreditation document titled *Educator*

Preparation Provider Overview, MAT program had the following goal: "to prepare teachers in diverse cohorts of 15 candidates who are capable of positively impacting student learning for all students, including English Language Learners (ELL) and students with disabilities" (Institutional Document #5). Additionally, the AMNH MAT worked to align its standards with Interstate Teacher Assessment and Support Consortium (InTASC) standards, which have been used in New York State and elsewhere as a model of effective core teaching strategies. Part of these strategies, as the following excerpt outlines, includes enhancing the chances of learning science for all students. According to a CAEP accreditation document titled *Standard 1 Summary Statement,*

> The program aims to graduate individuals with a strong understanding of variations in learner development and specific learning differences and of how to create learning environments that engage all students in standards-based science content (InTASC 1, InTASC 2, InTASC 3). MAT candidates work with a rich diversity of students in their residencies, including English Language Learners (ELL), students with special education designations, students who struggle with reading or mathematics, and gifted students. (Institutional Document #6)

The basic belief here was that creating a strong science learning environment involved understanding the many different ways students access content. The AMNH MAT's beliefs about the nature of learners manifested as two closely related sub-beliefs. One belief was that students bring many resources and assets to science classrooms. The second belief was that teachers should work to nourish in young people a life-long passion about science and an interest in science practices. In short, the first belief centered on pedagogical approaches, while the second focused on ideas about the purpose of teaching science.

Knowledgeable and Capable. In a document describing an overview of the AMNH MAT's mission, vision, and shared values, which was prepared for national CAEP accreditation, the program asserted that the MAT-prepared teacher:

- believes in and embodies the responsibility to help all students reach their potential;
- is able to design and differentiate instruction that promotes higher order thinking;
- uses and models scientific thinking skills to develop relevant knowledge and understanding. (Institutional Document #5, *Educator Preparation Overview*)

It is interesting to note here that in describing its shared values, the AMNH MAT codified its beliefs about the nature of learners: all children possess the knowledge and skills necessary to learn science, and it is the responsibility of good teachers to draw on students' strengths. This is further exemplified by one program leader and co-founder, who posited that the purpose of education is "to prepare and support teachers who believe all students can learn and who have the skills and abilities and knowledge to support all students" (Interview #7, Program Leader).

The two AMNH senior specialists also clearly articulated the program's commitment to preparing its candidates to reach all students. For instance, one program faculty member honed in on the idea that caring for students is a function of honoring and cultivating students' science identities:

> While we're teaching new teachers skills and pedagogies on how to get students interested in science and appreciate science and make good decisions as part of society… I think a bigger message that I'm pushing lately is like, show kids you care about them… we're doing it with this lens of …"If I show the kid I care about them, then maybe they're going to be more interested in how streams are road valleys." (Interview #10, Program Faculty)

Another program faculty also commented on ways to excavate students' prior knowledge, seeing it as an asset. She indicated that "effective teaching is having students working together and constructing that knowledge themselves" (Interview # 14, Program Faculty). Taken together, these excerpts demonstrate that the teacher educators and senior specialists, who had a heavy hand in the formation of how the residents learned to teach science, believed that it was the job of the teacher to understand each student as a knower *and* as a capable learner of science.

Finally, one program graduate aptly captured the belief underlying the MAT program that all learners are capable of acquiring deep science knowledge and developing science identities. He indicated that the program:

> emphasized inquiry [-based practices] because they understand that research shows that this is the best way to communicate information to students. This is the highest retention rate. This is the highest engagement rate…it is a real big hook for students in high needs settings who perhaps are deficient in literacy or deficient in other means and they emphasized us thinking about teaching multi-modally…I felt like whether it was formally or informally, those were all being communicated through the museum. (Interview #24, Program Graduate)

Clearly, AMNH MAT teacher preparation included the belief that all students deserve the experience of quality science instruction as well as quality science teachers who expect them to bring important knowledge and who believe they are capable of building on that knowledge.

Science Identity and Science Literacy. One of the program's key documents asserted that that "the MAT program aims to instill in its graduates an engagement with ongoing, lifelong learning that underlines the importance of science literacy" (Institutional Document #5, *Educator Preparation Provider (EPP) Overview).* That the AMNH MAT's believed in the capacity of its candidates to inspire youngsters to develop and sustain science literacy and curiosity was also indicated in its program standards as it asserted that the MAT candidate:

- knows that scientific thinking skills can be realized by people with differing abilities, cultural perspectives, and backgrounds;
- knows that science can be learned everywhere and is a way of thinking;
- understands that instruction must be relevant and useful to students and communities.

(Program Document #3, *2018-2019 AMNH MAT Handbook*)

These standards unearth another facet of the AMNH MAT's belief that all learners can become science-literate, and it places the onus on its prospective teachers to use their scientific expertise and pedagogical knowledge to engage and excite young people in myriad ways.

When asked to describe the AMNH MAT's commitment to all learners, particularly those in urban settings, many residents and program graduates referred to one particular course: *EDU 610: Content Area Literacy with Applications to Multilingual Contexts.* This is best exemplified by one resident, who commented on MAT coursework centered around working to promote science literacy in all students:

> All the coursework is very much centered around…literacy and multilingualism and sciences. So how to make science accessible and scaffold your work for…multilingual students, or students that are struggling readers…How can you build up scaffolds…to reduce some of that difficulty on students that don't have English as their primary language while still keeping the content level and the concepts rigorous… (Interview #19, Resident)

I return to this course in Chapter 6, when I analyze the program's approach to preparing urban teachers. In addition to this particular course, there was an overall belief that learning differences were to be respected and seen as assets to the learning in a science classroom. This was stated best by a program faculty, when I asked her about how the MAT program takes up effective teaching:

> I would also say a respect for difference as well. So [the candidates are] acknowledging that all the students in front of them come in with different personalities, different incomes. Like even if they had breakfast this morning…that might affect if they're paying attention but just knowing that and acknowledging that, I feel brings out that teacher identity. (Interview # 14, Program Faculty)

The findings of one AMNH-commissioned mixed-methods program evaluation, which examined key impacts of the program graduates on their students, demonstrated that MAT residents have been able to imbue their teaching practices with these sets of beliefs about the assets and abilities of all science learners. According to the study, "MAT graduates demonstrated impacts on students' engagement with and excitement about science. The new teachers identified myriad ways in which they were able to build an engaging, relevant curriculum that meets the diverse needs of the students in their high needs schools" (Institutional Document # 13, *Key Impacts of the American Museum of Natural History MAT Program: Evidence from the External Evaluation Program).*

As this section has shown, the founders and leaders of the AMNH MAT conceptualized learning to teach as a process of learning how to bring a science inquiry stance and the ability to engage in science practices to all learners. Particular beliefs about the nature of learners, along with beliefs about the nature of science teaching and learning and good teaching in particular, made up how AMNH program leaders and founders conceptualized the project of learning to teach. The teacher preparation program aimed to prepare deeply invested and knowledgeable teachers who were passionate not only about science, but about promoting a science literate society by reaching all of their students.

Conclusion

In this chapter, I have argued that teacher preparation at the AMNH MAT was *conceptually* coherent, coalescing around three interrelated sets of beliefs about the nature of science, teaching and learning. I assert that this conception of teacher learning ascribes to what Cochran-Smith and Lytle (1999) refer to as “knowledge-*for*-practice” because it centered “around enhancing teachers' knowledge of subject matter, of the standards and content of the various professions, and of research-based strategies for effective teaching and classroom organization” (p. 258). In other words, the AMNH MAT believed the project of learning to teach to be an undertaking that involved deep science content knowledge, a willingness and passion for the ongoing enhancement of a science identity in oneself and in one’s students, a knowledge base of research-based teacher practices, and a commitment to involving *all* students in learning science.

One caveat to note here is that there are some science educators and reformers who have raised questions along these lines, suggesting that the place to start instruction of science concepts is with students’ language and sources of knowing, rather than from a corpus of content knowledge per se. The idea here, as Brown (2019) suggests, is that teacher educators and teachers “should expect students to know some things, and when they share their knowledge, we should expect to hear that knowledge communicated in culturally specific language as well as science terminology” (p. 46). Similarly, advocating for a culturally expansive perspective on science, where teachers notice, support, and engage the diverse sense-making strategies of students, Bang et al. (2017) assert that “the bottom line is, the more you show genuine intellectual and scientific interest in your students' sense-making, the more you expand the space of possible relations among you, your students, and science" (p. 34). Taking these perspectives into account, the AMNH MAT's knowledge-*for*-practice approach to preparing science teachers could be perceived as placing emphasis on acquiring science content knowledge as a measure of understanding scientific phenomena. However, as I have shown, the museum MAT also prepared its teachers to prioritize student questions, to elicit students' responses, and to honor and uphold diverse learners in their classrooms.

As a next level of analysis, I have also argued that the MAT's program coherence was an intentional, mission-driven endeavor because its purpose was to nurture and advance effective earth science teachers, which to the AMNH meant promoting those capable of "chang[ing] the science conversation in schools." According to one museum-sanctioned program evaluation, the MAT program has been successful in working to intentionally fulfill this goal:

> Without question, the program has been effective in preparing Earth science teachers for teaching in high need urban schools, and in so doing the program has established the potential for long term and continuing impacts on the schools, teachers, and students. Successfully helping middle and high school students improve their performance in Earth science may lead to a long lasting ripple effect on their future science course taking patterns, performance, and possibly career choices. (Institutional Document #13, *Key Impacts of the American Museum of Natural History MAT Program: Evidence from the External Evaluation Program*)

As both this chapter and the next show, it is precisely a "long lasting ripple effect" that AMHH MAT program leaders and educators hoped to accomplish in efforts to conceive and carry out teacher preparation that "change[s] the conversation about science in schools."

In the next chapter, I extend the argument that teacher preparation at the AMNH MAT was characterized by a high level of program coherence by linking its underlying beliefs and assumptions about learning to teach, outlined in this chapter, with its enactment of engaging residents in multiple, overlapping communities of practice. I argue that this makes the MAT program not only *conceptually* coherent, but *structurally* coherent as well.

CHAPTER FIVE

'*This* Is…Effective Teaching': Enacting the Project of Learning to Teach

As Chapter 4 made clear, the belief that "science is king" was the central idea behind teacher preparation at the AMNH MAT. This chapter demonstrates that a consistent and pervasive reflection of the enactment of teacher preparation was the *AMNH MAT Observation Rubric Tool,* which represented many aspects of what the program considered to be "effective" teaching. This rubric, which was both a key program tool and a central assessment, is a centerpiece of this chapter because it was referred to over and over again by AMNH MAT faculty when asked about what effective teaching looked like. In fact, during my observation of the program's day-long workshop designed to orient the new cohort of AMNH residents to the Observation Rubric, one teacher educator who was facilitating the workshop held up the rubric document itself, pointed to it, and exclaimed that resident ought to become very familiar with this document because "*this* is what we see as effective teaching" (Observation # 9, *Observation Rubric Workshop*).

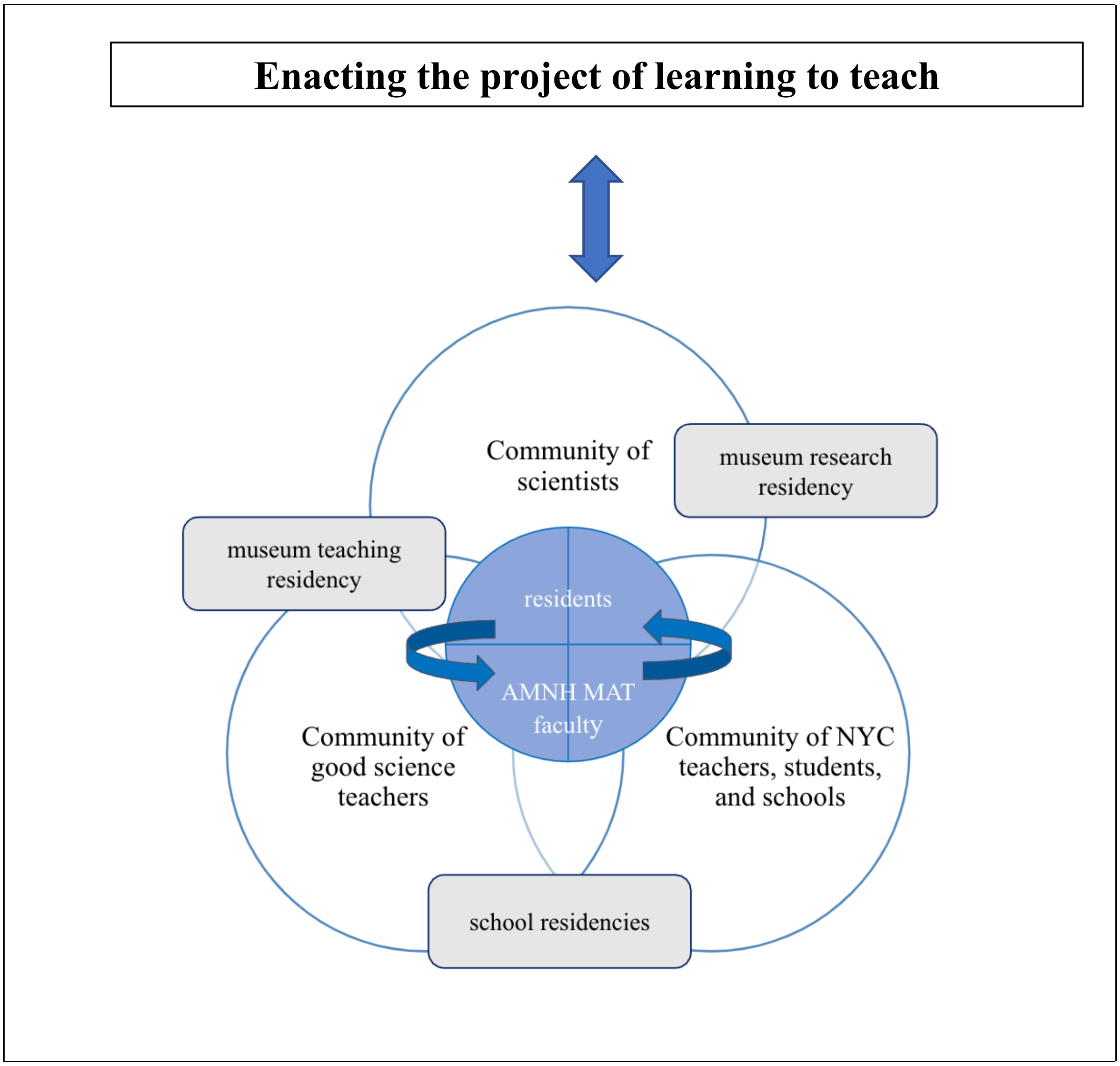
As Chapter 4 showed, the MAT program in Earth Science at the American Museum of Natural History achieved *conceptual* program coherence. The program consistently conceptualized learning to teach in urban secondary science classrooms as an endeavor involving cultivation of candidates' content knowledge and scientific identity as well as acquisition of research-based teaching practices, which would inspire learners from all backgrounds to develop their own identities as science-literate members of society. Chapter 5, which presents the second part of the main argument of this dissertation, demonstrates that the AMNH MAT also exhibited *structural* coherence. This *structural* coherence complemented the program's *conceptual* coherence in that key beliefs about *what* is involved in the project of learning to teach were embedded in *how* and *where* the project was enacted. In other words, how program leaders and founders conceptualized teacher preparation was highly consistent with the program's key structures, arrangements, and coursework, creating an aligned, integrated, and sequential experience of learning to teach for residents. I conclude this chapter by asserting that the AMNH MAT program's high level of overall program coherence was a vehicle for endeavoring to achieve the goal of changing the science conversation in schools, an ideal that was highly consistent with museum's larger public service mission.

Enacting the Project of Learning to Teach

This chapter argues that the AMNH MAT enacted the project of learning to teach by placing its residents at the nexus of three interwoven communities of practice: the community of scientists, the community of good science teaching, and the community of New York City teachers, students, and schools. These communities are depicted by the three major circles in Figure 14.

Figure 14

AMNH MAT's enactment of learning to teach: Three communities of practice



At the center of Figure 14 are the teacher candidates, referred to by the program as residents, and AMNH MAT faculty. In keeping with their discussion of communities of practice, Lave and Wenger (1991) would refer to the residents as "newcomers" to the field, while the faculty might be thought of as "old-timers," who helped broker residents' entrance into these three communities. AMNH MAT faculty, including museum scientists, teacher educators, and senior specialists, worked to introduce and assimilate the MAT residents into these three communities using key tools, assessments, and arrangements of the program.

The figure demonstrates that the relationship between the residents and the faculty was central to entrance into the three communities of practice, which are represented by concentric circles. These circles represent the fact that the communities were not separate components of the program, but rather that they were interwoven, concurrent, and overlapping experiences for the residents. The first community of practice was the community of scientists, into which residents were immersed within museum culture; this nurtured their identities as scientists and fostered informal science learning practices. The second key community of practice was the community of good science teachers. Residents' entrance into this community depended on deliberate teacher education pedagogies, including the particular tools and assessments that were used throughout the program to reify what good practice looks like. Finally, AMNH MAT residents were socialized into the community of New York City teachers, students, and schools, which depended on careful guidance from senior specialists, who helped the residents learn New York's requirements and the context of New York City schools and science classrooms during the school residencies.

In this chapter, I argue that one of the keys to supporting residents' entrance into these three communities of practice, which are discussed in further detail below, were the program's multiple residencies. Chapter 2 pointed out that research suggests that simply offering extended exposure to classrooms is not enough to prepare teachers for the complex work of teaching in urban schools. For instance, there are many issues related to the role of mentors in urban settings (Gardiner & Salmon, 2014; Garza et al., 2018; Goodwin et al., 2016; Kolman et al., 2017; Roegman et al. 2016; Wasburn-Moses, 2017), and there are many questions about whether science preparation programs actually incorporate the cultures, communities, and contexts of urban schools (Marco-Bujosa et al., 2020; Mensah et al., 2018; Rodriguez, 2015). In order to prepare science teachers for New York City schools and to socialize residents into three communities, the AMNH MAT program constructed a new version of the residency model for urban science teacher preparation by reinventing the concept of “field” in field experience. The residency model, which is now well-known, generally includes extended field experience in a classroom, often over the period of a year (Berry, Montgomery, & Snyder, 2008). With the AMNH program, as highlighted by the grey rounded rectangles in Figure 14, MAT residents participated in three different types of field experiences as a way to deliberately socialize them into teaching: a museum research residency, a museum teaching residency, and two school residencies. What makes this a reinvention of the concept of “field” for the AMNH MAT was that “field” didn’t just mean the school classrooms where residents worked, as is the case with most urban teacher residencies. Rather, for the MAT residents, “field” included the museum itself, two different classrooms in two different New York schools and the outdoor locations where they were engaged in “field research,” as elaborated below.

Communities of Practice: Teacher Preparation at the AMNH MAT

Together, AMNH MAT’s three communities of practice created what Wenger-Trayner and Wenger-Trayner (2015) call a “living curriculum,” which means that AMNH MAT residents’ learning was continuously developing in the context of the relationships they developed with each other, with their instructors and senior specialists, and with their mentor teachers. As I mentioned in Chapter 2, Lave and Wenger (1991) originally theorized the concept of *legitimate peripheral participation,* which positions newcomers as “peripheral” learners whose access to the knowledge, skills, and sociocultural practices of a given community is facilitated, at least in the beginning, by the old timers. This relationship was central to the AMNH MAT's "living curriculum" because it involved the ongoing negotiation of participation in three communities of practice. Wenger (1998) later built upon this concept by theorizing the multiple dimensions, connections, and negotiations of meaning involved in communities of practice. This chapter applies Lave and Wenger's (1991) and Wenger's (1998) ideas in order to theorize the AMNH MAT's enactment of the project of learning to teach as newcomers' entrance into three overlapping communities of practice scaffolded by the actions of old-timers.

As elaborated in Chapter 2, *communities of practice* are "groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly" (Wenger-Trayner & Wenger-Trayner, 2015). Underlying the concept of community of practice is the belief that learning is "fundamentally a social phenomenon" (Wenger, 1998, p. 3), and that those involved in communities of practice share passions, competence, and commitment to a particular domain, idea, or endeavor. A community of practice is best understood as "a joint enterprise [that] brings the community together through the collective development of a shared practice... [whereby] the definition of that enterprise- and therefore the meanings of the shared practice- are to be negotiated among the participants" (Wenger, 1998, p. 209). In other words, a community of practice involves a group of people, both new and veteran, who are committed to a joint *enterprise* and work on that enterprise through *mutual engagement;* in the process they build a *shared repertoire* of experiences, documents, and language as they learn together. Entry into a community of practice, then, is a matter of learning by working with others in particular ways, emphasized by Wenger (1998) as three dimensions of practice: *joint enterprise, shared repertoire,* and *mutual engagement*.

I utilize Wenger's key dimensions to highlight essential features of each of the three communities of practice into which the AMNH MAT residents were being socialized: I focus on the idea of *joint enterprise* to theorize how residents were socialized into the community of scientists; I highlight the concept of *shared repertoire* to elaborate how key program tools and assessments were used to socialize residents into the community of good science teachers; and I highlight the *mutual engagement* among AMNH MAT senior specialists, New York City mentor teachers, and residents to analyze how residents were socialized into the community of New York City teachers, students, and schools. It is important to note that all three of the program's communities of practice could be theorized using all three of Wenger's dimensions. However, in order to avoid redundancy and to highlight key features, I zero in on each community of practice using one of Wenger's dimensions as a lens.

According to Wenger (1998), socialization into coherent communities of practice involves multiple opportunities to concretize initiation into communities. These opportunities and access points are negotiated by more experienced others, whom Wenger calls *brokers*, by consistent use of particular artifacts, documents, terms, or concepts, referred to as *boundary objects*, and by experiences that allow newcomers to negotiate meaning, called *boundary encounters.* Wenger's point here is that brokers and boundary objects act as bridges for newcomers, assisting their entrance into and understanding of the people, procedures, ideas, and concepts of a particular community of practice. As Wenger (1998) asserts, "The job of brokering . . . involves processes of translation, coordination, and alignment between perspectives. It requires enough legitimacy to influence the development of a practice, mobilize attention, and address conflicting interests" (p.109). Nowhere was brokering more apparent than in the work of the program's senior specialists, who facilitated residents' learning across the AMNH MAT academic courses and the school residencies to help residents connect the core ideas needed to enter the community of

New York City teachers, students, and schools. The program's key tools and assessments functioned as *boundary objects,* or "artifacts, documents, terms, concepts, and other forms of reifications around which communities of practice can organize their interconnections" (Wenger, 1998, p. 107). Finally, Wenger's (1998) *boundary encounter* referred to *as immersion* worked to negotiate meaning for the participants as they entered the community of scientists because it offered them "a broader exposure to the community of practice being visited and to how its members engage with one another" (Wenger, 1998, p. 122).

All of these strategies for connecting newcomers to the interrelated communities of practice were forms of what Wenger (1998) referred to as *reification*. As I pointed out in Chapter 2, Wenger (1998) asserted that entrance into a community of practice involved a *participation/reification duality. Participation* is the ongoing, active social involvement in a community, as theorized in this chapter. *Reification* is the iterative process of codifying and clarifying participants' understanding of their experiences in tangible ways. Reification is always changing because participation involves the inevitably unplanned and/or unexplained occurrences that happen during entrance in any community that require explanation for newcomers. In this way, *brokering, boundary objects,* and *boundary encounters* all clarified the residents' understanding of the ongoing, varied, and multiple aspects of their participation all three overlapping communities. Wenger (1998) describes why this is the case:

> Reification is essential to repairing the potential misalignments inherent in participation: when the informality of participation is confusingly loose, when the fluidity of its implicitness impedes coordination, when its locality is too confining or its partiality too narrow, then it is reification that comes to the rescue. (p. 64)

Below I take up each of the three communities of practice in turn to theorize how AMNH MAT program leaders, founders, and faculty enacted the project of learning to teach. Figure 15 is offered below as a heuristic for reading the remainder of this chapter; it shows how I use Wenger's (1998) concepts to theorize the program's enactment of teacher preparation as socialization into three coherent communities of practice.

Figure 15

Theorizing enactment of AMNH MAT teacher preparation as communities of practice (Wenger, 1998)

	Community of scientists	**Community of good science teachers**	**Community of New York City teachers, students, and schools**
Wenger's key dimension of practice	joint enterprise	shared repertoire	mutual engagement
Program strategies for making connections	Arranging *boundary encounters*--immersion in museum culture	Using *boundary objects*--Observation Rubric, 5E Instructional Model	*Brokering* museum and school learning--senior specialists, NYC mentor teachers

The Community of Scientists

A key feature of program enactment at the AMNH MAT was its efforts to inaugurate residents into the community of scientists. This occurred through the residents' *immersion* in museum culture, resources, and activities, which deliberately situated the residents and museum scientists alongside one another as they engaged in the *joint enterprise* of doing science. The AMNH MAT's opportunities for informal science learning experiences and the science residency encouraged residents to work alongside scientists, inviting a sense of membership into the community of practicing scientists who were dealing with the complex world of earth science wherein single right answers rarely existed. According to Wenger (1998) *joint enterprise* involves community of practice participants' response to their environment and conditions; the community itself mediates its own production of practices, thereby constructing its own *enterprise.* As I pointed out in Chapter 2, Wenger (1998) argued that *joint enterprise* is what happens when members work together to "negotiate response[s] to their situation," making their experience "belong...to them in a profound sense" (p.77). The sense of *joint enterprise* was central as AMMH residents and scientists worked together on multiple projects, coursework assignments, and experiential learning opportunities. Wenger (1998) also argues that *joint enterprise* involves "developing specialized sensitivities, an aesthetic sense, and refined perceptions that are brought to bear on making judgments about the qualities of a product or an action" (p. 81). As I pointed out in Chapter 4, participants in the AMNH MAT assumed that science is a process of inquiry, often leading to more questions than definitive answers. In this way, the residents and the scientists *jointly* engaged in the *enterprise* of asking questions versus seeking answers.

In order to enact this practice of asking scientific questions, residents experienced *immersion* into informal science settings and into the practices of museum scientists. The idea behind this strategy was to foreground the informal science environment of the museum and the work of the museum scientists. In a way, this meant that the residents, while working with scientists, actually "'background[ed]' their membership in order to advance the boundary relation and maximize exposure to or influence on the practice of the visited community" (Wenger, 1998, p. 112). In other words, the residents at times were in the background, while observing and learning the practices of the scientists. That the residents were at times in the "background" as a way to immerse them into this community does not imply that residents' learning was passive. On the contrary, their active participation in the ongoing experiences at the museum was prioritized as way to nurture their understanding of the museum's ideology and affordances, with the goal of negotiating entrance into the community of scientists.

Central to the *joint enterprise* of AMNH MAT residents and scientists was the idea that science is a process, the work is never finished, and everyone is capable of asking important, meaningful questions. The idea here was that encouraging the asking of scientific questions would also become characteristic of the residents' own secondary classrooms, as they learned to empower their students, who were assumed to be knowledgeable and capable, to also enter into the community of scientists. This phenomenon of nurturing a scientist identity from scientist to prospective science teacher to secondary student was best described by a program graduate:

> And any time that we could have the kids make a model or do a lab or something we did. So, I got so used to looking for avenues for kids to…engage as scientists, and to make their own observations and discoveries and things,…that's something that I really tried to follow…because it also makes class more engaging, and it makes them like science that much more. (Interview #22, Program Graduate)

What follows in this section provides more detail about the manner in which the AMNH MAT engaged its residents in *joint enterprise* with the scientists and *immersed* the into museum culture and resources. In sum, the museum MAT socialized its residents into the community of scientists by assimilating residents into museum culture and using its resources, through its unique co-teaching model, and finally through its efforts to reinvent the "fieldwork" by introducing a museum science residency into the program.

Museum Culture and Resources. As introduced above, the museum itself was a key component of socializing AMNH MAT residents into the community of practicing scientists. By virtue of learning to teach in a world-renowned museum that placed an admittedly "high premium on expertise" (Interview # 7, Program Leader), the residents were being assimilated into a culture that deeply valued scientific knowledge and discovery. AMNH MAT residents were in close proximity to scientists and their cutting-edge work, and at times worked alongside scientists grappling with difficult geoscience concepts. For example, one program graduate described a museum scientist as "one of the greatest geology educators I've worked with . . . his ability to question was fantastic . . . his eye in the field was also fantastic" (Interview #23, Program Graduate). Clearly, MAT residents gained from working with the museum scientists because they felt both inspired and encouraged.

Scientists helped immerse the residents into informal learning opportunities and state-of-art resources of the museum, making for a smooth entry for the residents into the community of scientists. One teacher educator captured the experience of learning to teach science in a museum:

> Just access to the scientists and the specialness of this place [is] so cool …At this place, we have a bunch of scientists that we can put [residents] in direct contact with. The content courses the scientists teach along with an educator. The second summer, the practicum in the summer, they actually do research. So, I think, to have that experience at the beginning of their teaching career. I think is really special. So not that universities don't have scientists too. It's like, I think the culture here is a little different. (Interview # 9, Program Faculty)

That the culture was "special" was further explicated by a scientist who taught in the AMNH MAT, who pointed out that "the integration with real practicing scientists is probably what sets [the program] apart . . . they're actually looking at how science is done" (Interview #

12, Program Faculty/Scientist). In describing her teaching methods, she indicated that “there's usually not a beginning and an end that I necessarily have in mind. There's one beginning, and maybe 20 different ends, depending on what the students are observing and where they direct the answer” (Interview #12, Program Faculty/Scientist). This student-centered approach to teaching content, where questions, not answers, are made central, is a key component of informal learning, or the kind of learning that takes place in museums. She further argued that this is what allowed the residents to go into their classrooms and build the idea with their students that they, too, could be scientists. She went on to describe how she worked with the AMNH MAT residents to understand teaching:

> How can you… put it in terms of, ‘This is the question, how can we come up with a hypothetical answer based on things we've collected?’ And that is what happens in a museum every day. It's what we show in our halls. It's what we show in our classrooms and our field trips. And, understanding that as a creative way of teaching students very specific content, I think, can be very unique. (Interview #12, Program Faculty/ Scientist)

By working alongside and learning from scientists, the AMNH MAT residents were not only participants in the community of scientists, but they were learning how to foster this kind of experience for their own students as well. For instance, one MAT program graduate described the value the AMNH MAT placed on museum-based learning this way:

> The mission is to prepare teachers to teach informal science education to New York City urban youth…So, practicing different inquiry methods, different hands-on methods, taking students out of the classroom, bringing them places, doing field work, and doing authentic science inquiry with projects, rather than, more of the formalized talk and chalk. (Interview #21, Program Graduate)

As this graduate revealed, the AMNH MAT offered its residents several opportunities to become immersed in teaching and learning in the informal science environment of the museum, suggesting that bringing these practices into the formal setting of the classroom could only work to enhance teaching and learning therein.

Socializing candidates into the community of scientists was also about bringing museum resources to classrooms. During one of my observations at the museum, for instance, I observed MAT residents lined up, waiting to sign out museum resources and materials to take with them to their residency classes (Observation # 13). These were presumably resources that were otherwise unavailable in their residency schools, such as museum artifacts, curriculum materials, and technology such as overhead projectors. That the residents were bringing these affordances of the museum to the schools is an example of how they were assimilated into a culture of informal science learning as a valuable tool for teaching science.

Co-teaching Model. That the program was committed to helping residents enter into the community of scientists was also demonstrated through its one-of-a-kind co-teaching model. As noted, all of the courses in the museum MAT's program were co-taught by a museum curator and a PhD level science educator (Institutional Document #18, *2011 NSF, DRK-12 Proposal;* Institutional Document #19, *2014 TQP Grant Proposal*). This feature distinguished the MAT program at the AMNH from many other nGSE programs, which utilized classroom teachers as instructors (e.g., High Tech High GSE, Sposato GSE, and TEACH NOW GSE), and also from many teacher preparation programs at colleges and universities, which do not have scientists actively involved in the preparation of teachers. The museum's unique arrangement was designed to emphasize the importance in teacher preparation of deep science content knowledge as well as to engage residents in research-based teaching practices. One teacher educator, who co-taught two courses in the program with two different museum scientists, described the benefit of having this level of expertise for the residents' experience of learning to teach:

> Obviously, having co-teaching pairs is something that every institution doesn't necessarily have that luxury to afford…I think it's especially useful and helpful [for] the scientist and the educator in the two courses that I teach because I can often just be like, 'Oh, that's a really deep science question that this other person can answer for you,' instead of making up an answer or saying I don't know. We have an expert right here who can help. (Interview # 10, Program Faculty)

To encourage residents to enter the community of practicing scientists, both methods and content courses were co-taught. In a course on weather and climate change, for example, small groups of residents explored how living organisms both alter and are altered by climate by using a simulation model with real data (Observation #1, *Weather and Climate Change* course). In an interview, the scientist co-instructor pointed to the importance of "working with the teachers on actual data . . . I think [this] gives them an edge when they get into the classroom to really be able to convey some of the complexities of what we know and don't know about the earth" (Interview # 12, Program Faculty/ Scientist). The pedagogies used by the instructors in the MAT program immersed the residents into the community of scientists who deal with the complex world of earth science where questions are generally privileged over answers.

Another example where AMNH MAT faculty negotiated residents' entrance into the community of scientists was in one of the key courses in the program, which was offered over the course of the academic year (September-May). This course was titled *EDU/SCI 660 Earth Science Literacy Journal Seminar.* This course was taught by a teacher educator, who was also a senior specialist in the program, and a museum scientist, who was also a program leader and co-founder. The purpose of this course was to provide residents with multiple opportunities to engage in the practice of teaching earth science rooted in current research, practices, and processes of science. As the course title suggests, the course also provided ample opportunities for the residents to reflect on their learning. In fact, they were specifically asked to write a two-page reflection after the conclusion of each course meeting. This reflection asked residents to share their understanding of the earth science content as well as to reflect on pedagogy and practices learning in class (Program Document # 303, *EDU/SCI 660 Earth Science Literacy Journal Seminar* syllabus). The main objectives of this course reveal its commitment to infusing science teaching with science content knowledge:

> Residents…will be able to:
>
> 1) Understand how scientists ask questions, develop and use models, plan and carry out investigations, analyze and interpret data, use mathematics and computational thinking, construct explanations, engage in argument from evidence and obtain, evaluate, and communicate information through scientific journal articles, in-class activities, and written assignments;
>
> 2) Teach the process of science integrated with scientific concepts and ideas specifically related to Earth science;
>
> 3) Use media and written materials presented in class to infuse scientific practices, concepts and ideas into their own teaching;
>
> 4) Understand that Earth science is the physical, chemical, and biological study of Earth as a system.
>
> (Program Document # 303, *EDU/SCI 660 Earth Science Literacy Journal Seminar* syllabus)

Clearly, this ten-month long course was designed to ensure that the residents had many opportunities to be immersed in geoscience concepts. This course also aided residents' conception of science as process, with the goal of being able to in turn teach science as process to their own students. The big ideas of this course centralized the importance not only of scientific concepts and practices, but of specific pedagogical practices designed to nurture students' understandings as well.

In one class session of this course that I observed, MAT residents were immersed in several activities designed to hone their scientific knowledge as well as an opportunity to practice specific teaching practices designed to foster the concept of science as a process. For instance, the class session opened with a group of three students presenting the readings assigned for the week, which were on ocean acidification (Observation #2, EDU/SCI 660). They demonstrated a deep understanding of science concepts in their lecture. Additionally, all of the tasks the residents engaged in during this class centered around the content of ocean acidification. At times, residents were asked to record their own synthesis and summaries of learning in composition books (Observation #2, EDU/SCI 660). At other times, they were called upon to connect this content to *Next Generation Science Standards* or to develop and respond to questions raised (Observation #2, EDU/SCI 660). The pedagogical design and instructional implementation of this course was clearly influenced by the collaboration of a science educator and a scientist, as residents continued to oscillate back and forth between science concepts and teaching practices. AMNH MAT residents were socialized into the community of scientists by being directly taught by scientists as well as being called upon to consistently connected the process of science to the teaching of science.

Museum Science Residency. A final aspect of AMNH MAT program enactment that contributed to residents' entrance into the community of scientists was the museum research residency, one of three types of residencies in the program, as noted. The museum science residency is the best example of the program's unique approach to science teacher preparation because it immersed residents in a research field site, requiring them to conduct research and report their findings. This is not a typical approach to enacting science teacher preparation, including in programs that prioritize field experiences, such as teacher residencies. The AMNH residents were deeply absorbed in a week-long field research experience at Black Rock Forest, located about an hour and half outside the city in Cornwall, New York. This experience, which occurred in the second summer of the program, was entirely centered on the residents as scientists, with little direct application to teaching science. This required research residency experience makes the case that the AMNH MAT reinvented what it meant to conduct "fieldwork" in teacher preparation.

The museum science residency also served as a capstone, culminating project, which was required for earning the master's degree at the museum. As I mentioned in Chapter 4, AMNH MAT faculty were committed to the idea that their residents, prospective teachers of science, needed to be competent in the content of earth science. This course was the ultimate example of this, as its objectives revealed:

> We will emphasize practical applications of the geosciences, field techniques, use of field and scientific equipment, and some of the many ways research is conducted in Earth Sciences. Specific goals include:
>
> - Develop an understanding of local (NYC, NYS, some NJ) geology and tectonic history, which may be useful in future teaching positions.
> - Learn proper methods for collecting, recording, and organizing geoscience data.

- Learn and implement safe field and laboratory practices and be able to communicate and demonstrate these practices to peers and future students.
- Complete a small research project, including all phases of research: sample/data collection, laboratory/data analysis, data interpretation, and reporting of results in both written and oral format.
- Use the skills and experiences of the Summer Research Practicum to develop a teaching resource for use in future classrooms.
- Gain a more complete understanding and appreciation for scientific research and the scientific process that is necessary for scientific advancements (Program Document # 372, *SCI680 Syllabus)*

I observed part of a two-hour presentation conducted by the residents of Cohort 8, who were about to graduate and become teachers of record in New York high-needs schools. Five residents presented their findings from a quantitative study of bivalves (i.e., clams, mussel, oysters, and scallops) (Observation #12, *Museum Science Residency* Presentations). Through sophisticated quantitative analysis, the residents found, among other things, that if a species was not affected by the forces of extinction, its body size would grow over time (Observation #12, *Museum Science Residency* Presentations). Interestingly, this finding, which was consistent with other research in the field, supported the argument that mass extinctions "fundamentally shift the set of traits that mark groups of species for destruction" (Garthwaite, 2021). The AMNH MAT grads presented to an audience of about 30 AMNH faculty, some of whom were connected to the MAT program, and some of whom were not. The audience posed interesting, probing questions that the residents seemed eager and equipped to answer (Observation #12, *Museum Science Residency* Presentations). Overall, this research practicum helped achieve the MAT's goal of providing its residents with an experience commensurate with a master's in Earth Science, since it was entirely based in scientific knowledge and research. The level of expertise required to accomplish this field experience exemplified *joint enterprise* because the residents, alongside the scientists, were mutually accountable for their findings, their questions, and their overall research. Indeed, in this instance, the residents *were* scientists.

A final point to make about the residents' socialization into the community of scientists is that *immersing* the residents into a context where deep science content knowledge and curiosity were part of everyday life and encouraging them to bring that knowledge and disposition into the schools was a core value of the AMNH MAT's program enactment. Along these lines, in a chapter titled "Breaking Dichotomies" written for an edited book called *Intersections of Formal and Informal Science* (Avraamidou & Roth, 2017), AMNH MAT faculty argued that residents transferred the teaching knowledge, skills, and practice they learned in the informal learning setting of the museum to their school residencies. To make this point, they articulated that the museum and the school "ha[d] porous boundaries…Residents who have learned to use the structures of the museum carry that agency and associated structures into their formal classroom space and then back" (Institutional Document #15, Gupta, Trowbridge & Macdonald, 2015). These experiences, facilitated by AMNH faculty, including the scientists, left the residents with the impression that an identity as a scientist was key for becoming a good science teacher. In other words, because they engaged in a *joint enterprise* with museum scientists in the act of learning to teach, residents were able to move back and forth through the community of scientists at the museum and the other two communities of practice: good science teachers and New York City teachers, students, and schools.

The Community of Good Science Teachers

A second major feature of the enactment of learning to teach at the AMNH MAT was the socializing of candidates into the community of good science teachers. Wenger (1998) theorized that over time, communities of practice develop and revise their respective *shared repertoires,* creating resources that help community participants negotiate what it means to become members, such as routines, words, ways of doing things, stories, genres, discourse, actions, or concepts. For the AMNH MAT program, the *shared repertoire* of the community of good science teachers was represented in four key program documents, which were resources for residents' learning as well as instruments for their evaluation by mentors and senior specialists. These resources functioned as what Wenger calls *boundary objects* in that they reified what it meant to be a member of the community of good science teachers by offering a "nexus of perspectives" (Wenger, 1998, p. 107), designed for "participation rather than just use" (p. 108). Put another way, *boundary objects* included ideas and concepts represented from all participants involved and were part of the daily work of practice itself. The notion of "boundary" itself connotates that there is a crossing over that occurs when entering a new community of practice. *Boundary objects,* then, help to do the work of bridging ideas, concepts, patterns, ways of being and doing from one community of practice to the next or from one's identity as a newcomer to one's eventual identity as an old-timer in the community. Put another way, in the AMNH MAT program, these key instruments were used as strategies for connecting the residents with the ideas, practices, and dispositions needed for good science teaching. Lave and Wenger (1991) argued for the importance of a shared discourse for those newly entering communities of practice, emphasizing the need to learn by active participation: "For newcomers then the purpose is not to learn *from* talk as a substitute for legitimate peripheral participation; it is to learn *to* talk as a key to legitimate peripheral participation" (p. 109). Three of the four main instruments used at the AMNH MAT, described in detail below, illustrate the program's efforts to prepare candidates not simply to learn *from* good science teachers, but to learn *to think like* and *to talk like* and *to be* good science teachers.

The key AMNH MAT program tools also revealed "the discourse by which members create[d] meaningful statements about the world, as well as the styles by which they express[ed] their forms of membership and their identities as members" (Wenger, 1998, p. 83). In other words, the program's key tools and instruments, three of which were the *AMNH MAT Observation Rubric Tool* (hereinafter Observation Rubric) and two separate instruments contained in the *5E Instructional Model* (hereinafter the Unit Plan Tool and the Lesson Plan Tool), represented the "discourse" through which its participants understood what it meant to be good science teachers. It is important to note that a fourth key tool, the *Dispositions Continuum for Teaching and Learning Tool*, was also used to communicate what it meant to be a good science teacher according to the MAT program. However, unlike the other two this tool was not used as an assessment; it was primarily meant as a tool of self-reflecting for the residents (Program Document #43, *Dispositions Continuum for Teaching and Learning Tool*). Because of the nature of the AMNH MAT's dispositions, I describe this tool in Chapter 6 to highlight the manner in which the program specifically attended to preparing its candidates for urban contexts.

The Observation Rubric and the 5E Instructional Model were simultaneously referred to as "tools" and "assessments" at the AMNH MAT. While not made explicit in program materials, my analysis of multiple data sources suggests that the word "tool" was used to refer to the observation rubric when it meant a useful mechanism for carrying out the work of good science teachers. The term "assessment," which has many meanings in education, was used when it meant an instrument through which the residents' teaching performances, during coursework, teaching at the museum, and in the school teaching residencies, were evaluated. The Observation Rubric in particular was used as a tool by both the residents and the faculty as a starting point for discussing, planning, and enacting good science teaching. It was also used to assess the residents' ability to teach good science lessons during each teaching experience that was observed by teacher educators both at the museum and in the school residencies. The 5E Instructional Model was used a bit differently. This was a blueprint for how to lay out a five-lesson instructional unit. In this sense, the model was used as a tool for helping residents learn how to construct good units for the science curriculum. As this chapter will show, the 5E Instructional Model was used in multiple assignments throughout the program's coursework, making it also form of assessment. Using the Observation Rubric and the 5E Instructional Model in this dual way- as both devices used by those who were engaged in learning how to do good science teaching and as instruments of evaluation used by those assessing them- demonstrates the heavy emphasis the AMNH MAT placed on these documents to reinforce good science teaching.

The AMNH MAT faculty themselves developed the Observation Rubric (Program Document #42), which was utilized more pervasively than any other document throughout the program, making it a clear *boundary object* for entering the community of good science teachers. To examine the criteria of the Observation Rubric, see Appendix H. A second *boundary object* used by the AMNH MAT was the well-known 5E Instructional Model, created by the organization, the Biology Sciences Curriculum Study (BSCS). This instructional model included two additional tools: the AMNH Unit Plan Tool (Program Document #45) and the Lesson Plan Tool (Program Document #44). Most of the experiences where these *boundary objects* where used involved practicing specific teaching strategies identified as a *shared repertoire,* which were instantiations of the AMNH MAT's beliefs about the nature of good teaching. In particular, the museum teaching residency, which was the residents' first foray into teaching, was also the resident's first opportunity to make sense of how the Observation Rubric connected to actual classroom teaching.

In the sections that follow, I describe key tools and experiences that together were used to socialize the residents into the community of good science teachers, as defined by program leaders, faculty, and specialists: the Observation Rubric and the 5E Instructional Model*,* both *boundary objects,* and the opportunities to practice teaching during program coursework and during the museum teaching residency, examples of the *shared repertoire* of good science teachers. This makes the argument that the faculty and leaders of the AMNH MAT worked to develop skillful practitioners by anchoring the project of learning to teach in these key artifacts, which were both central pieces of the *shared repertoire* of good science teaching practices *and* key *boundary objects* that helped the residents cross over into the community of good science teachers. In other words, the AMNH MAT program's *shared repertoire*—or its "way of doing things" (Wenger, 1998, p. 83)—was captured in the core tools of the Observation Rubric and the 5E Instructional models. These tools functioned as *boundary objects*, or "reifications around which communities of practice can organize their interconnections" (Wenger, 1998, p. 107). As I mentioned previously, *reification* as Wenger (1998) defined it, is a process complementary with participation, meant to help participants in a community of practice make sense of their experiences by encapsulating the knowledge of the community in concrete objects and artefacts.

Observation Rubric. AMNH MAT faculty's beliefs about what constitutes good science teaching were crystallized in a key boundary object, the Observation Rubric (Program Document

#42). In fact, this tool was used pervasively to concretize good science teaching, especially during observations of teaching either in the museum setting or in the school residencies. Along these lines, a document that program leaders prepared for accreditation purposes highlighted the AMNH MAT's commitment to incorporating the Observation Rubric throughout multiple aspects of the program:

> The Observation Rubric is used to assess the development of the AMNH MAT candidates' pedagogical skills over the course of their clinical practice. The rubric measures candidates' abilities to implement science instruction, recognize and respond to students' needs, use appropriate content knowledge in instruction, and explicitly attend to safety concerns in the classroom…The Observation Rubric is used by the program's clinical faculty (Summer 1 museum teaching residency faculty, MAT faculty senior specialists, and partner school mentors). (Institutional Document #2, *CAEP Accreditation, Program Assessment Addendum Update*).

The Observation Rubric was a 19-page document with seven multipronged criteria for good science teaching. This expansive document included pedagogical approaches, such as "aligns science instruction with state standards appropriate to grade level," "develops and manages diverse and effective student groups," and "uses questioning and discussion strategies." It also included instructional strategies, such as "uses a variety of strategies to assess students," "uses technology effectively to support learning," and "plans for and attends to material safety" (Program Document #42). The above criteria were derived from Ball and Forzani (2011, 2012) high-leverage teaching practices and Windschitl et al.'s (2018), ambitious science teaching framework, both of which are described at length in Chapter 4. The Observation Rubric focused on:

> the various skills and abilities that residents should demonstrate to show achievement of [7 of the 11 AMNH MAT] program standards...The evidence collected using the rubric over several observations is used each semester during the Academic Milestone Meetings (January and June) at which residents progress in MAT program is evaluated. Residents are expected to average 'Basic' across all rubric components by their January meeting and to average 'Proficient' by their June meeting. (Program Document #42).

Clearly, the Observation Rubric was used regularly and consistently throughout all aspects of the program to both instruct and to monitor the residents' ability to engage in good science teaching. Following the tenets of the rubric was a key part of the *shared repertoire* of the community of good science teachers, as evidenced by the fact that facets of the rubric were referred to each time residents were engaged in actual teaching activity during coursework or in their residency experiences. Program faculty referenced the rubric as an assessment during milestone meetings for residents, further making it clear that the rubric was a central *boundary object.* The Academic Milestone Meetings, described as "vital to the MAT program's monitoring of candidate progress" (Institutional Document #8, *CAEP Standard 3 Summary Statement*), occurred in January and June and were formalized assessments of candidates' progress and ability to complete the program. These meetings were "attended by three faculty (one MAT science faculty member, one MAT education faculty member, and the senior specialist assigned to the candidate's residency school) and the candidate, and they t[ook] place at the end of the first school residency in late January and then again at the end of the second school residency in June" (Institutional Document #8, *CAEP Standard 3 Summary Statement*). The point here was that residents who were proficient—in that they were performing in a way consistent with the criteria spelled out on the rubric—were assumed to be well on their way to becoming members of the community of good science teachers.

Another point to make about the Observation Rubric is that it was co-constructed by AMNH MAT faculty to codify their beliefs about good science teaching. What this shows is that the AMNH MAT believed that in order to become members of the community of good science teachers, residents needed to learn the particular skills and practices included in the Observation Rubric. When describing the rubric, for instance, one co-founder and program leader indicated that,

> [it] is our main tool for showing [the residents] what are we asking [them] to do… Definitely, I would say everybody is mindful of it…I will say that…the work we've done over the last few years to evolve the observation instrument, actually helped us a lot, because all of our teaching faculty were involved in those discussions. (Interview # 7, Program Leader)

This was a point made by several teacher educators, and the Observation Rubric was often mentioned when I asked about what they believed effective teaching looked like. Faculty often noted that they had co-constructed this assessment tool carefully and with research-based practices in mind. This is best highlighted by pointing to what one teacher educator/senior specialist indicated: "We've kind of articulated what an effective teacher is via our observation rubric, which I'm hoping is a living document that over time changes. It already has in eight years in the program" (Interview #10, Program Faculty). This idea that the Observation Rubric changed many times throughout the years is in keeping with the concept of *reification,* which in itself is an ongoing process, because "as a constituent of meaning" it is "always incomplete, ongoing, potentially enriching, and potentially misleading" (Wenger, 1998, p. 62). That the

Observation Rubric was an iterative document meant that it served the participants entering of the community of good science teachers well because its constant revision made it current and relevant for the residents. As the creators of this document, the AMNH MAT faculty asserted their authority over the kind of practices that made for good science teaching. In this way, the rubric was very clearly a *boundary object,* communicating what membership into the community of good science teaching meant.

Residents were introduced to the Observation Rubric during a Saturday morning three-hour workshop. That the AMNH MAT had a specific day carved out for an introduction to this tool and assessment, which contained curated criteria that exemplified what counted as good science teaching, clearly demonstrated that they saw the rubric as a crucial component to learning to teach. Throughout the workshop, residents had the opportunity to unpack rubric criteria and examine how they were related to teaching practices with which they were familiar. The instructors in this workshop stressed the expectation that over time and with support, the residents would become adept at incorporating rubric criteria into their teaching practices (Observation #9, *Observation Rubric Workshop*). In short, MAT program faculty invited residents to form their identities as members of the community of good science teachers by utilizing the language built into the Observation Rubric, deliberately pointing out the *shared repertoire* of the community, which included ways residents were expected to talk about, think about, and assess their own lessons.

A final point about the Observation Rubric is that it was used to assess the development of the AMNH MAT candidates' pedagogical skills over the course of their entire year-long clinical experience in schools. This is shown in three excerpts below, taken from grant proposal narratives or accreditation documents written by MAT program leaders:

- "Residents are also monitored and given feedback through the program's Observation Rubric" (Institutional Document #21, *AMNH MAT's 2019 TQP Grant Project Narrative*).
- "Faculty seek to ensure that planning, instruction, and assessment course assignments are based in the clinical experience and are designed to support development of candidates' abilities in the areas measured by the Observation Rubric" (Institutional Document #2, *CAEP Accreditation, Program Assessment Addendum Update*).
- "The rubric measures candidates' abilities to implement science instruction, recognize and respond to students' needs, use appropriate content knowledge in instruction, and explicitly attend to safety concerns in the classroom" (Institutional Document #2, CAEP Accreditation, Program Assessment Addendum Update).

The reason behind this heavy monitoring was that the AMMH MAT faculty believed that good teaching was exemplified by the knowledge, skills, and dispositions laid out in the Observation Rubric, which made this assessment function as a *boundary object,* paving the road to entrance into the community of good science teachers for the residents. For instance, the rubric's third standard stated that: "The resident understands and uses a variety of instructional strategies to encourage student development of critical thinking, problem solving, and performance skills" (Program Document #42, *AMNH MAT Program Observation Rubric*). The subsequent criteria in this standard included specific strategies such as "surfaces and responds to students' ideas," "relates science to the personal lives, needs, and interests of students" and "uses questioning and discussion strategies" (Program Document #42, *AMNH. MAT Program Observation Rubric*). At the AMNH MAT, these practices were measured, evaluated, and assessed for the purposes of nurturing residents' teaching performance in the classroom.

5E Instructional Model. A second *boundary object* used to connect candidates to the practices of participants in the community of good science teachers was The Unit Plan Tool and the Lesson Plan Template, two templates derived from the research-based the 5E Instructional Model. Taken together, these tools provided a specific blueprint for how to conceive and carry out good science lessons, suggesting that there were also considered to be essential parts of the *shared repertoire* of good science teaching practices. For example, in one particular course, the unit plan was described this way:

> The MAT program at AMNH defines a unit plan as an instructional sequence of 4-8 lessons that completes a full learning cycle described by an accepted instructional model (such as 5E or 7E (BSCS, 2016)). The unit plan supports students' conceptual understanding of a central focus and includes appropriate learning goals and lesson objectives. An instructional model is an organization of the unit that helps to achieve instructional goals and maximize learning. The BSCS 5E Instructional Model is a research-based model that consists of five phases that each have a specific function and contribute to the teacher's coherent instruction and the learners' development of skills and knowledge. (Program Document #87, *Origin of the Universe and the Solar System Unit Plan)*

Interestingly, the unit plan tool was referred to by two AMNH faculty as a "narrative through line" for teaching specific scientific concepts, ideas, and practices (Interview # 9, Program Faculty; Observation #6, *Museum Summer Residency*). This concept, mostly used in literature, refers to the idea that there is, or ought to be, connecting themes or plot lines in a larger work, operating in a way as the backbone of the story. That the faculty referred to the unit plan this way demonstrates that they saw the unit plan as a way to create a cohesive sequence of lesson that all add up to one central idea or set of ideas, a "storyline" of sorts. This points to the discourse used to construct the idea of what good science teaching is, making it an important aspect of the *shared repertoire*.

The unit plan demonstrated that good science teaching involved a series of phases, all of which were connected together to examine one "big idea," making for a cohesive learning experience for secondary students (Program Document #388, *Big Ideas and Essential Questions)*. These phases were enacted as five lessons, all of which had a specific aim. The first lesson in the unit was called "Engage," where AMNH MAT residents were meant to offer an opening activity, access prior learning, and stimulate interest in their students. The second lesson, "Explore," provided science practices and concepts for students to examine, offering multiple access points for learning. The third lesson, "Explain," worked to connect students' understanding to scientific concepts and vocabulary, deepening their understanding. The fourth lesson, "Elaborate," required students to connect what they have learned to their own lives and to apply new concepts to other learned concepts. Finally, lesson five, called "Evaluate" is the culminating component of the Unit Plan Tool, where the prospective teachers, AMNH MAT residents, analyzed student learning through assessments, by asking additional probing questions, and by asking students to reflect on their own learning (Program Document # 45).

AMNH MAT residents were required to create unit plans in at least two courses throughout their time in the program. This stringent requirement revealed that the unit plan tool itself acted as a *boundary object,* working to prepare residents to be participants in the community of good science teachers by requiring them to shape their own ideas about what good teaching looks by incorporating research-based concepts and ideas. For instance, I observed the residents working on one section of a unit plan in a course titled *SCI652, The Solar System*

(Observation #7). As they worked on their "Explain" lessons, the third lesson in the 5E sequence of lessons, they consulted each other and AMNH MAT faculty. After this course, I interviewed the science teacher educator, who described the enactment of the unit plan tool this way:

> [It's]…a cool way to help people…think about how to structure and how to put their instruction together. So that it tells a story as an arc and uses a research-tested instructional model. It's a pretty intensive curriculum design…It's tools that take you through different stages of planning for instruction that is designed for the [Next Generation Science Standards]. And [today] we were doing tool three…And tool three is where you learn more about an instructional model if you need one, learn about how phenomena fit, and what's the role of phenomena in your instruction. So, it kind of helps you develop the story a little bit more. And before that they would have put together a blueprint of all the concepts. (Interview # 9, Program Faculty)

This teacher educator prioritized the Unit Plan Tool in his course because he believed "intensive curriculum design" was used to "tell a story as an arc," making this tool a component of the *shared repertoire* of good science teachers because the residents themselves were encouraged to use this tool to create their own "storyline" for their sequence of lessons. The AMNH MAT residents were guided to create their own blueprint of a unit plan for their students, using the AMNH MAT's Unit Plan Tool as a structure upon which to build out their own ideas for teaching science practices to their students. The tool functioned as a *boundary object by* offering the residents the chance to bridge what they understood about science teaching and learning with the research-informed structure for how to construct a good science lesson.

As noted above, the AMNH MAT Unit Plan Tool was comprised of five phases. Each phase is itself a lesson, meant to be mapped out via the AMNH MAT Lesson Planning Tool

(Program Document # 44, *Lesson Planning Tool*). In this way, the template that the AMNH MAT required its residents to use when planning lessons is a component of the AMNH Unit Plan Tool. Each lesson that residents created was required to have a central focus on a scientific concept which was generally a provocative, open-ended question. Additionally, the lesson planning tool required that residents incorporated *Next Generation Science Standards* into their lessons, including but not limited to such science practices as: asking questions, developing and using models, analyzing and interpreting data, and constructing explanations (Program Document # 44, *Lesson Planning Tool*). MAT residents were required to comment on the "theories of learning and educational research on effective teaching" that supported "the decisions [they] have made about the design and implementation of this learning experience for students" (Program Document # 44, *Lesson Planning Tool*). Finally, in addition to standard lesson plan components such as activating prior knowledge and addressing preconceptions, MAT residents were also required to account for all learners by planning for differentiated instruction as well as examining the "language demands" of the required texts for the lesson (Program Document # 44, *Lesson Planning Tool*).

The Lesson Planning Tool was a template designed to demonstrate a way of thinking about creating good science lessons. In this way, it acted as a *boundary object* because it was a tool connecting the practice of good science teachers, members of this community, to the practices of the AMNH MAT residents. In addition to writing and implementing lessons in their museum and school teaching experiences, the residents were also required to create and enact lessons during coursework. In fact, one of the key courses in the program, *EDU/SCI 660 Earth Science Literacy Journal Seminar* required residents to complete an assignment called Teaching the Process of Science, which was described this way:

> Residents will develop and teach two lessons about one practice of science... The pair of lessons should be either Engage & Explore lessons or Explore & Explain lessons (as per the 5E instructional model). Residents will develop lesson plans that include differentiation of instruction for English Language Learners and/or Special Needs students. It is important to use the Lesson Plan Tool so the instructors can see and provide feedback on the thinking that residents are incorporating into their lesson plans …Residents will teach these two lessons to a class of students during one of their school residencies and will be observed by a mentor teacher and another MAT resident. (Program Document #355, *EDU/SCI 660 Earth Science Literacy Journal Seminar* Teaching the Process of Science Assignment)

What is important to notice here is that the Lesson Plan Tool was a pivotal component of the *shared repertoire* of good science teaching practices because it was a template that outlined a way to think about how good lessons should be planned. Interestingly, this tool also acted as a *boundary object* in that the socialization into the community of good science teachers depended on the residents' ability to utilize this template to both construct and to reflect on their own teaching.

Practicing during Coursework. A third key aspect of the AMNH MAT residents' socialization into the community of good science teachers was the careful tutelage of the teacher educators throughout coursework**.** AMMN MAT faculty mediated residents' understanding of good science teaching by offering many opportunities for residents to practice specific strategies during coursework. These included such practices as "eliciting student responses" and "constructing scientific explanations" (Observation #13, *EDU 620: Curriculum and Instruction for Teaching Earth Science in Secondary Schools;* Program Document #42, *AMNH MAT*

Observation Rubric Tool), which were consistent with the ideas of high-leverage practices and ambitious science teaching. Also important to mention here is that MAT teacher educators used McNeill and Krajcik's (2012) research-based practice "constructing scientific explanations" in this course to teach residents the explicit instructional model "claim, evidence, and reasoning," which is a structured model for thinking, talking and writing about science. These practices, and the work to improve residents' ability to incorporate them into their own lessons, contributed to the *shared repertoire* of what it meant to be a participant in the community of good science teachers. To best illustrate this point, I offer two examples where the AMNH MAT practiced using specific teaching strategies during their coursework.

First, during a course called *EDU620: Curriculum and Instruction for Teaching Earth Science in Secondary Schools,* I observed two AMNH MAT faculty—one science teacher educator and one scientist—facilitate a group of three residents' who were practicing "eliciting student ideas" (Observation # 13). In other words, the residents were enacting a lesson that they had prepared prior to this particular class session; the lesson's objective was to get students to share their ideas with the whole class and with each other. Because this was a kind of "simulated teaching," the "students" in this case were the other residents in the class. This simulated teaching, which was sometimes called a "demo lesson" by AMNH MAT residents, was followed by a round of feedback from both faculty and residents. The teacher educator who taught the course described the purpose of this activity this way:

> I think that getting students talking, surfacing ideas is a big part of it. Sharing ownership in the classroom, that it's not just, 'I'm the teacher. I'm going to stand here and deliver all this stuff to you,' but instead, thinking about where the places where the kids can be

having conversations with each other, kids can be coming up and teaching their peers. (Interview # 10, Program Faculty)

Just before this demo lesson began, one AMNH co-teacher indicated that "the function of this teaching is to get students ideas going" (Observation #13). She also indicated that this "can attach to the Observation Rubric" (Observation #13). During this demo lesson, I observed three residents team teaching a lesson on air pressure, which took the students through a series of opportunities to share their ideas, which were bucketed into four parts of the lesson: "safety, predict, observe, explain" (Observation #13). After the demo lesson was over, the class engaged in a feedback session. There were two appointed "noticers," AMNH MAT residents, who facilitated the session by sharing their ideas about the teaching they just witnessed. The "noticers" mostly offered positive feedback, including that their "teacher" peers had good wait time, captured students' ideas well, and modeled a thinking process (Observation #13). The residents also seemed curious about this lesson, asking lots of questions of each other about "what actually are clouds?" (Observation #13). This demonstrated the residents' enthusiasm for the opportunity to not only engage in practicing teaching, but to reflect on it together as well.

During her interview, one resident mentioned the impact of this particular activity on her own process of learning to teach:

> That class I think has been great, especially, when they have us do the eliciting student ideas thing**.** Every class where we do like a demo and then we... just like the idea of doing that and like how, how do... how, how am I supposed to like act and what do I say when doing these things?...But, you know, that's like how I would, I would do it. You know because I have no idea. So just like have guidance of like this is how you get ideas from students, this is how you pull ideas out of kids, and this is how you like use those ideas

later on. And you're teaching, it's like it's when you're teaching...That kind of stuff is cool, for me, you know, that, that was like kind of transformative. (Interview # 16, Resident)

The important thing to notice in this example is that activities like this one, where the residents essentially practiced teaching in front of each other and received feedback from their instructors and each other, were predicated on the idea that in fact a *shared repertoire* of ideas and concepts that constitute good science teaching does exist. In this case, that *shared repertoire* included the ability to elicit ideas from students.

A second example where residents were socialized into the community of good science teaching during coursework can be seen in the team teaching activity I observed in one class session of *EDU/SCI 660 Earth Science Literacy Journal Seminar.* This course ran from September- May, which made it the longest running course in the program. This activity was described this way on the course syllabus:

> The team teaching activity will be an Explore learning activity (as per the 5E instructional model) conducted by teams of 2 residents that allows their peers to investigate concepts central to specific charts and figures found in the Physical Setting/Earth Science Reference Tables assigned by the faculty. This lesson should incorporate use of technology and materials/equipment and relate to students' lives. This should be an activity that might take secondary students 45 minutes or more to complete but can be completed by adult learners (your peers) in 20 minutes. (Program Document # 257, *EDU/SCI 660 Earth Science Literacy Journal Seminar* Team Teaching Activity).

The description of this assignment shows that the lesson plan tool, which was the template required for creating this lesson, acted as a *boundary object* because accomplishing the creation and enactment of a lesson this way solidified entrance into the community of good science teachers. This activity that used the lesson plan tool acted as part of the *shared repertoire* of good science teaching practices in that it called upon residents to contribute their own ideas about how to best approach teaching specific science concepts and practices. This helped to establish the boundaries of good teaching by providing a kind of map, or a landscape of what good teaching was supposed to look like.

Museum Teaching Residency. A final, but key, aspect of socializing residents into the community of good science teachers was the museum teaching residency. As I mentioned, the AMNH MAT's model of multiple and prolonged residencies was a reinvention of the residency model itself. The museum teaching residency is a key example of the program's unique approach here. For starters, this residency accomplished two central goals. Because it occurred in the residents' first months as participants in the program, it was the first opportunity for the residents to begin to practice the program's ideas and conceptions of good science teaching, primarily as outlined by the Observation Rubric. Furthermore, because this teaching residency occurred in one of the museum's existing programs for teens, Planetary Boot Camp, it necessarily privileged informal science teaching and learning practices with actual students. This made the museum teaching residency particularly instrumental because its goal was to socialize residents into the program's ideas, practices, and concepts, their *shared repertoire* of the community of good science teachers. This residency involved three opportunities to teach at the museum:

> Throughout the summer, residents are divided into teams of two to three people and rotated through experiences in various Museum programs. These experiences include: teaching at educational touch carts, designing short activities and teaching in the Discovery room, observations in the Lang Science Program three-week institute and

designing learning experiences for high school youth who attend the Summer Science Institute (Planetary Bootcamp). This scaffolded set of experiences positions them to participate in one-on-one conversations with museum visitors, conduct in-depth classroom observations of students in AMNH's out-of-school time programs, and co-develop and teach a short earth science lesson at the end of the summer. (Program Document #402, *RES001 Overview)*

The museum teaching residency was designed to ensure that residents had ample experiences teaching in the informal science setting of the museum and it also encouraged residents to see these experiences as opportunities to begin developing a repertoire of good science teaching practices. In fact, according to the *2018-2019 AMNH MAT Program Handbook*, the goals of this first of four residencies in the program were:

- to provide Residents with an opportunity to observe and teach in low-stakes settings in order to accomplish the following objectives:
- Contribute to their understanding of how people learn and how that learning is mediated by multiple factors including culture, gender, and age.
- Become familiar with using Museum exhibits/objects as teaching tools
- Become familiar with how informal science institution resources can be used for motivation, engagement and demonstration of key ideas
- Begin their journey in developing high leverage teaching practices, specifically eliciting student thinking and classroom discourse.
- Deepen dispositions for teaching and learning (Program Document #3, *2018-2019 AMNH MAT Program Handbook*)

What is important to notice here is that the museum teaching residency engaged the AMNH MAT residents in a *shared repertoire* of good science teaching by way of initiation into key ideas about learning to teach, especially the importance of informal science environment for teaching and learning and the positioning of high-leverage practices as key for good science teaching.

As part of this initial teaching experience, AMNH MAT candidates planned and taught a three-hour lesson to students in this summer program. I observed part of this teaching experience, where three residents team taught a set of activities and tasks that together made up their three-hour lesson for the day, which was meant for a group of motivated youth. Part of this experience involved immediate feedback from peers, which was facilitated by the Observation Rubric. I hone in this feedback experience here because it is a key example how the AMNH MAT leveraged the museum teaching residency to socialize its candidates into the community of good science teachers by using the Observation Rubric as a *boundary object.*

The conclusion of the day-long lesson centered on feedback that occurred in two sessions. First, residents received feedback from their peers: residents who taught reflected on ways to improve, and the residents who offered feedback practiced applying newly-learned pedagogical concepts to actual teaching (Observation #10). The second round of feedback came from museum faculty, which involved rich explanations about places where the residents could improve their teaching (Observation #10). Both feedback sessions, although different, were conducted in the same manner: AMNH MAT faculty and residents went through each criterion of the Observation Rubric, "indicator by indicator" (Observation #10) and gave the residents who taught a rating, such as "developing" or "proficient" based on their teaching performance that day (Observation #10). Each rating was followed by a detailed explanation of why these ratings were given, such as "next time, make sure you make your connection between activities more clear" and "I loved the model [that you asked students to construct], but I almost wanted to ask the kids what they made today… They have to know what it is they are making a model of, otherwise it's a waste of 45 minutes" (Observation #10).

There are two important things to notice in this example. First, this museum teaching residency by design included informal science teaching and learning practices, thereby inviting the residents into the community of good science teachers by encouraging them to include the features and aspects of informal science environments into what would become their *shared repertoire* of good science teaching. The second thing to notice here is that this residency experience required residents to engage in critical feedback of their own work and their peers' work, including them as valuable contributors to the ongoing revision of the *shared repertoire* of good science teachers. Considered this way, the museum teaching residency was a two-pronged effort to engage AMNH MAT residents developing the *shared repertoire* of what good science teachers do, even at the very beginning of the program.

As this section has shown, the AMNH MAT deliberately socialized its candidates into the community of good science teachers by way exposing them repeatedly to what was considered to be the *shared repertoire* of concepts and ideas central to that community. This *shared repertoire* involved the residents' input and ideas as well, as they had multiple opportunities in coursework and during their museum teaching residency to create unit plans and lessons plans of their own design meant to ignite excitement and inspire learning for their students. Importantly, as this section has shown, the residents were also invited to reflect on their own lessons as well as the lessons of their peers, enhancing their ability to contribute to the *shared repertoire* of good science teaching practices at the AMNH MAT.

Inviting residents to become participants in the community of good science teachers also was accomplished by using the Observation Rubric and 5E Instructional Model as *boundary objects,* kind of signposts for what it means to be a good science teacher. When describing the mission of the MAT program, one resident described what he believed to be the main priority of the two senior specialists: "[they] are just like, 'We just want good science teachers. This is what good science teaching is like, right?'… they're… pushing …like this is what a teacher should be" (Interview #15, Resident). This perception reveals that the AMNH MAT faculty believed good science teaching could be defined in terms of particular elements of practice, which were reflected in key tools and assessments, and which collectively codified the ways the boundaries of the community of good science teachers.

The Community of New York City Teachers, Students, and Schools

The third key community into which AMNH MAT teacher candidates were being socialized was the community of New York City teachers, students, and schools. This community is particularly important because, in line with the goals and requirements of the program, most residents become teachers of record in New York City schools or in schools with similar demographics and resources (Institutional Document #25*, Summary of Research Findings for the AMNH RGGS MAT Earth Science Residency Program*). Because of this, program leaders and faculty worked to involve its residents in shared practices regarding what it meant to teach in New York City. One caveat to mention here is that New York City is obviously an urban community, or as one program faculty put it, "it's the urban-est urban" (Interview #10, Program Faculty). While the following section of Chapter 5 discusses the NYC community of teachers as the third community into which the residents were socialized, this chapter does not examine in depth the program's approach to preparing residents for the complexities of urban school contexts in particular. This topic is essential, however, especially given that this context involves communities who have experienced multiple and concurrent vulnerabilities, such as poverty and racism. To ensure that these issues are given appropriate attention, I take them up in full in the next chapter, Chapter 6, which focuses in its entirety on how and to what extent the program prepared teacher candidates *specifically* to teach in urban schools.

As discussed in Chapter 2, Wenger (1998) referred to the shared practice of communities in terms of *mutual engagement*, which involves drawing on the collective competences of participants in a community of practice. *Mutual engagement* is about the "ability to connect meaningfully…to the contributions and knowledge of others," which makes it "inherently partial" (Wenger, 1998, p. 76), because it is about working together on what is known and what is not known. From this perspective, the idea of partiality is not considered a detriment, but rather, "this partiality is as much a resource as it is a limitation" (p. 76). This is important because the residents, newcomers to the community, only had a partial understanding of the knowledge, skills, and dispositions needed to be NYC teachers, which was bolstered by the extensive experience of the museum MAT's faculty. In fact, a reciprocal relationship existed between the residents and AMNH MAT faculty and school-based mentors: while the newcomers gleaned important skills and dispositions from the old-timers, the old-timers' were challenged to rethink their ways of being and doing in light of the fresh ideas and questions of the newcomers. In this way, both the residents and their more experienced mentors *mutually* contributed to each other's *engagement*; their learning depended on the learning of each other, hence the social and contextual nature of learning in a community of practice. Beginners, on the edge of a new community, are socialized into this community of practice by doing "whatever they do" (Wenger, 1998, p. 75)- in this case, this refers to being New York City teachers of science. It is precisely this act of *mutually engaging* that fosters residents' connection to the community of New York City teachers, students, and schools because their voice and their work are immediate contributors in the classrooms.

To assist in building the newcomers' confidence, AMNH MAT senior specialists acted as *brokers,* using their own expertise and savvy to assist the residents in becoming members of this community. As I mentioned in previously, Wenger (1998) argues that *brokering* is a complex process because those who *broker* must be legitimate members of multiple communities of practice in order to adequately initiate newcomers. This was the case for the senior specialists, who had many years experiences as New York City teachers themselves, held doctorates in science teacher education, and were faculty at the AMNH. In essence, this made them members of multiple communities, all of which were important for the residents as they learned to become New York City teachers.

AMNH MAT residents were socialized into the community of New York City teachers, students, and schools in three major ways. First, the program's coursework dedicated a significant amount of time to candidates' learning the New York State's standards and requirements for teaching. Second, MAT instructors and the mentor teachers in the school residencies offered ample feedback and support. By learning about New York's standards and through the support of their peers, the senior specialists, and New York City mentors, the residents learned that "practice does not happen in the abstract . . . practice resides in a community of people and the relations of *mutual engagement*" (Wenger, 1998, p. 73) (emphasis added). Residents were also encouraged to disagree and challenge each other's perspectives, which led to richer conversations. Although these two components were important, the major way residents were socialized into the community of NYC science teachers was by spending four days a week in secondary classrooms working with earth science teacher mentors. Residents' practice-centered learning was facilitated primarily by senior specialists. Throughout their time in the school residencies, AMNH MAT senior specialists observed and assessed residents' lessons, which were followed by debriefing sessions. This process of lesson teaching followed by debriefing occurred about 10 times per semester for each candidate, or 20 times overall through the year across two different school residencies. Seniors specialists' and residents' ongoing *mutual engagement* in feedback and debrief sessions helped newcomers develop an understanding of how to plan and enact lessons that could ignite the curiosity of their students. Below I take up each of these three key aspects of the socialization of residents into the community of New York city science teachers. Practice.

New York State Standards and Requirements. The AMNH MAT had high expectations concerning residents' knowledge of the expectations, terminology, and context of New York City schools. For instance, the *Next Generation Science Standards* (NGSS), newly adapted by New York State in 2017, were considered imperative for prospective teachers to know and understand. One program graduate best described the program's commitment to preparing its prospective teachers for the newly-required NGSS learning standards:

> Before we even got in there, it was like, introducing us to the standards, to the science and engineering practices, cross cutting concepts [of the *Next Generation Science Standards*]. Just getting us familiar with that, because that's where science is headed... and that's how teaching will be judged. We got fully versed in that, and that's definitely probably one of the main focuses [of the program]. (Interview #25, Program Graduate)

This resident understood and appreciated the MAT program's attention to the required learning objectives for the science courses they would teach in New York City schools. That the program instructors prioritized New York standards demonstrates their commitment to ensuring that the residents were prepared for the teaching expectations they would enact during the school residencies and later, as New York teachers themselves.

All New York State K-12 learners are required to pass the New York Regents exam. As noted in Chapter 4, one of the ways the AMNH MAT measured the success of its efforts to "change the science conversation in schools" was the extent to which the eventual students of its graduates were able to pass the Regents Examination in Earth Science. Both coursework and fieldwork emphasized the importance of preparing secondary students for this state-required exam to the extent that, as one resident put it: "It's all, honestly a lot of it is Regents. Regents, Regents, Regents, you've got to get your kids to pass the Regents" (Interview # 18, Resident). This goal was central in one internal program evaluation:

> The evidence indicated that students of the MAT graduates are doing as well as students taught by other Earth science teachers with similar years of experience in NY City. The MAT teachers teach a higher percent of students who qualify for free and reduced price lunch and are lower performing in science relative to students taught by other Earth science teachers with similar years of experience in NY City. Therefore, MAT graduates have been able to bring their students to the same level of performance as students who had higher levels of achievement. (Institutional Document #13, *Key Impacts of the American Museum of Natural History MAT Program: Evidence from the External Evaluation Program*)

It is clear that the AMNH MAT considered working to improve secondary student outcomes on state standardized tests as a priority for entry into the community of New York City teachers, students, and schools. The residents' understanding of what it meant to be a high-needs New

York school was shaped by this, and they *mutually engaged* in the prioritization of the Regents when planning their own instruction. For instance, some of the lesson plans the residents were required to design in their coursework were meant to specifically prepare their students for the Regents Examination in Earth Science (e.g., Observation # 13, *EDU 620: Curriculum and Instruction for Teaching Earth Science in Secondary Schools*). In order to do this, they worked together to create lessons and received feedback from the MAT teacher educators. This gave residents the opportunity to see themselves as members of the community of New York City teachers, since preparing students for the Regent's test was considered a priority in the city's schools.

In addition to the state requirement that students pass the Regents Exam, teacher candidates were required to pass the edTPA, which is a "performance-based, subject-specific assessment and support system used by teacher preparation programs throughout the United States to emphasize, measure and support the skills and knowledge that all teachers need from Day 1 in the classroom" (edTPA, "About edTPA," para. 2). Many coursework assignments were geared towards helping the residents compile their edTPA portfolios for evaluation. In fact, I observed one class session where AMNH MAT teacher educators spent a considerable amount of time directly connecting a course assignment to edTPA-required documentation called *edTPA: Assessment Commentary Template*. The assignment required the residents to identify patterns of student learning, such as their progress toward "conceptual understanding," their "use of scientific practices during inquiry," and their "development of an evidence-based explanation" (Program Document #106, *edTPA: Assessment Commentary Template*), supported by samples of students' responses (Observation #13, *EDU620: Curriculum and Instruction for Teaching Earth Science in Secondary Schools*). During this class session, the faculty went through this document thoroughly, clearly explaining what residents were required to complete for each section, which included quantitative evidence of student learning of specific standards. The assignment also required residents to include evidence that they provided ample feedback to students. Here, the faculty encouraged residents to be “very detailed,” advice one resident indicated he “really appreciated… [it’s good to] go through this edTPA stuff” (Observation #13, *EDU620: Curriculum and Instruction for Teaching Earth Science in Secondary Schools).*

This level of attention to the edTPA requirements proved not only useful, but memorable for AMNH MAT graduates. For instance, one program graduate indicated: “it was really very beneficial…I think really the biggest thing they did which was the most helpful was edTPA preparation…That could not have been better” (Interview #25, Program Graduate). Yet another program graduate pointed out that:

> in terms of becoming a licensed teacher in the state of New York, you have the pass the edTPA…the amount of support that they offered us through that…we were able to see every single layer of the Danielson rubric…we filmed ourselves teaching in the residency program, brought it back in and saw moments where perhaps what we were doing was alienating a population or perhaps what we were doing wasn’t exposing enough of this type of science, you know, really troubleshooting through. (Interview # 24, Program Graduate)

By all accounts, a very explicit way that the AMNH MAT program socialized residents into the milieu of New York City teachers, students, and schools was by ensuring that their teaching practices, including the documentation required for licensure, were carefully aligned with state requirements.

Instructor and Mentor Support. A second strategy for socializing candidates into the community of New York City teachers, students, and schools was the frequent, clear, and consistent feedback and support the AMNH MAT faculty gave to the residents about their teaching practices. This support and feedback often, though not exclusively, materialized as helping residents navigate their experiences in the New York City school residencies. This level of support included things like helping the residents try out classroom management strategies to ensure that all students were learning or offering suggestions for ways to make the science being taught relevant to students' lives. The mentors were key supporters in this way as well. In fact, according to the *2018-2019 AMNH MAT Program Handbook,* residents were guided and supported by two different mentors:

- A school mentor, who is a highly qualified teacher in the school where the Resident is doing his or her residency. Residents will have two different school mentors: one in their first residency school and a second in their second residency school;
- A museum Senior Specialist will help the Residents integrate their academic and professional learning of both content and pedagogy at AMNH and in the schools; (Program Document #3, *2018-2019 AMNH MAT Program Handbook)*

The program handbook clearly defined these two roles as specific kinds of support for the residents' who were learning to teach. The program's clear arrangement of support for the residents created the structure necessary for *mutual engagement* to happen.

As I have shown throughout this chapter, much of the feedback of faculty and senior specialists concerning residents' teaching practices was filtered through the Observation Rubric. This was also the case with the feedback residents received from the mentor teachers, as an accreditation document pointed out:

> Residency school mentors (classroom teachers with whom the MAT candidates are placed) also use the Observation Rubric in their work with the candidates throughout their placement…Mentors use…the rubric criteria to create a final evaluation of their candidate's performance during their residency using a three-point scale, indicating if the resident was below, at, or above target proficiency…. School mentors additionally perform a summative observation with the rubric at the end of each of the fall and spring residencies. (Institutional Document #2, *Observation Rubric, Addendum Update*)

The fact that the mentor teachers clearly understood and enacted teacher preparation using the Observation Rubric made them, in addition to AMNH MAT senior specialists, *brokers,* assisting the residents' entrance into the community of New York City teachers, students, and schools. This coherent approach to enacting teacher preparation proved helpful for residents:

> My mentor was, in my residency, was great…And…pretty much everything that I learned that I learned from her, and then we go through the observation rubric and…talk about all the things that I could have done better to get like more points…I did learn some stuff through that. But those are kind of…like it's like things to remember while you're, while you're teaching. But from my mentor, it's like I learned about more so like how I'm acting, like, like, like how to handle certain situations, you know, like classroom management is a huge thing. (Interview #16, Resident)

The important thing to notice here is that the AMNH MAT faculty and residents' main way of working together to prepare the residents was by using the Observation Rubric clearly and consistently to *broker* entrance into the community of New York City teachers. Conversations like the one the resident shared above were commonplace between the residents and their mentor teachers, occurring both formally after residents' taught, and informally during planning periods.

The above interview excerpt also reveals that the mentor teachers modeled good teaching practices, which were central to the process of socializing residents into the community. Because the residents felt that they were part of this process, it was clear the mentors collaborated in the act of learning to teach, and that this *mutual engagement* coalesced around the Observation Rubric.

A final aspect of the supportive environment fostered by the AMNH MAT program were the senior specialists' biweekly observations of each resident during both of their school residents. It should be noted that this itself was unusual. As I pointed out in Chapter 2, many urban teacher preparation programs, especially urban teacher residencies, are not able to accommodate this level of observation, feedback, and support (Gardiner & Salmon, 2014; Kolman et al., 2017; Wasburn-Moses, 2017). One accreditation document clearly outlines this level of commitment to *brokering* residents' socialization into the community of New York City teachers, students, and schools:

> Mentors and senior specialists continually communicate with candidates during their residencies about the meaning of each rubric line [of the Observation Rubric]. During the first residency, the assigned senior specialist meets separately with mentors and candidates once every month. During the second residency, the senior specialist, mentors, and candidates meet together once every month. Each meeting is focused on a subset of rubric lines, enabling mentors, senior specialists, and candidates to describe and develop a shared understanding of what each rubric line 'looks like' in the context of the partner schools. (Institutional Document #2, *Observation Rubric, Addendum Update)*

As this excerpt shows, the AMNH MAT required its mentors and senior specialists to work consistently and frequently with residents on understanding the particular approaches and strategies outlined in the Observation Rubric as part of what it meant to become a member of this community. In other words, the newcomers and the old-timers meaningfully connected each other's ideas about teaching science for New York City schools by using the Observation Rubric as a guidepost. There was a symbiotic relationship between the careful support of the AMNH MAT instructors, senior specialists, and mentors and the conscientious learning of the residents, which was anchored in the teaching strategies and approaches outlined in the rubric. All the members of the community of practice contributed to a shared understanding of how the teaching practices designated in the rubric actually played out in schools.

"Monthly meet-ups" were a key demonstration of the level of support and feedback the residents received. During monthly meet ups with residents, mentors, and AMNH MAT faculty, senior specialists focused on particular science teaching practices introduced in courses, particularly those outlined on the Observation Rubric. For instance, during one monthly meet-up at a partner school where AMNH MAT faculty, the mentor teachers, and the residents focused exclusively on two criteria of the rubric, Standard 2A, which was "addresses students' different learning challenges, strengths, and socio-emotional needs" and 3D, which was "develops and manages diverse and effective student groups" (Observation # 3, *Monthly Meet-Up, Induction Year 1;* Observation #5, *Monthly Meet-Up, Bronx Early College Academy*). These criteria were used to analyze and critique another teacher's lesson. The purpose of narrowing in on these two instructional strategies was itself an act of *mutual engagement;* the participants in this meeting listened to each other's ideas and commentary about this lesson using the standards from AMNH, which in turn allowed mentor teachers and residents to reflect on their own practices, ultimately brainstorming new ways to differentiate group work in their respective classrooms

(Observation # 3, *Monthly Meet-Up, Induction Year 1;* Observation #5, *Monthly Meet-Up, Bronx Early College Academy*).

That the AMNH MAT also had such a clear and consistent arrangement for conducting intensive feedback and support was not lost on its residents, as one program graduate indicated that, “I do think they’re so supportive, like not even just through the stipend and through the residencies, I think that as people they do also like care about you, and care about your wellbeing, and set you up for success” (Interview #22, Program Graduate). Also, a current resident pointed out that “I like how…we are 100% their [the AMNH MAT faculty’s] focus, which is awesome” (Interview # 18, Resident). As this section reveals, this level of scaffolding and support was filtered through the Observation Rubric, which was used as its own kind of “holy grail,” because it fostered the *mutual engagement* of the AMNH MAT and New York City teachers (old-timers) and the residents (newcomers) as they worked together to connect specific teaching practices considered effective with their own ideas and classroom practices.

New York City School Residencies. The fact that the residents were required to spend an entire semester in each of two different NYC schools is the best (and final) piece of evidence regarding the residents’ socialization into the community of New York City teachers, students, and schools. As I mentioned previously, the extended time in two of the MAT program’s partner schools was part of the way the program reinvented the concept of “field” in teacher preparation fieldwork, given that learning from two different mentor teachers in two different schools is not common in urban teacher residencies. The AMNH MAT residents expressed their appreciation for this kind of unique fieldwork. Unequivocally, when I inquired about what aspects of the MAT program the residents and program graduates felt most prepared them for actual teaching, they all in some way or another mentioned the school residencies. As one program graduate aptly put it:

> I think just the practice of like so many at-bats, of being around kids and being around different types of colleagues. Usually when something happens now, something similar to it has happened before. Whether it's an interaction with a student, or a colleague, positive or negative, then I feel I know how to navigate it. (Interview #22, Program Graduate).

As this excerpt shows, this amount of exposure to science teaching and learning in real time seemed to ignite confidence in the residents. In fact, another resident pointed out that "there's …definitely an aspect of training wheels while also, like, you're teaching the lesson. It's your lesson. Like the kids see you as their teacher" (Interview #19, Resident). This quotation points to the *mutual engagement* of at once being supported by the mentor teacher (e.g., "training wheels") and also being seen as capable of fostering learning (e.g., "kids see you as their teacher"). The partiality of the residents' teaching experience combined with their burgeoning ideas about good practice are both supported and enriched by the mentors.

To best illustrate the *brokering* that occurred in the school residencies and that worked to socialize AMNH MAT residents into the community of New York City teachers, students, and schools, I once again turn to the program's utilization of the Observation Rubric. The senior specialists had a precise and congruent understanding of what good teaching ought to look like in the residencies, and they were able to communicate this to the residents by connecting the criteria on the Observation Rubric to the teaching practices and strategies used in the residency classrooms. In other words, the senior specialists *brokered* the residents' connection to good science teaching as they assimilated into teaching New York city kids. This good science teaching was rooted in the criteria of the Observation Rubric, which I have by now clearly shown was the AMNH MAT's gold standard for good teaching. That both of the senior specialists had a corresponding conception of what good teaching ought to look like was highlighted in a key accreditation document:

> The Observation Rubric is used most frequently by the senior specialists in their observations of candidates in their residency school placements. To ensure reliability of the rubric, MAT staff were originally trained on how to use the tool in a series of sessions, during which they watched three videos of science classroom teaching. Each individually scored the teachers in the videos on particular criteria and shared evidence to justify each score. This training activity established a shared understanding of the rubric criteria and enabled the MAT faculty to come to a consensus on what each rubric line should 'look like' in the classroom, including what constitutes a Basic, Proficient, and Accomplished performance level. (Institutional Document #2, *Observation Rubric, Addendum Update)*

The senior specialists had a shared conception of how the teaching strategies on the Observation Rubric ought to be enacted in residency classrooms, and they used this conception to mentor and coach the residents before, during, and after they implemented lessons. I observed three residents teach in their respective residency classrooms. After each lesson, a senior specialist met with the resident for a debriefing session, using criteria on the Observation Rubric that was applicable to the particular lessons taught. The debriefing sessions lasted about 30-45 minutes, and each time the senior specialist and the residents *mutually engaged* in an understanding of the teaching that had just occurred (Observations #14-16, *School Residency*).

For instance, after one resident taught a lesson on contour maps in a tenth grade earth science course, the senior specialist and the resident decided together to focus on three particular criteria: "6a: Aligns science instruction with state standards appropriate to grade level," 7a: Aligns goals, strategies, and assessments," and "7b: Uses a variety of assessments to assess students" (Program Document #42, *AMNH MAT Observation Rubric*). They chose these criteria because they were working on the resident spending more time on the purpose of the lesson, or as she put it: "Why are we doing this?" (Observation #15, *School Residency*). The senior specialist and the resident also agreed that what was missing in the lesson was greater attention to scientific terminology, which should have been explicitly taught to the students (Observation #15, *School Residency*). Finally, both agreed that modeling should have been used as a strategy to help students understand the purpose of creating contour maps (Observation #15, *School Residency*). Importantly, this conversation felt comfortable, the decisions for improvement of teaching seemed mutual, and the senior specialist instilled confidence in the resident as she began the debriefing session by saying that she enjoyed watching the lesson because she "got to write down all the wonderful things you did" (Observation #15, *School Residency*).

What this instance highlights is the *mutual engagement* occurring in the school residencies; the senior specialist helped the resident align her ideals about teaching with the context of New York City classrooms. This was a process that was not one-directional; the senior specialist did not require the resident to change her approaches. Rather, the two mutually agreed on which particular strategies and practices ought to be shifted before the residents next lesson. This conversation was different for all three debriefs I witnessed because in each case, the participants were different, which means there were experiencing learning to teach and practicing teaching differently. This required *mutual engagement* with the senior specialist tailored to their current learning process, making for a partial, yet relevant experience (Observations #14-16, *School Residency*). The "medley of people" (Wenger, 1998, p. 75) involved in the debriefs in the school residencies made for rich *mutual engagement.* In fact, experiences like this one proved powerful for the residents, as one pointed out that "it feels good to lead the lessons that I do and... I don't think I have moments where like I totally got this…but I do like meeting with [senior specialist] afterwards and gaining those insights and getting really specific feedback and that to me seemed super valuable" (Interview #15, Resident).

As residents' reactions to the support they have received and to their experiences in the school residencies has shown, socializing residents into the community of New York City teachers, students, and schools proved to be central to the enactment of the project of learning to teach at the AMNH MAT. The *mutual engagement* fostered in the coursework and the school residencies allowed the residents the space to share their own ideas about practices, to try new approaches, and to receive ample, specific, and useful feedback along the way as the senior specialists in particular *brokered* their connection to this vital community of practice.

Conclusion

As this chapter has shown, the AMNH MAT deliberately socialized its candidates into three overlapping and interrelated communities of practice, all of which they believed to be integral to the enactment of the project of learning to teach. Wenger (1998) argues that "as communities of practice differentiate themselves and also interlock with each other, they constitute a complex social landscape of shared practices, boundaries, peripheries, overlaps, connections, and encounters" (Wenger, 1998, p. 118). The "complex social landscape" of the AMNH MAT program involved multiple key actors–namely, the scientists, teacher educators, and senior specialists- who facilitated the residents' socialization into the communities of scientists, good science teachers, and New York City teachers, students, and schools. According to Lave and Wenger (1991), "moving toward full participation in practice involves not just a greater commitment of time, intensified effort, more and broader responsibilities within the community, and more difficult and risky tasks, but, more significantly, an increasing sense of identity as a master practitioner" (p. 111). What all this added up to for the MAT residents, who were absorbed in the project of learning to teach science, was multiple overlapping identities as members of multiple communities of practice, all of which contributed to being effective teachers of science for New York's high-needs schools.

A final point to make here is that the three sets of beliefs about science teaching and learning that undergirded the AMNH MAT's conceptualization of learning to teach, described in great detail in Chapter 4, were deeply connected to, and supported by, each of these communities of practice. Importantly, while traces of each set of beliefs were seen in all aspects of the program, particular beliefs were more dominant in certain areas of enactment, and therefore worked to solidify the tight coupling of conceptualization and enactment of teacher preparation at the AMNH MAT. This is what ultimately aligned the AMNH MAT's conceptions of teacher preparation with the structures it had in place for learning to teach. For instance, at the AMNH MAT program, learning to teach was conceptualized in terms of the belief that deeply knowing and being passionate about science was essential for good teaching. Along these lines, one resident described the program's goal: "to get... real scientists in the classroom teaching earth science" (Interview #18, Resident). Central to this conception of learning to teach was the understanding that the museum itself and its multitude of resources were a key context for effective science teaching, both informally at the museum and formally in classroom settings. As a way to enact this belief, the museum MAT structured its programming to include multiple access points for residents to learn from, and make use of, museum resources and to engage in scientific research themselves in order to become initiated into the community of scientists.

Next, the AMNH MAT's belief that good teaching centered on the enactment of research-based practices; this belief was enacted in the ways the residents were carefully socialized into the community of good science teachers. According to one resident, the AMNH MAT's "vision is to prepare like a highly effective teacher…you are so well prepared and with so many resources that when you start teaching, it doesn't feel like you're a new teacher…you have all these tools…all this knowledge that they have given you" (Interview #17, Resident). This quotation reveals that the AMNH MAT faculty had specific ideas, concepts, tools, and practices that accounted for "effective," or "good science teaching." For instance, in Chapter 4, I argued that the AMNH MAT believed that research-based teaching practices, such as high-leverage practices and ambitious science teaching, were what constituted good science teaching. Chapter 5 expanded on that argument by asserting that the program's key tools, assessments, and opportunities to practice teaching supported this belief, hence coupling the conceptualization and enactment of learning to be a good science teacher at the AMNH MAT.

And finally, the AMNH MAT's beliefs about learners as knowledgeable and capable was supported by the ways in which it socialized residents into the community of New York City teachers, students, and schools. In addition to its beliefs about the nature of science teaching and learning and good teaching, Chapter 4 also argued that the AMNH MAT believed in prioritizing the styles and types of all learners when preparing its residents to teach. New York City classrooms, reflecting the city itself, are filled with young people with multiple and varied cultures, heritages, languages, and cognitive abilities. Therefore, it was imperative that AMNH MAT candidates understood how to approach multiple learning styles and abilities by enacting various teaching strategies and practices in order to be socialized into the community of New York City teachers, students, and schools.

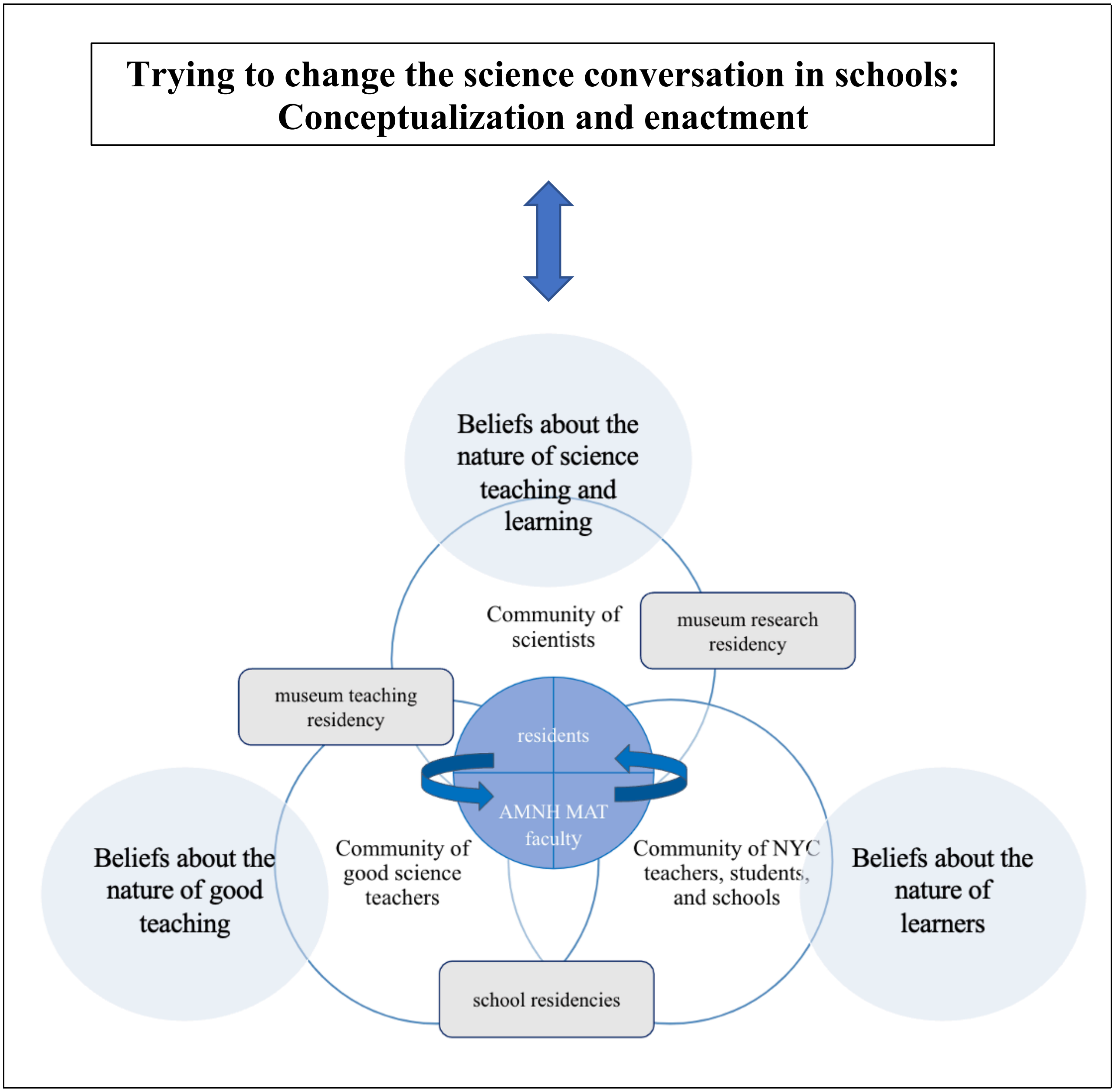
In Chapters 4 and 5, I argue that the AMNH MAT conceived and carried out the project of learning to teach science based on three tightly-related sets of beliefs, all of which involved the idea that there is a strong knowledge base for the practice of good teaching and that residents need to be carefully socialized into three communities of practice. When it comes to preparing teachers of science, it appeared that the AMNH MAT achieved Darling-Hammond's "holy grail" (2014) of teacher education program coherence because, as I have shown, teacher preparation at the AMNH MAT was not only *conceptually* coherent, but also *structurally* coherent.

Achieving program coherence in the first place is no small feat in teacher preparation. However, as I argued in Chapter 4, what a program coheres around is equally as important as whether and to what extent it is actually coherent. In fact, tightly cohering around a set of beliefs and ideals and then enacting them accordingly, as the AMNH MAT did, reveals the values of the program. In the case of the AMNH MAT, a cohesive experience of learning to teach science for New York State's high-needs schools was created with the goal of "chang[ing] the science conversation in schools." As one program leader and co-founder asserted, "We want science to look different in schools that hire our teachers" (Interview # 7, Program Leader).

I conclude this two-chapter argument by asserting that science teacher preparation at the AMNH MAT was a remarkably coherent enterprise because in all aspects of the program an observer could see its beliefs, values, and commitment to preparing prospective teachers who would not only "change the science conversation in schools," but who would work to fulfill the museum's mission to "discover, interpret, and disseminate— through scientific research and education—knowledge about human cultures, the natural world, and the universe" (AMNH, "Mission Statement" para. 1). Figure 16 is a depiction of this culminating argument, demonstrating the tight coupling of the conceptualization and enactment of teacher preparation at the AMNH MAT by merging the two key figures in Chapters 4 and 5.

Figure 16

High level of program coherence in the AMNH MAT



CHAPTER SIX

'Mostly Its All Science…': Teaching in Urban Schools

Building on Chapters 4 and 5, which analyze the museum MAT program's conceptualization and enactment of the project of learning to teach, this chapter focuses explicitly on issues related to the preparation of teachers for urban schools. Here, I argue that while the MAT program was exceptional in terms of the level of coherence it maintained between conceptualization (Chapter 4) and enactment of teacher preparation (Chapter 5) for good **science** teaching, the program's approach to preparing teachers specifically for **urban** schools was less comprehensive and consistent. In other words, while there is overwhelming evidence in the data that the AMNH MAT concentrated on producing teachers steeped in science in terms of content knowledge, interests, science identities, and abilities to teach, the evidence suggests that there was more unevenness and inconsistency in terms of the program's focus on urban schools.

To elaborate on this assertion, I begin this chapter with the words of one MAT program faculty member who described the tight-knit nature of the 130 + members of the AMNH faculty dedicated to science education programming at the museum, which included the MAT program. The faculty member said, "I really feel like… [the museum] is a center or a hub for [science education], because I feel like everybody who works here knows everybody in the science education field" (Interview #14, Program Faculty) and went on to say, "A lot of the education department is specifically about science… Mostly it's all science. Not too much cultural" (Interview # 14, Program Faculty). When I asked for elaboration, the faculty member offered the following:

> I mean, it's a sad reality…I feel like a lot of the education department is based on science education, [but] not necessarily the cultural halls. Or will connect the science to the cultural halls, but a lot of times I don't think we do a lot with cultural halls…We don't do a lot of programs and grant funds are not going into the hall of African people, the hall of Asian peoples, we're not doing programming there that much. A lot of it is based on science…Scientists are revered here…whereas the educators are not nearly as so…That's the history of this place. (Interview #14, Program Faculty)

What this faculty member was referring to was the fact that the education programming at the museum, including and especially the MAT program, concentrated an enormous amount of effort on incorporating into teacher preparation programming the dioramas, exhibits, and displays in the science halls, while at the same time, at times overlooking the extraordinary resources related to culture that the museum itself also housed. As this faculty member implies, these cultural exhibits were equally as accessible as the science exhibits and could have been incorporated more into the MAT curriculum.

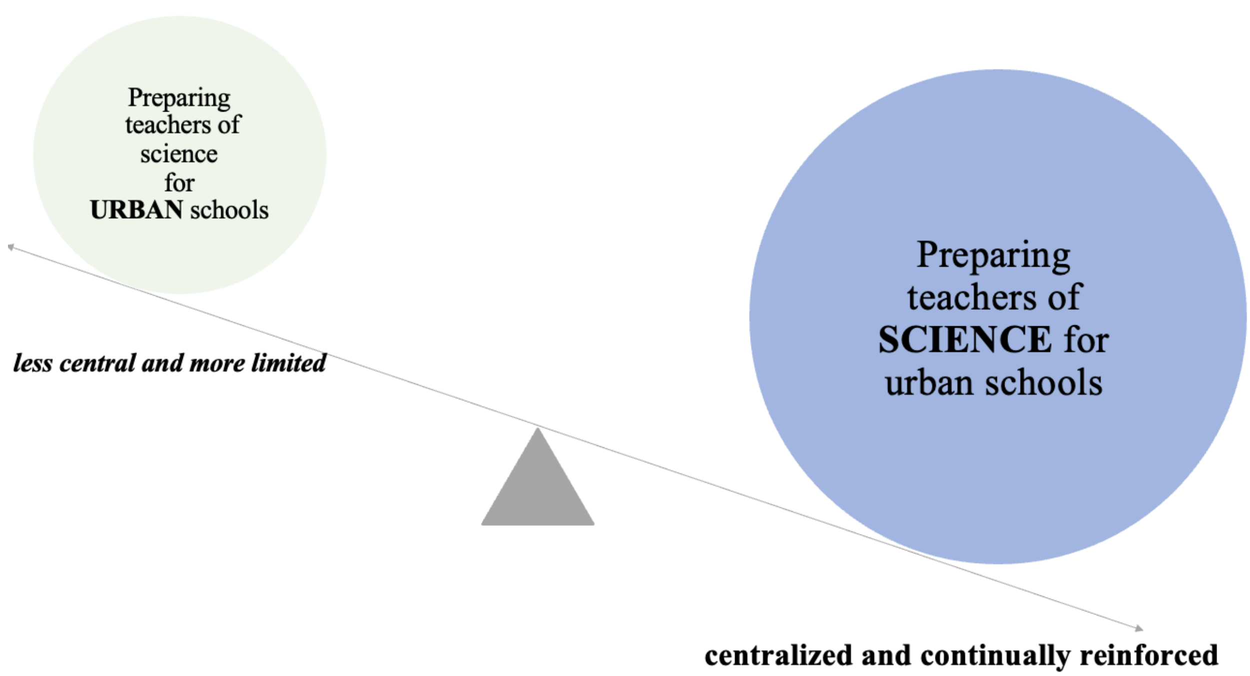
This is not to say that the AMNH in general and the MAT program in particular did not make important, concentrated efforts to work with New York City's urban youth. The museum has a very long history, dipping back to the late 1800s, of providing interesting and innovative programs for the city's youth to access science. The museum's *Urban Advantage* program, for instance, which the residents participated in during their first summer of the program, was established in 2004 as a support program for New York City public school students in grades 3-8 and uses "culturally responsive sustaining" practices. As this chapter shows, the MAT program embodied the museum's mission of public service, as its faculty and part of its programming demonstrated a deep commitment to the urban schools of New York City and ways to ignite students' curiosity within that space. This chapter and the next also points out that in recent years, especially beyond the scope of data generation for this case study (January 2020), the MAT program was working towards including more culturally responsive and sustaining science pedagogy into its curriculum.

However, the general trend—that science learning was prioritized above cultural learning in the museum's education programming—was evident in my analysis of the MAT program. In this sense, the comments of the faculty member quoted above can be regarded as something of a metaphor for the MAT program's uneven approach to urban teacher preparation. Compared to its unusually coherent programming for preparing **science** educators, the program's efforts to prepare **urban** teachers was less central to the program. Put another way, the museum MAT's preparation for science teachers was *centralized and continually reinforced* with many overlapping opportunities to engage in science activities and to practice the strategies and approaches the program emphasized in its notion of effective science teaching. I refer to the science programming as *centralized* to demonstrate the major program emphasis and the sheer quantity of science courses, science activities, and science requirements. I suggest that the science preparation was *continually reinforced* to indicate that there was not only a large number of opportunities for MAT residents to engage in scientific research and practices, but also that these opportunities were high quality and lengthy experiences, wherein residents worked alongside experts in the fields of science and science teacher education.

On the other hand, the museum MAT's preparation for **urban** school contexts was somewhat *less central and more limited.* Here, I use the term *less central* to point out that in terms of quantity, there were fewer opportunities for residents to engage in coursework or fieldwork specifically geared toward deep introspection and the kind of critical interrogation that is involved in centering race and racism, especially compared with the *centralized* science preparation. I use the term *more limited* when describing the AMNH MAT's approach to preparing urban teachers to suggest that in addition to there being fewer opportunities to understand and become critically conscious and antiracist teachers, the opportunities that were present were not deeply connected to, or centered on, antiracist pedagogy or other similar approaches, especially when compared to the multiple, varied, and rigorous science-centered experiences. I suggest in this chapter that while some components of the program provided excellent opportunities for residents to learn what it meant to be urban teachers, these were not as cohesive, consistent, or comprehensive as opportunities to learn how to be science teachers. Figure 17 is a graphic representation of the discrepancy between the museum MAT's approach to preparing **science** teachers and its approach to preparing teachers for New York's **urban,** high-needs contexts.

Figure 17

AMNH MAT's approach to preparing teachers for urban schools



Preparing Teachers for Urban Schools: Challenges and Frameworks

As I noted in the introductory sections of this dissertation, my perspective on urban teacher preparation is based in part on my own experience as a long-time teacher in urban public schools. In this context, wherein I frequently worked with teacher candidates and teacher educators from multiple preparation programs, I found that candidates and novices were at times not adequately prepared for the urban contexts in which they were likely to begin their careers, particularly in terms of their understandings and abilities to begin to tackle the immense challenges posed by state-mandated standardized tests, by large school district procedures and protocols, and especially by the outside-of-school factors that shape urban classrooms. In essence, I have found throughout my career that it is often difficult for beginning teachers in urban schools to sustain the initial goals that many of them have to be change agents within urban school systems that historically have had many seemingly intractable challenges.

These experiences are concerning and widespread across teacher education. Many urban-focused teacher preparation programs have faced many challenges for many years when it comes to adequately preparing teachers for urban schools. Teacher preparation has historically been and currently is a predominantly white space in that one of its "most visible and distinctive feature[s] is [its] overwhelming presence of white people and [its] absence of black people" (Anderson, 2015, p. 13). To be sure, pockets of teacher preparation programs have made tremendous strides in terms of preparing teachers for urban school contexts wherein multiple cultures, languages, heritages, and backgrounds are represented. However, there are also many teacher educators who understand that their current work is not enough, and who are working to understand how to develop better programming to require that the nation's teachers become antiracist. Generally speaking, it is extremely difficult for predominantly white spaces to support the development of (mostly) white prospective teachers as critically conscious educators (Seider & Graves, 2020)—that is, educators who are racially literate (Sealey-Ruiz, 2021) and who know how to create rich and ample learning opportunities (Milner 2010; 2020a) for children from backgrounds that are unlike their own.

Given this backdrop, and in line with the goal of the larger study, the purpose of this section of my case study analysis is to understand- *not to judge or evaluate*- how a unique teacher preparation program, designed specifically to prepare teachers for one of the world's largest urban areas, was tackling this difficult task of preparing urban teachers. My analysis of the AMNH MAT program reveals that although there were innovative initiatives and efforts designed to assist the residents in understanding urban contexts, there were also aspects of the program's approach that were consistent in many ways with the problems and challenges that face the larger field of urban teacher preparation.

The Challenges of Urban Schools

As I have shown throughout this dissertation, especially in Chapters 1 and 4, the museum teacher preparation program had two objectives—preparing candidates to become good science teachers and preparing good science teachers for urban schools, which have historically had difficulty attracting and keeping quality STEM teachers as well as dealing with lack of resources, high general teacher attrition rates, and cultural mismatches between teachers and students. These disparities are particularly problematic because the young people who attend urban schools tend to be from multiple and varied cultures, heritages, and backgrounds (National Council for Education Statistics, 2015), often bringing viewpoints, perspectives, and funds of knowledge that may not be in line with dominant viewpoints present in curriculum and instructional practice. There are other challenges in urban schools, such as large numbers of students who are emergent bilinguals (and multilinguals) but who are required to learn English and complex subject matter concurrently, especially at the lower and upper secondary levels (Mensah et al., 2018). With particular regard to science, as I noted in Chapter 2, culturally and ethnically diverse students often have particular difficulty acquiring science content knowledge while concurrently acquiring competency in the English language, which could have major implications, such as increasing dropout rates or lowering earning capacity for the lifespan of these vulnerable students (Marri et al., 2011).

Like many teacher preparation programs around the country, the leaders and faculty of the AMNH MAT program believed that an important goal of teacher preparation was equity. For instance, a program co-founder and leader said, "We see education as an equity proposition. It's about supporting individuals so that they have an equitable access to what's available in the world" (Interview #7, Program Leader). On the other hand, however, and also in line with many university-sponsored teacher preparation programs, the AMNH MAT program was primarily a white space. One caveat to note here is that during the period in which I gathered data about the program and interviewed and observed many participants, I did not explicitly ask faculty or teacher residents how they self-identified in terms of race, ethnicity, or cultural background. What I did observe, however, was that the MAT program itself was a predominantly white institution given that almost all of the MAT faculty were white people, as were many of the residents. Because many urban schools have long-suffered the burden of society's inequities, it is crucial to acknowledge how race enters into and plays a part in how, by whom, and under which circumstances decisions get made, as well as who is directly and indirectly impacted by these decisions. This is particularly important when it comes to teacher preparation for schools that serve many students from minoritized communities, which was the case with the AMNH MAT.

Sealey-Ruiz (2021), whose work examines teacher education through a racial literacy lens, argues that what is largely missing in urban teacher education is what she calls an "archeology of the self." She asserts that "teacher education candidates, those specifically who are being prepared to teach in urban school settings, are not sufficiently and consistently encouraged to delve into sustained self-work and to develop their racial literacy during their coursework and outside of their teacher preparation experiences" (p. 281). Sealey-Ruiz's claim here is consistent with part of what I found as I examined the AMNH MAT's teacher preparation program. Generally speaking, program documents, observations, and interviews did not seem to suggest "sufficient and consistent" encouragement of residents to examine their own beliefs and experiences and to understand the impact racism has had and continues to have on schools, teachers and students, especially in schools in which the students represent multiple races, many of which have been historically oppressed.

My introductory comments here are intended to call attention to the idea in general that teacher education programs, particularly those that aim specifically to prepare teachers for urban schools, including the AMNH MAT, need to do more to help prospective teachers understand and honor the context, cultures, and communities represented in their classrooms. They also must help prospective teachers understand the intersection of these contexts and their own identities if they are to become what Sealey-Ruiz (2021) calls "interrupters of inequality" (p. 282). To elaborate, Sealey-Ruiz (2021) argues that nurturing this kind of educator requires explicit and coherent attention to issues of race:

> Schools of education must be clear and intentional about teaching their candidates the reality of the intersection of race and class and its impact on educational outcomes for students. Candidates need more than the one diversity course that is supposed to help

> them 'do away with' their racist beliefs. This knowledge must exist across courses – methods, teaching seminars, and, yes, 'diversity' classes – for students to have an opportunity to develop a deeper understanding and discourse that can propel them to action regarding their role in the educational spaces they enter and occupy. (Sealey-Ruiz, 2021, p. 282)

What is important to notice here is that Sealey-Ruiz (2021) argues that urban teacher preparation programs need to be restructured to exhibit higher levels of coherence around the impact of race and class on teaching and learning. It is worth pointing out here that Sealey-Ruiz (2021) is calling for a level of program coherence around **urban** teaching that is precisely what the AMNH MAT exhibited around **science** teaching**.** As I argue in this chapter, however, the AMNH MAT was less coherent and comprehensive when it came to preparing **urban** teachers. In other words, Sealey-Ruiz (2021) argues for an approach to preparing urban teachers that is consistent with the AMNH MAT's *centralized and reinforced* approach to preparing teachers of science, whereas the AMNH MAT's *less central and limited* approach to preparing urban teachers might be thought of by Sealey-Ruiz as being insufficient and/or inconsistent.

Opportunity Gap Framework for Urban Teacher Preparation

In this chapter, in order to make sense of and theorize the AMNH MAT's approach to the project of preparing science teachers for urban school contexts, I draw especially on the work of Richard Milner, current American Education Research Association President and a well-known scholar in the field of urban education. In particular, I apply his widely-disseminated analytical tool, the *opportunity gap framework* (2010; 2020a), which is meant to be read as an "alternate paradigm- a different way for educators to make sense of and approach their work with young people" (Milner, 2020a, p. 21). This framework was designed to challenge educators to transform current belief systems and practices in order to better address the gaps in opportunity experienced by many students in urban schools. This is especially important because “educators’ mind-sets, beliefs, and overall paradigms about students and their capacity influence the ways in which they address gaps in opportunity” (p. 23). Finally, this framework is meant to be applied to all teachers in all settings, making it “transferable to different sociopolitical contexts” (p. 258), but it is particularly useful when considering preparing teachers for urban school contexts, who must not only be able to identify where gaps in opportunity exist, but how to interrupt them and create more and better growth opportunities for students.

Milner (2020a) asserts that “there is no magic potion to disrupting centuries of oppression, White supremacy, and inequity” (p. 22). Therefore, the idea of preparing educators who “center opportunity,” rather than prioritizing outcomes, is less about adhering to a specific list of criteria and more about helping educators develop the mindsets, dispositions, and belief systems to recreate opportunities and opportunity structures for the young people in their classrooms. Furthermore, as his book title suggests, Milner (2010; 2020a) posits that teachers and teacher educators should “start where they are, but don’t stay there,” which refers to the ongoing active learning process of recognizing the power, potential, and need to do better on behalf of students. This process of becoming a teacher who centers opportunity involves recognizing- and even leaning into- the cultural disconnects and inevitable conflicts that occur in the classroom. It involves getting to know students, and, importantly, paying attention to flaws in one’s own teaching. This means being able to adjust and to create inputs and inroads that connect student learning to the content being taught. An opportunity-centered teacher steps into students’ worlds, so to speak, and figures out how to bring the content to them in ways that are interesting and meaningful.

Like Sealey-Ruiz (2021), Milner (2020a) also argues for "deliberate and consistent" efforts on the part of educators "to address opportunity" and to "becom[e]…more aware of contextual realities that influence their current and future students and their environments" (p. 27). To examine the extent to which the AMNH MAT program was "deliberate and consistent" in its efforts to prepare urban educators, for the remainder of this chapter, I use Milner's (2010; 2020a) five "interconnected areas that... shed light on and address opportunity gaps" (p. 23), which, as I pointed out in Chapter 2, he primarily refers to as principles. Figure 18 depicts these five principles, which I explain in the following paragraphs.

Figure 18

Essential principles of Milner's (2020a) opportunity gap framework

Milner's (2020a) *opportunity gap framework* principles
Rejecting colorblindness
Shifting low expectations and debunking deficit mind-sets
Understanding cultural conflicts
Recognizing the myth of meritocracy
Countering context-neutral mindsets and practices

Milner's first principle, *rejection of colorblindness,* is a way to center race as an asset that all members of the classroom bring with them when they set out to learn together, rather than trying to be colorblind or ignoring aspects of race. Educators who reject colorblindness in effect embrace the idea that multiple races, heritages, and cultural backgrounds must be considered when teachers prepare their curriculum and instruction. Milner's second principle has to do with educator's ability, willingness, and skill to understand, acknowledge, and utilize the inevitable *cultural conflicts* that occur in their classrooms. This is important because, as Milner (2020a) indicates, "cultural experiences inform policies that are constructed, how those policies are interpreted and enacted, and on behalf of whom they are conceived and operationalized. Thus, it is essential for educators to understand the role of culture and cultural practices as they work to address opportunity gaps in education" (p. 24). The third principle in Milner's framework is an educator's ability and willingness to understand how the *meritocracy myth* operates. This involves a necessary interrogation on the part of educators to understand the opportunities they have been afforded or denied based largely on their familial and cultural backgrounds. It also means that prospective teachers must be willing and ready to engage in a similar exploration when they meet their students because, as Milner (2020a) notes, "The enormous variation in students' social, economic, political and educations opportunities is in stark contrast to the 'American dream,' which has meritocracy as its core" (p. 46). In other words, while the American dream works for some, it marginalizes others. And prospective urban educators must be aware of and able to recognize how this might impact their students' learning.

Milner's fourth principle is particularly important to approaching the opportunity gap in schools and classrooms because it requires teachers to be able and willing to recognize, disrupt, and shift *low expectations* and *deficit mind-sets.* This tenet requires educators to start with what students already know, not with what they do not know. This makes this principle an opportunity-focused idea in that educators who reject deficit mindsets are able to build on students' knowledge, assets, and skills, recognizing them as opportunities, rather than seeing their ideas as either right or wrong. The fifth principle of Milner's framework is critical because it forces educators to consider the context in which they will teach, making it impossible for them to have *context-neutral mind-sets and practices.* According to Milner (2020a), "educators who reject context-neutral mind-sets are those who continuously examine the places, people, and resources of a community- both inside and outside of a school" (p. 27).

One caveat to mention here is that in Chapter 5, I offered an analysis of how the AMNH MAT program enacted teacher preparation, part of which was socializing candidates into the community of New York City teachers, students, and schools. NYC is without question a complex urban context containing multiple urban schools and communities. As a whole, however, Chapter 5 examines how the AMNH MAT's program enacted the project of learning to teach by tightly coupling key beliefs about science, teaching, and learning with the program's key design elements, including activities and coursework/fieldwork arrangements. Chapter 6 is different. It is about the AMNH MAT's approach to preparing urban teachers specifically. Therefore, although in a way, Chapter 6 is an extension of Chapter 5 in that I zero in on how and to what extent the program prepared its residents specifically for the urban school context of New York City, Chapter 6 is important in its own right because of the concentration on urban teacher preparation.

Preparing Teachers for Urban Schools: The AMNH MAT

Based on the data, I identified three areas of the AMNH MAT program that were meant specifically to prepare residents for urban schools contexts. For heuristic purposes, I grouped these into three categories: courses and practices, tools and supports, and arrangements and commitments. Within each of these categories, I describe specific features of the program, and I try to unpack how they are related to issues in urban schools. Throughout this chapter, I draw on Milner's (2010; 2020a) principles to raise questions about the MAT program's approach to preparing teachers for urban school contexts and to unpack the extent to which the program engenders the kind of deep, self-critical work necessary to prepare teachers to prioritize opportunities over outcomes, especially in urban schools. It should be noted that because Milner's principles are, by definition, interrelated, each one could be applied to each of these three program areas. However, to shed light on the particular practices, tools, and arrangements designed specifically to prepare urban teachers in each of the three categories, I focus in on one or two of his principles, which are most applicable. Figure 19 is a graphic representation of how the rest of the sections in this chapter are organized.

Figure 19

AMNH MAT program elements that worked to prepare for urban teaching

Program elements	Preparing teachers for urban schools
Courses and Practices	Urban context course Other courses Culturally relevant practices
Tools and Supports	Dispositions Tool DEI workshops Mentor Academy
Commitments and Arrangements	Recruitment of diverse teacher candidates Partnership with NYCDOE/School residencies

Courses and Practices

This section offers an analysis of the coursework and the instructional practices used by the AMNH MAT to prepare its residents for urban school contexts. These aspects of the program were designed to offer useful and meaningful experiences that nurtured residents' ability and willingness to create opportunities for young people in urban schools. However, as my analysis shows, these experiences were limited, occurring sparsely in the program of study and in the design of the coursework.

Rejecting colorblindness is a principle that is in many ways at the heart of Milner's opportunity gap framework because it centers understanding race and its impact on the lived experiences of teachers and students, which is critical for creating opportunities in classrooms. Milner (2020a) asserts that "rejection of color blindness and [having] race consciousness allows educators to co-construct curriculum and instruction practices that connect to, align with, engage, speak from the point of view of, embrace and celebrate students of color, their communities" (p. 29). Conversely then, "color blindness tends to result in curriculum practices that are static and that reinforce [w]hiteness— preferences, points of view, and historical insights, for instance, that place [w]hite people, their practices, and contributions at the center of teaching and learning" (p. 29). In other words, working to create opportunity structures for young people means, by necessity, not only acknowledging race and racial experiences, but prioritizing them as main features of curriculum and instruction.

In addition to attempting to help teacher candidates *reject colorblindness,* the institutional documents I analyzed and interviews I conducted revealed that program also tried to help residents do what Milner referred to as *shifting low-expectations* and *debunking deficit mind-sets.* This principle of Milner's (2010; 2020a) opportunity gap framework is meant to nurture prospective teachers' understanding that there are multiple ways of knowing, that there are multiple ways for young people to access that which they don't yet know, and that it is the job of educators to understand this balance and be able to navigate their instruction to create opportunities to honor both of these ideas. Put another way, this principle requires teacher educators to prepare urban teachers to hold high expectations for all of their learners, but not to expect that there is only one way to demonstrate competence in learning a skill or concept. The program's efforts in these areas occurred primarily in three particular courses and in general efforts to include more culturally relevant practices in programming.

Urban Context Course. The best example of coursework designed to prepare residents for urban schools was EDU 650: *Foundations of Education in the Urban Context* (hereinafter urban context course). This course was designed to focus on key aspects of the sociocultural and sociopolitical contexts of urban schools and students, working to center race and racism and their impact on urban schools in particular. In fact, when I asked AMNH MAT participants how and to what extent they felt the program prepared residents for urban schools, almost all of them pointed to this course. According to the syllabus, this urban context course had the objective of:

> examin[ing] education's historical, philosophical, legal, and social contexts with a focus on New York State and New York City…Schools are a central focus for American society, reflecting conflicting beliefs, values, goals, and visions of schools and education. Both conflict and consensus emerge from the power struggles over American education. What we teach in schools is the result of societal conflicts (and efforts to resolve them), power struggles among competing beliefs and goals, and the actual knowledge and skills

> society requires for sustaining and advancing itself. (Program Document #208, *EDU 650: Foundations of Education in the Urban Context* syllabus)

Given this description, it is clear that a major aim of this course was to help the MAT residents understand the relationship between power and conflict in society and the structures and arrangements in schools. This course was taught by a science teacher educator and by a lawyer, who acted as an adjunct instructor, and who was not an AMNH MAT faculty member. This is noteworthy because, as I described in Chapter 5, almost all other courses in the program were co-taught by a science teacher educator and a scientist, both of whom where AMNH faculty. This teacher educator described the goal of her course this way:

> The role of this course, as I see it is helping [the residents] see systemic racism, helping them see that we might think that our system is fair [but it is not] …They might not think they're racist, but they benefit from a racist system. That kind of idea… And another part of that course is helping them develop a critical lens on society in terms of race and oppression and how schools feed into that and are shaped by that. (Interview # 11, Program Faculty)

In terms of her co-teacher, she identified him as "an expert in the law…he's really helping [the residents] think about the federal laws of education…And he often uses the word activist teacher" (Interview #10, Program Faculty). I observed a lecture by the co-teacher's in the urban context course, wherein he described the legal system and its relationship to education policy and practices. He unpacked what he referred to as a "cascade" of the hierarchy of laws in the state of New York, from the state "regs" to the individual school districts (Observation #8, *EDU650: Foundations of Education in Urban Contexts*). He ended the lecture this way: "Let me just say one more thing while I am at this precipice…get involved…it is a democracy…you just have to know how [the system] works… we want you to be teacher activists" (Observation #8, *EDU650: Foundations of Education in Urban Contexts*).

In order to enact this goal of nurturing "teacher activists," this course included assignments such as a critical reflection log, which required residents were to write their own educational autobiographies through a cultural lens. Another key assignment was called the Science and Citizenship Paper, which the course syllabus described this way:

> Select a societal/environmental problem that has significant science connections and determine the science knowledge citizens need to know to intelligently discuss and vote upon the issue. Topics will include issues such as climate change, natural disasters like earthquakes and hurricanes, the impact of invasive species, and other environmental problems. In addition to the science involved in your selected problem, the paper will involve the social, economic, and political issues that need to be considered. (Program Document #208, Syllabus, *EDU 650: Foundations of Education in the Urban Context)*

The teacher educator who taught this course explained this assignment as a key example of how she helped residents connect societal issues with earth science:

> Science is done by people. It affects society. Society affects it. It's wrong to pretend it's this objective thing…. I like [this assignment] because it gives [the residents] the opportunity to put science in a real social context… This assignment allows them to do something that shows how they will use their understanding of science to help kids, not just think about science in their own environments but how they might do something about it. (Interview #11, Program Faculty)

This assignment was key because it required the residents to situate science as a social justice issue and asked them to think through ways to instruct young people using this relationship as a kind of framework.

Another point to make about this course is that some of the required readings were intentionally selected by the teacher educator to center race and the impacts of historical and institutional racism in America. These included excerpts from the autobiography *Narrative of the Life of Frederick Douglass, White Rage,* written by African American scholar Carol Anderson, and *White Fragility,* written by white sociologist Robin DiAngelo. When I asked the residents and program graduates which aspects of their coursework prepared them for urban school contexts, many of them referred to their class discussion on *White Rage* and *White Fragility* in particular. One program graduate's response best highlights this:

> *White Fragility* was the name of the book, and we read that, and that one definitely stood out to me the most because, as a white male, it spoke to me…a lot of chapters were literally like describing my friend group. It was actually quite scary, how some of the things that this author was writing about was really about me and how I... can change, and... speaking about race. (Interview #25, Program Graduate)

This interview excerpt reveals that this course was helping residents *reject colorblindness* by identifying racist societal structures and systems and their impact in schools and on their identities. This course also offered multiple opportunities for residents to think about, discuss, and apply practices that worked to center opportunities for their students and to become science-literate activists themselves.

Despite offering some powerful ways to address societal racism, this required urban context course also reflected the program's limited focus on preparing teachers for urban schools. Like many teacher preparation programs at predominantly white institutions, where conversations about race are often led by white people, it can become difficult to delve into the complex issues that race presents in K-12 classrooms. My observation of this urban context course revealed that this was also true at the AMNH MAT. For instance, I had the opportunity to observe this course, where I witnessed residents engaged in an important discussion about the kinds of racism that they experienced in their respective upbringings (Observation # 8, *EDU 650: Foundations of Education in Urban Contexts*). This conversation, which was anchored in DiAngelo's *White Fragility,* gave residents the space to explore and compare their own identities. They discussed such topics as "subverted racism," gentrification, tracking or leveling in schools, and biased ideas about other races within their families (Observation # 8, *EDU 650: Foundations of Education in Urban Contexts*). All of this was valuable to these residents as they were about to enter classroom spaces comprised of young people from various backgrounds and heritages.

However, during this discussion, I also observed something else that is noteworthy in terms of the program's approach to preparing urban teachers. Two AMNH residents in two different groupings for this discussion surfaced the same concern about different minoritized groups discriminating against one another. For instance, in one group, a male resident who identified as Latinx shared an anecdote about his parents' reluctance to let him have Black friends. He used this example to point out that he had "noticed that racism against black people among Latinos is so obvious" (Observation # 8, *EDU 650: Foundations of Education in Urban Contexts*). A few others in that group went on to share similar examples. In the other group, where the teacher educator was present, one resident, who also identified as Latinx, asked the teacher educator towards the end of the discussion: "So I feel like we focused on white people [today] …do we ever focus on how people of color can be racist to other people of color? Or do we always talk about white people being racist?" (Observation # 8, *EDU 650: Foundations of*

Education in Urban Contexts). The teacher educator did not really answer this question, as it was asked during a transition time- from the end of the discussion to a time for individual writing and reflection.

Because these two similar comments stuck with me, I asked the instructor about this later, in an interview. She admitted that she felt “a little anxious” adding that, “This idea of intercommunity racism... It’s hard to know... I feel uncomfortable as a white woman talking about that. That doesn’t mean I shouldn’t [talk about it], I just don’t feel like I know enough. I know that it exists. It exists among African Americans even” (Interview # 11, Program Faculty). As a white woman urban teacher and teacher educator myself, I share her hesitancy regarding this topic. As an observer in this moment, I myself wondered just how best to approach this moment as a *rejection of colorblindness* and a way to help these prospective teachers understand ways to enact this principle in their own classrooms.

This is not to say that white teacher educators cannot and should not do this work. But what this does point out is that working to center race and racism in urban teacher preparation courses requires, as Milner argues, careful, “deliberate and consistent” efforts to do so. This course created the space for the residents to surface their ideas and concerns about race, racism, and class in their impact in the classroom. Beyond this discussion, and others like it in this course, there did not seem to be many ways for residents to connect their thinking to the practice of teaching and to explore and understand the myriad ways that racism operates outside of schools. This is especially the case because centering race in this way was not persistently present in all aspects of the program.

As I have pointed out previously, this is a problem not specific to the AMNH MAT, nor is it a new problem. For instance, over twenty years ago, Cochran-Smith (2000), a white woman teacher educator and well-known scholar in the field, wrote honestly and tellingly about her struggles to prepare teachers for the urban schools of Philadelphia. She suggested that white teacher educators have “blind vision” – having the “vision about the importance of making issues of race and diversity explicit parts of the preservice curriculum,” but in this process “grappling (sometimes blindly) with the tension, contradiction, difficulty, pain and failure inherent in unlearning racism” (Cochran-Smith, 2000, p. 8). Building on Milner and Cochran-Smith, I would suggest that working to disrupt racism in teacher education coursework requires careful, conscientious, and collaborative planning among multiple faculty and educators from various backgrounds and experiences. This cannot be the work of single teacher educators in single courses, nor can it be the work of white teacher educators alone, otherwise there is a risk that racism in teacher education and in teaching will continue to be perpetuated- no matter how well-intentioned and antiracist white teacher educators work to be. Without the presence of faculty perspectives from multiple and varied cultures, heritages, and backgrounds, and dedicated attention to handling discussions about race, just the one described above, teacher education runs the risk of actually remaining *colorblind,* in spite of their efforts to reject it.

Finally, I want to suggest that by itself, this course raised some questions that helped the residents *reject colorblindness* as an approach to preparing teachers to create opportunities in classrooms. However, the issue is that this course was the main way the program directly tackled racism. Teacher educators and scholars have long argued that this kind of “add-on approach” is problematic because it has a limited influence on prospective teachers’ attitudes, abilities, and willingness to disrupt racial inequities in classrooms and schools (Cochran-Smith, Davis, & Fries, 2003; Ladson-Billings, 1995, and; Villegas & Lucas, 2002). In other words, the AMNH MAT “respond[ed] to demands to address the increasing diversity of students by adding on a single course in multicultural foundations" (McDonald & Zeichner, 2009, p. 598). As these researchers found, this kind of approach has a "limited impact on prospective teachers' beliefs and attitudes about and practices with students of color, low-income students, and English language learners" (p. 598).

Another reason that this approach is problematic is that it may create a "dangerous dichotomy" in that it presents a "separation between preparing teachers with subject matter and pedagogical content knowledge and preparing them with knowledge of students from diverse backgrounds and commitments to social justice" (McDonald & Zeichner, 2009, p. 598). Similarly, Sealey-Ruiz (2021) argued that while courses such as this one are imperative for urban teacher preparation, they are also not enough. In short, urban teacher preparation programs writ large need to work towards a more pervasive, consistent approach to preparing teachers for urban schools. One course alone does not make a comprehensive, cohesive approach to preparing teachers for the complexities of urban schools. This kind of "add-on" approach does not give residents multiple access points for interrupting their own ideas and for learning ways to challenge status quo in schools. Also, placing the responsibility for creating and enacting the primary coursework for preparation of urban teaching on the shoulders of one teacher educator feels like an uneven responsibility. Therefore, I suggest that this course was the key example of the AMNH MAT program's approach to *rejecting colorblindness,* which was helpful in some ways, but, as stand-alone courses tend to be, was ultimately incomplete for preparing residents for the complex context of urban school.

Other Courses. In addition to the urban context course, there were two other courses that residents and program graduates referred to in interviews as useful in preparing them for urban school contexts: *EDU 610: Content Area Literacy with Applications to Multilingual Context* (hereinafter the multilingual contexts course), which I briefly discussed in Chapter 4, and EDU630: *Developmental Variations: Development, Assessment, and Instruction with a Special Needs Focus* (hereinafter the developmental variations course). Together, these courses were designed to help residents understand how to have high expectations for students in part by acknowledging the assets that each student brings to the classroom. This is related to what Milner (2010; 2020a) referred to as *shifting low expectations and debunking deficit mind-sets.* Just as was the case the urban context course, however, these courses partially approach this opportunity-centered principle.

The aim of the multilingual contexts course included residents' ability to understand and develop literacy lessons for emergent bilingual and multilingual learners, as evidenced in its objectives:

> Demonstrate understanding of the integral nature of communication skills, including language acquisition for English Language Learners, and the role of communication in the practice of science, the learning of science, and science literacy…Demonstrate the ability to prepare differentiated lessons for presenting science information to students with varying English language abilities; Demonstrate the ability to design and use graphic organizers and other strategies for scaffolding science learning for all students. (Program Document #409, Syllabus, Multilingual Contexts Course)

Generally speaking, the requirements of this course required MAT residents to know, understand, and apply content-area literacy teaching practices as well as practices designed specifically for aiding multilingual learners in learning English *and* science concepts and practices.

A main feature of this course, which was alluded to in Chapter 4, was that it required residents to organize a field trip to the museum for students from their respective school residencies. In fact, when I asked residents and program graduates how the program prepared them to be urban teachers, many mentioned the impact this particular assignment had on their understanding of teaching young people from different heritages and backgrounds. For instance, here is one resident's account of this experience:

> We just finished [an assignment] for the multi literacy course. We had to design a field trip that integrated a science hall and cultural hall. They asked that we specifically try to include students that were non-primary language English speakers, EL students or ENL…So we really tried to focus on designing the curriculum around that. And I found it really rewarding and the students really responded well. I had some of my students say 'it was so exciting to see stuff from where my family is from in the museum. I didn't even know the stuff was here.' I thought that was a really nice moment-... to see how making those connections really meant something to the kids. (Interview # 19, Resident)

This assignment worked to center students' cultural and linguistic backgrounds, honoring their funds of knowledge and recognizing their heritages as assets to learning. It is also interesting to point out here that this particular course *did* incorporate an AMNH cultural hall, unlike other MAT programming, as this chapter opened up explaining. This makes this course an example of the museum MAT's efforts to do what Milner referred to as *debunking deficit mind-sets* into the curriculum because many of the assignments in this course required residents to prioritize the primary language and culture of their students in order to teach them important science concepts and practices.

The developmental variations course also offered residents opportunities to create learning environments where high expectations were fostered, and where differentiation in teaching and Universal Design for Learning (UDL) principles were applied to create greater opportunities for all learners, especially those with special needs. While not an overt centering of marginalized perspectives can be seen in this syllabus, the course description reveals its focus on supporting and motivating all students:

> This course is designed for middle and high school science teachers in urban settings and takes into account school and life contexts of adolescent students. Students will study human developmental processes and variations, including the impact of culture, temperament, heritage, socioeconomic level, classroom ecology, and other factors that may impact a student's readiness to learn. The course uses the pathways of learning to focus on adolescent development, both "typical" and "atypical" … A key principle is to utilize students' strengths as a vehicle to support areas of struggle and as motivation in a safe and respectful environment. (Program Document # 410, Syllabus, Developmental Variations Course)

When asked how this course was helpful for preparing them for urban schools, a few residents and graduates mentioned that they learned a lot of helpful classroom management strategies from the book, *Make Me! Understanding and Engaging Student Resistance in Schools,* written by Eric Toshalis. Toshalis (2015) offers perspectives and practical advice on how to understand adolescent behaviors in the classroom. One resident commented on this course in general, indicating that:

> This is something I was looking forward to since the program started is [that] they have a really big focus on special needs and how to address students that have different learning

needs that maybe need extra scaffolding in different areas because those are the students that need extra help. So they do a good job with that. (Interview #19, Resident)

When teachers witness what can be at times the mercurial behaviors of adolescents as moments to be understood and used to develop relationships with students rather than as nuisances and distractions, they create opportunities for students to discuss their emotions. Put another way, when educators see their students' outward behavior—no matter how it manifests—as a way to look inward at how they are understanding their environment and the course curriculum, then they are moving toward understanding students' perspectives as assets. This in essence works to create high expectations for students because educators refuse to let them fail. Milner's (2010; 2020a) *shifting low expectations/debunking deficit mind-sets* principle is as much about responding to students' current well-being as it is about creating opportunities for learning at multiple levels. This course offered MAT residents a chance to create classrooms of opportunity through some practical advice and useful instructional strategies for working with young people.

Taken together, these two courses did some of the work involved in helping residents *debunk deficit mindsets* and *shift low expectations.* However, while they offered important insights, neither of the courses completely addressed the ideas behind Milner's principles. In terms of the multilingual contexts course, the important literacy practices residents learned were framed as useful for *all* contexts, including urban contexts, and they were not overtly specific to the multi-layered linguistic backgrounds of students in New York City schools. In terms of the developmental variations course, the strategies and dispositions emphasized were useful tools for facilitating any secondary classroom but did not tackle head on or centralize the many complex layers of race and racism that impact minoritized youth in particular. Also, important to note is the fact that it is an imperative that all public school teachers learn how to teach emergent bilinguals and students with special needs; these are not features specific to urban schools. Rather, they are part and parcel of becoming a teacher in any location or sociocultural context. In this way, the MAT program addressed important aspects of public schools in general, but it did not use these courses as opportunities to center urban school contexts in particular. This means that the program only partially attended to the core issues related to rejecting *deficit frameworks and low expectations* for minoritized students emphasized in Milner's framework.

Culturally Relevant Practices. As I mentioned, the leaders of the AMNH MAT, along with many teacher preparation programs around the country, stated that a commitment to equity was a goal of teacher preparation. One demonstration of this was the program's growing commitment to culturally responsive teaching practices, particularly when those practices worked in tandem with high-leverage science practices. In Chapter 4, I described the MAT's recent and specific attention to what it referred to as "high-leverage culturally responsive science teaching practices" (Institutional Document #20, *2018 NOYCE Grant application*; Institutional Document #21, *2019 TQP Grant application*). As I described in Chapter 4, for the AMNH MAT, this meant

> specific strategies and concrete moves teachers can make in their classroom to implement [CRT] culturally responsive teaching…. The program focuses on helping residents with the four key aspects of CRT identified by the NYSED: creating a welcoming and affirming environment; fostering high expectations and rigorous instruction; identifying inclusive curriculum and assessment; and engaging in ongoing professional learning and support. (Institutional Document #21)

This effort was corroborated by program faculty, one of whom noted, "I think that in more recent years, we've just become a lot more transparent, brought [equity] a lot more to the forefront…Having a lot more conversations about it" (Interview #5, Program Faculty). Interestingly, another program faculty added to this claim, pinpointing a specific moment in the program's history when they began to pivot to more deeply incorporating culturally relevant practices:

> A lot was going on in that first summer [2016] they [Cohort 5] were here. There was the death in Minneapolis, the death in South Carolina of two black men. There was a lot happening…The Pulse incident... So, there was just a lot of turmoil, not just around race, but race being a big one. And I think the program started to see that they needed to figure out ways to integrate, maybe not a course, but something to address race a little bit more head-on…bring that into the program more. Because… you could see certain teachers were not really that comfortable with dealing with the Latinx kids and the Black kids in the room…They were…making a lot of assumptions and saying a lot of…stereotypical things that you're like, 'Wow. No one really pushed you to think about where these ideas come from and how they're actually getting in your way of being effective.' (Interview # 13, Program Faculty)

Here, this MAT faculty captured the program's commitment to reconsidering its programming to include more ways to challenge and interrupt residents' ideas about what constitutes culturally relevant approaches to working with marginalized young people. She valued examining the impact of societal events on schools and schooling and worked to bring exploration of privilege and self to the AMNH MAT. Some additional examples of what this looked like in practice can be seen in the next section, which discusses tools and arrangements the program used to prepare residents for urban schools.

A final example of the AMNH MAT's recent efforts to ramp up its culturally relevant practices was shown in its publications and conference presentations**.** For instance, in January 2020, members of the AMNH MAT faculty, along with one MAT mentor teacher and one program graduate, presented a paper at the American Association of Colleges for Teacher Education (AACTE) titled: "Disrupting Inequities through Culturally Responsive-Sustaining Science Teaching: From Preservice to Inservice" (Kinzler et al., 2020). New York State defines "culturally responsive sustaining education," as being "grounded in a cultural view of learning and human development in which multiple expressions of diversity (e.g., race, social class, gender, language, sexual orientation, nationality, religion, ability) are recognized and regarded as assets for teaching and learning" (NYSED, 2019). This paper argued that the museum MAT engaged in "culturally relevant sustaining education" in three key places in its program: the *AMNH MAT Program Observation Rubric* (described in detail in Chapter 5*)* as it was used in the residency partner schools, the *AMNH MAT Dispositions Continuum for Teaching and Learning Tool*, and various assignments in one particular course, *EDU 640: Methods & Assessments in Student Science Research* (a course about which I have very little data). This paper also argued that the AMNH MAT was investigating "stories from the field," which was an opportunity for recent graduates to come together to share their experiences with culturally relevant sustaining science teaching practices. This reveals that the MAT program believed that it included key aspects of culturally responsive and sustaining pedagogy, which include *shifting low expectations* and *debunking deficit mind-sets.*

It is important to reiterate that data collection for this case study occurred from May 2019 to January 2020. This means that the data for this case study, like that of many dissertations, is already somewhat out of date by the time the dissertation is written in that the written document does not represent all the current efforts in which program leaders and faculty may be involved, including very recent efforts related to culturally relevant practices. Because the MAT program has clearly been involved in increasing its efforts to understand and center culturally responsive and relevant pedagogy and practices over the past two years, a point I take up again in Chapter 7, it can be presumed that this work has been strengthened since the period of data generation. Also, given that the museum MAT's mission is to serve the public, and because of the recent public traumas brought on by the pandemic and ongoing racial reckoning, it would be interesting to see how the program has continued to increase its efforts to center race and racism.

This section has shown three specific ways in which the MAT's courses and practices attempted to do what Milner refers to as *rejecting colorblindness*, *shifting low expectations,* and *debunking deficit mind-sets.* I have also shown that while these efforts were compelling in certain ways, it was also clear that this work was also incomplete because these activities were not pervasive, meaning that they could not be seen throughout all experiences in the process of learning to teach at the museum. They were also at times not directly connected to the context of urban schools in particular, nor were they explicitly focused on what Milner believed was necessary for creating opportunities in urban classrooms. A final point to make is that the program's *less central and more limited* attempts to prepare urban teachers is made particularly clear when compared to the MAT program's *centralized and continual reinforcement* of science knowledge, science identity, and high-leverage science practices.

Tools and Supports

I use "tools and supports" as the second heading for analyzing the AMNH MAT's specific efforts to prepare residents for urban schools contexts. The *AMNH MAT Dispositions Continuum for Teaching and Learning* (Dispositions Tool hereinafter) was a tool used in some of the programming for the MAT, including the Diversity, Equity, and Inclusion (DEI) workshops, which were for residents, and the Mentor Academy, which was designed to support mentor teachers as they worked with residents. The tool was also used in the monthly induction support that was offered to program graduates once they were teachers of record. While induction activities occurred after *preparation* to teach, I include it briefly here because the museum MAT's induction programming was in fact a feature of the program that set it apart from many other teacher residency programs, I point I make in Chapter 2. In addition, program graduates found the induction sessions incredibly useful for their practice, using phrases such as "phenomenal," "a nice benefit," and a "safe space" to describe this experience (Interviews # 21, 22, 25, Program Graduates). For instance, one program graduate indicated that "if I didn't have induction I wouldn't have made it through my first year" (Interview # 21, Program Graduate). The best indication of MAT graduates' positive experience was captured in this comment from a graduate:

> So, we had induction for three years. I felt that [this] was so much more meaningful than anything I learned in the classroom [i.e., MAT coursework], any of the books that I read… Like, nothing that we're really talking about or doing in class or in the graduate program was really relevant to my experience in a New York City urban school. (Interview #24, Program Graduate)

This program graduate makes a clear statement that induction programming, which occurred after preparation while she was a teacher of record, was valuable and meaningful. In doing so, however, she also implies that the program coursework was not so relevant to her experience as a New York City teacher of record. This kind of comment adds to the case that the AMNH MAT offered *some* quality support programming for its residents and graduates, but that this was limited in scope and depth.

It is important to note here that a single AMNH faculty member was responsible for all of the above-described support programming—the DEI workshops, the Dispositions Tool, and the Mentor Academy. I refer to these as “support” programming because these aspects of the program were designed to supplement teacher preparation at the AMNH MAT but were not integrated into the major science content and science pedagogy courses. Another way to look at this is through an analogy. Typically, curriculum and instruction are understood to be the main vehicles involved in K-12 teaching, whereas tutoring and advising are seen as ways to support teaching. The AMNH MAT’s dispositions tool and support programming were like tutoring or advising –that is, they were parts of the program designed to assist candidates, but they were *not* the main components of the curriculum.

To help understand this tool and support programming, I apply Milner’s (2010; 2020a) principle of understanding *cultural conflicts*. In his general framework, Milner (2010; 2020a) argues that *cultural conflicts* are inevitable events in classrooms; thus, they should not be avoided or ignored, but rather they should be addressed and interpreted as chances to build stronger relationships between and among teachers and students. This is particularly important because, “When teachers operate primarily from their own cultural ways of knowing, the learning milieu can be foreign to students whose cultural experiences are different from educators’ experiences” (Milner, 2020a, p. 38). If prospective teachers do not have opportunities to examine their own practices, they might be prone to reproducing culturally disconnected teaching practices. Over time, this could lead to gaps in opportunities in the classroom because the teacher might struggle to connect with her students. Milner (2020a) posits that prospective teachers need to be prepared for cultural conflicts to happen in classrooms, and they also need to understand the implications if they are not addressed. Milner (2010; 2020a) argues that not addressing the *cultural conflicts* that may occur between white teachers and students of color tends to exacerbate inequity, such as the well-documented fact that students of color disproportionately receive more disciplinary referrals, including suspensions, than their white counterparts (Skiba et al., 2000). In essence, then, recognizing and learning how to work through *cultural conflicts* is necessary to create opportunities for students to experience deep, meaningful learning in classrooms.

In addition to understanding *cultural conflicts,* Milner (2020a) also argues that prospective teachers need to pack the *myth of meritocracy*, which is the false notion that hard work is all that is required to be successful. To understand this, residents need to examine and understand their own lived experiences and how they are impacted—either positively or negatively—by the central narrative of this myth. Milner emphasizes that this narrative is problematic because it ignores "the enormous variation in students' social, economic, political, and educational opportunities" (p. 46), wrongly assuming that all students go to school on an even playing field with the same amount of support and resources. Challenging this myth involves educators' self-interrogation and examination of how they can build practices that create opportunities for young people to see themselves as not only capable of success, but also as powerful enough to disrupt this false narrative. This requires that prospective teachers have multiple opportunities to examine their own positionalities and identities and to consider how they impact the decisions and interpretations they make about what to teach, how to teach it, and what to do when young people struggle to learn it or challenge them to be better, which inevitably happens in any given classroom.

What I want to suggest below is that the AMNH MAT program partially addressed both *cultural conflicts* and the *myth of meritocracy* through the Dispositions Tool and two specific components of the program—DEI Workshops and the Mentor Academy. These are described together because, as noted above, they were created, organized, and facilitated by the same faculty member, who also co-developed the Dispositions Tool and designed and facilitated the induction support. Also, during my observations and interviews, I found that DEI Workshops and the Mentor Academy were usually described together in light of their common aim to help residents explore their own identities.

Dispositions Tool. Developed primarily by two AMNH faculty, the Dispositions Tool was comprised of "eight dispositions or professional attitudes, values, and understandings demonstrated through both verbal and non-verbal behaviors that educational research has demonstrated support teaching and learning in classrooms and school communities" (Program Document #43, *Dispositions Tool*). At four points throughout the program, described below, residents were asked to evaluate themselves using the Dispositions Tool, which resulted in a rating that ranged from "emerging" to "aspirational" in terms of their ability to understand each of the eight dispositions. The tool also asked residents to reflect on any "red flags" that "need immediate attention;" in other words, they were asked to notice their own attitudes and behaviors inconsistent with those listed on the Dispositions Tool.

The Dispositions Tool identified the following dispositions as necessary for effective teaching: belief in potential for growth, respect for difference, humility, persistence, self-awareness, reflection, honestly and ethics, and accountability (Program Document #43, *Dispositions Tool*). This tool was not a program assessment in that it was not used to rate or grade residents' teaching performance, but rather it was meant to offer structured support for the residents as they reflected on their own teaching during the program's residency experiences. The first time the residents worked with the Dispositions Tool was during the museum teaching residency, where they were asked to reflect on four of the eight dispositions after teaching on the carts and in the museum's teen programming, both described in Chapter 5. According to one of the faculty members responsible for creating and implementing the Dispositions Tool, this first activity with the Dispositions Tool was meant to be reflective:

> We're trying to give people an immersive experience and not just like talk about what the disposition is… the residents are paired, and they will ask each other, 'How do you think you're doing with [this] disposition?' And then they have to give some evidence…they fill the tool out themselves. (Interview #13, Program Faculty)

This comment specifies that this was a self-reflective tool, meant to ask residents to recognize what dispositions they brought to their first teaching experience at the museum.

Guided by their mentor teacher and a senior specialist, the residents also used the tool as a way to record how and to what extent they were enacting the dispositions on the list at the start of their school residency during the fall of the program. The tool was also used during the January and June Milestone Meetings, also described in Chapter 5, which were designed to ensure that the residents were making progress and meeting all program requirements for a successful graduation the following September. The AMNH MAT faculty who co-designed the tool explained: "We come back to it three times in the program because we want the residents to see their own identity being shaped through the program. And can they see, you know, how even for some of them, even just asking them to reflect on their identities, like, 'What are you?'" (Interview #13, Program Faculty).

Because the Dispositions Tool was a self-reflection tool intended to offer residents opportunities to examine their own attitudes and behaviors in the classroom, it can be understood in part as an attempt to help its residents work through *cultural conflicts.* Importantly, however, this tool was used almost exclusively within the activities I refer to above as support programming and was not consistently interwoven into the readings, assignments, or activities of the major courses. In this way, while residents' applying the Dispositions Tool to their own growth was an important activity, it was not connected to the science practices and pedagogies residents were learning in their courses. The Dispositions Tool, on its own, did not offer the residents a well-rounded, or complete, exercise in learning how to see *cultural conflicts* in the classroom as opportunities. Also, the tool itself did not ask residents to examine their interactions with students that specifically were about culture. While the tool did focus on key dispositions needed for creating a caring classroom environment, it did not explicitly offer residents the opportunity to delve deeply into circumstances where cultural conflicts occurred.

It is important to also point out that the Dispositions Tool was positioned as a key component of preparing its residents for diverse populations, as this excerpt from an accreditation document states:

> MAT candidates' development of professional dispositions, which are key to teaching diverse populations of students, is supported through the Dispositions Tool (piloted in 2016–2017 and officially launched in 2017–2018). Specifically developed as a tool rather than a rubric, it is used to support and monitor growth of candidates' attitudes, values, and behaviors, with an emphasis on supporting positive interactions with students, families, and colleagues. It is also used to support graduates during their first and second years of teaching. (Institutional Document #4, *Diversity Cross-cutting Theme*)

What this excerpt reveals is that the AMNH MAT believed that this set of dispositions in particular was necessary for teaching diverse populations. It is possible to argue that dispositions such as "belief in potential for growth," are connected to the residents' understandings of *cultural conflicts* because this belief was defined as "residents hold[ing] high expectations and emphasiz[ing] strengths" by "understanding that students, families, colleagues, and they, themselves, all have the potential to develop emotionally, socially, and intellectually" (Program Document #43, *Dispositions Tool*). However, these dispositions are general; they relate to *all* teachers in *all* kinds of schools. One might expect that a tool centered on dispositions in program designed to prepare teachers for urban schools would more directly address teacher candidates' ability and willingness to deal with cultural conflicts as opportunities to learn about their students' strengths. The Dispositions Tool did not explicitly address preparing teacher candidates for the *cultural conflicts* in the sense that Milner (2010; 2020a) talks about it.

While this might be the case, the Dispositions Tool was particularly useful in terms of supporting residents' and program graduates' understandings of teaching, as pointed out by a resident:

> They're looking for someone, as far as they tell us, that exudes all of the dispositions that they care about. I can list them if you want… belief in potential for growth, there's honesty and ethics, accountability, reflection, humility, persistence.…So they're looking for those things, and I think that's because of the emphasis on relationship-building. Like those are all very important for you to be a professional…I think that embodies what they're hoping their graduates are. And they're hoping that we're ready to go out into the world and create scientists or inspire scientists. (Interview # 20, Resident)

What this comment suggests is that the residents very clearly understood that the program positioned these eight dispositions as key characteristics of good teaching. This comment also suggests that while the eight dispositions were linked broadly with the program's important goal of preparing teachers to "go out into the world and create scientists or inspire scientists," they were not directly linked to urban school contexts. In this way, the program's ambivalence with regard to understanding *cultural conflicts* was clear.

According to Milner (2020a), educators need "to understand the ways in which privilege and power emerge in classroom settings to maintain the status quo" (p. 25). This level of deep, critical understanding was not present in AMNH MAT programming, as one resident indicated:

> In the summer we did a lot of reading about the history of racial segregation in the city. And sort of talking about how the school system is sort of deeply rooted in that… And different ways to address it and make sure that we're comfortable being in sometimes uncomfortable situations when you're talking about racism and the history of racism and l science and history…. I think it'd be nice to have a little bit more open conversations about that because it, it can be very awkward in the classroom, and it does come up all the time. (Interview # 19, Resident)

What this resident was suggesting was that the required course readings were useful in understanding larger issues of societal and historic racism, but that there was not enough time dedicated to unpacking these readings and, more importantly, to applying them to residents' teaching experiences in the school residencies. This means that while the AMNH MAT introduced the residents to some issues related to societal racism, it did meet Milner's expectations for how to include opportunities for residents to understand and practice how to use their knowledge and experience to strengthen relationships with students. This same resident offered a specific example that speaks directly to this limited approach to addressing *cultural conflicts:*

> We don't have a lot of hard conversations I think as a cohort…that are led by the instructors. And it's fair because it is a very difficult conversation to…really talk about like what do you do when a student calls you a racist…But that's something [that] does every now and then come up. Like I tell students…I studied human evolution in South Africa. And one of my more outspoken kids was like, 'Ma'am that's racist to say we all came from Africa.' And I was like, okay let's dial it back. Let's talk about what that means. (Interview #19, Resident)

Here is a prime example of a *cultural conflict* in a classroom, and this resident revealed that she felt stuck in this moment because she did not have enough practice with or ideas about how to respond. As an urban teacher of many years, I can say for sure that hearing the comment, "Miss, that's racist," was not an unusual experience in classrooms. I use this example to highlight that while the AMNH MAT acknowledged the value of diverse cultural perspectives and worked to ensure that the residents developed certain generic dispositions, they stopped short of providing ample opportunities to nurture the dispositions and skills need to work through *cultural conflicts* in classrooms, which Milner (2020a) argues could deny students opportunities to learn.

DEI Workshops/ Mentor Academy. The AMNH MAT's efforts to emphasize culturally relevant practices, described in a previous section, were part of a larger institution-wide focus on diversity and equity. In addition to more recent efforts to understand and incorporate culturally relevant teaching practices, the MAT program also included DEI Workshops in their programming for residents and mentors, using its Dispositions Tool as a foundation for discussions, activities, and instructional planning during these workshops. This was described in a 2019 grant proposal:

> In 2018, the [Museum's] Board of Trustees adopted a statement reflecting AMNH's approach to diversity, equity, and inclusion (DEI), and the institution has engaged in designing a comprehensive DEI work plan that addresses the full spectrum of the Museum's operations and activities with specific actions and measurable outcomes. Part of this effort includes designing and offering a set of learning experiences, informed by the deepening practice of the MAT-R[esidency] faculty, for all AMNH Education staff with a focus on foundational research principles undergirding culturally responsive teaching (CRT) and an initial repertoire of CRT practices. (Institutional Document #21, *2019 TQP Grant Proposal Narrative)*

The work of incorporating culturally relevant pedagogy into the AMNH MAT program also involved greater opportunities for residents to engage in DEI Workshops:

> Beginning with the 2017–2018 (Cohort 6) program year, candidates are engaged in five diversity, equity, and inclusion (DE&I) workshops spread out across the 15 months, designed to deepen their understanding of the connections between professional dispositions (using the Dispositions Tool) and DE&I. Themes of the workshops include *What does it mean to be Culturally Relevant?* And *Setting up an Equitable Classroom*. DE & I work is also integrated into Mentor Academy and into new teacher induction. (Institutional Document #4, *Diversity Cross-cutting theme, CAEP Accreditation*)

As mentioned, the AMNH faculty member who drove the efforts to incorporate more attention to diversity, equity and inclusion in the program was also the co-creator of the Dispositions Tool. She described her reasoning for fusing together DEI Workshops and the Dispositions Tool this way: "If you were really valuing these dispositions and modeling these behaviors, all the time, then you probably have a pretty good diversity, equity, inclusion perspective about teaching" (Interview #13, Program Faculty).

The fact that the Dispositions Tool, described in detail above, was the anchor of the DEI workshops reveals two important things. First, it reveals that there was some cohesion in terms of how the residents experienced learning to teach for urban schools because the residents experienced both the Dispositions Tool and DEI workshops at multiple different points in their process of learning to teach. Importantly, each time they were called upon to examine their own positionalities and teacher identities, they used the same concepts and language to do so. This level of consistency is beneficial for examining how one's cultural background and lived experiences inform one's ability to connect with others, especially as a classroom teacher in urban schools.

The second point to make here is that the Dispositions Tool and the DEI workshops partially accomplished the goal of interrupting the *myth of meritocracy* by challenging the residents to exhibit "self-awareness," which was described as "reflect[ing] and examin[ing one's] own perceptions and behaviors on others" (Program Document #42, *Dispositions Tool*). One component of self-awareness is understanding the inextricable relationship between one's life experiences and the way one sees the world. In this sense, when residents reflected on their own perspectives, they took an important step towards understanding how and to what extent they themselves either benefitted from or were burdened by the *myth of meritocracy.* Also emphasizing "respect for difference," the Dispositions Tool and DEI workshops helped residents "embrace differences and model respect in communities…in a manner that affirms and protects the dignity of every individual" (Program Document #42, *Dispositions Tool*).

It is important to highlight here that "self-awareness" is an important place to begin in terms of understanding how the *myth of meritocracy* has impacted others. However, this "self awareness" and the corresponding programming did not directly or overtly tackle racism and poverty, which are part of the systems and structures that support the *myth of meritocracy.* This is problematic because racism and poverty characterize many large urban schools, but the program did not use the Dispositions Tool and corresponding support programming in ways that Milner (2010; 2020a) suggests are necessary to prepare urban teachers to create opportunities for young people. In fact, nowhere were the constructs *poverty* or *privilege* mentioned directly in the Dispositions Tool. And *race* and *class* were only referred to once- together along with "all cultures, languages…ethnicities, religions, ages, sexual orientations, and gender"- under the criteria "respect for difference," described above. This suggests that the DEI workshops were a partial attempt to address Milner's principle of disrupting the *myth of meritocracy*. It is certainly necessary for all prospective teachers to be self-aware and to respect differences. But, as Milner and others argue, it is a moral imperative for urban teachers to understand and unpack the many ways that larger societal oppression infiltrates the lived experiences of young people in urban schools and also shapes their own attitudes, expectations, and assumptions.

In addition to the DEI workshops, the Mentor Academy also partially debunked the *myth of meritocracy.* This programming was offered as a "six-day [training] to prepare mentors to support Fellows' development of high-leverage culturally responsive science teaching practices" (Institutional Document #20, *2018 NOYCE Project Narrative Proposal*). The purpose of this professional development for the mentor teachers in NYC partner residency schools was to assist them in guiding the MAT residents as they navigated the complex settings of their classrooms, as the faculty member responsible for his program articulated:

> A lot of the diversity, equity, inclusion work, we brought that into the mentor work because the mentors want that too. Because everyone, I think, when you set it up right, people, I think, want to talk more about complex issues around race, and class, and want help like how do I deal with this in the classroom or how do I mentor for this. It's one thing to feel like you…have some insight into yourself, but it's another thing to say, 'Okay. You just witnessed your resident do something pretty, like it was subtle, but you saw…a deficit focus. (Interview #13, Program Faculty)

What this faculty member meant here when she referred to the concept of "how do I deal with this in the classroom" was what Milner (2020a) would refer to as a necessary and pivotal experience in urban teacher preparation: the bridge between ideas, theories, and concepts to understand race and racism and the pedagogies and practices educators can use to be antiracist every day in their classrooms. This is deeply challenging work, and one way the AMNH MAT attempted it was by including the mentor teachers from their partner schools in their DEI workshops and in their use of the Dispositions Tool.

However, this programming comprised only part of the project of learning to teach at the AMNH MAT because it was primarily offered as workshops, and not overtly embedded in coursework or requirements of the program, nor was it offered to MAT faculty themselves. In this way, I argue that like the program's single urban context course, this programming can be considered an "add-on approach" (McDonald & Zeichner, 2009) to preparing urban teachers. Also, this tool and support programming were to a certain extent marginalized in the overall program in that there was one AMNH faculty who was primarily responsible for the design and facilitation of this crucial work of helping residents examine their own backgrounds and identities and interrupting ideas about meritocracy. This was made clear when another teacher educator cited this programming as important work for preparing urban teachers, work that she herself was trying to incorporate more in her coursework:

> We're calling them [DEI] workshops where we've done things like identity wheels, talking about race, how do you talk about race, we've talked to the mentor teachers as well like, how do you talk about race? How do you mentor someone who is asking these questions or wanting to know different things about it?... I try to make it more prevalent in my course but that's something I'm working on. How can I make this course that's about science and teaching science be also about identity and privilege? Every year, I try to add another thing to try…We're working on it. Most of the work that I do directly with the residents is probably informal, casual, like the kind of conversations I just happen to have with them. (Interview #5, Program Faculty)

This faculty member acknowledged the importance of focusing on identity and privilege in DEI workshops. She demonstrated the challenge of working to honor and expand this work in her own courses. Her struggle to incorporate curriculum that helped residents understand *cultural conflicts* and debunk the *myth of meritocracy* in her course about science teaching and science practices, despite her beliefs in the importance of doing so, reflects the difference between the *centralized*, *continually reinforced* efforts the program made to focus on science teaching practices, as opposed to the *less central* and *more limited* way they prepared the residents to understand and challenge the *meritocracy myth.*

Commitments and Arrangements

This is the final section of the chapter, which analyzes some of the AMNH MAT's commitments and arrangements related to preparing residents specifically for the urban context of New York City schools. The AMNH MAT program was committed to recruiting candidates of color, which was part of its larger commitment to diversifying the teacher workforce in New York high needs schools. In addition, the AMNH MAT's partnership arrangement with the New York City Department of Education (NYCDOE) was strong, as evidenced by each candidate's two five-month residencies in each of two New York City partner schools. Time spent in these schools is significant, since most residents went on to become teachers of record in New York City schools. These commitments and arrangements collectively reveal that the program partly attended to the specific urban context where it was preparing teachers, first by working to recruit and graduate teachers who reflect the diversity of NYC schools and second by brokering a relationship with the schools themselves.

These efforts to recruit the people and contexts of urban schools are related to what Milner (2010; 2020a) referred to as *rejecting context-neutral mind-sets and practices.* In essence, *rejecting context-neural mindsets* is interconnected with *rejecting colorblindness* because both principles work together to make central in both curriculum and instruction the knowledge sources, assets, and cultural traditions of the people and communities that make up urban schools. While *rejecting colorblindness* can be seen as an ongoing effort on the part of educators to create curricular opportunities to explore and examine race and racism, rejecting a *context-neutral mind-set* might be thought of as the ongoing practices of teachers and teacher educators to incorporate the lived experiences of their students, families, and communities into the daily workings and practices of the classroom space. Milner (2020a) argues that having such context knowledge is as important as— maybe even more important than—having content knowledge: "It is not enough for educators to have deep subject-matter knowledge if they lack strong context-centered knowledge" (p. 57). On the one hand, the AMNH MAT's deep commitment to its residents having extensive science content knowledge seems to contradict Milner here. On the other hand, it can be argued, as I do here, that the AMNH MAT's commitment to diversifying the earth science teacher workforce along with maintaining strong partnership arrangements with New York City schools reveal its commitment to preparing its residents to be successful teachers in the particular context of urban schools.

Like Milner (2020a), Matkso and Hammerness (2014) argue that one necessary component of preparing teachers for the context in which they will teach is offering them tools and practices to analyze any educational context, with the goal of developing a nuanced understanding of its people and characteristics. This level of understanding, they argue, will help beginning teachers move beyond generalizations and cultural stereotypes, enabling them to see how to recruit the assets of their students, their colleagues, and the community in their respective classrooms (Matkso & Hammerness, 2014). As I mentioned in Chapter 2, Matsko and Hammerness (2014) referred to this targeted approach as *context-specific teacher preparation,* which is defined as teacher education programs that include multidimensional aspects of context in coursework and programming. These multidimensional aspects are: federal/state policy context; the public school context; local geography context; local sociocultural context, the district context, and; the classroom and student context. In the next two sections, I highlight the school residency experience as an example of the program's attempt to address local geographic and sociocultural contexts and the classroom and student context of New York City schools.

Recruitment of diverse teacher candidates. In materials that leaders of the MAT program prepared for CAEP national accreditation, a commitment to recruiting a diverse pool of teacher candidates was made clear, as exemplified in this excerpt:

> The program recruits a diverse group of high quality candidates who must demonstrate that they possess the skills, interests, and dispositions necessary for teaching successfully

> in high-needs urban schools. The program targets universities with large geoscience departments and diverse student populations and partners with campus-based governing bodies and student organizations (e.g., Black, Hispanic, Native American, Veteran, and English language learners (ELL) student groups) to help with outreach. (Institutional Document #4, *Diversity Cross-cutting Theme*).

This excerpt reveals some of the procedures used to attract diverse candidates, including specific vetting for diverse racial and ethnic backgrounds during the application process as well as the program's efforts to seek out diverse candidates by recruiting students from particular universities or other settings. Despite its intentions and efforts, however, the AMNH MAT faced challenges in accomplishing its goal of diversifying its cohorts of residents, which were acknowledged and contextualized in its accreditation documentation:

> The program faces two challenges related to recruitment: 1) the small number of individuals with the Earth science undergraduate degree (or equivalent course work) required by NYS for MAT programs preparing secondary Earth science teachers, and 2) the lack of diversity in this limited pool. For example, in the year 2013–2014, the National Center for Education Statistics reports that of the 1,870,000 bachelor's degrees conferred across all fields, 105,000 were in the fields of biological and biomedical sciences, while just 5,800 were in the physical sciences and science technologies, of which geoscience is only one of several disciplines. (Institutional Document #8, *Standard 3 Summary,* CAEP Accreditation)

These statistics situated the dearth of diverse earth science teacher candidates as part of a much larger concern because of the small number of people majoring in the geoscience field. When it came to attracting candidates, the AMNH MAT was faced the twin troubles of finding qualified applicants who had completed the required coursework in the sciences *and* finding qualified applicants of color. As I pointed out in Chapter 2, this is not a problem specific to the AMNH program. Across the country there has been a dearth of prospective STEM teachers and prospective STEM teachers of color for quite some time. Indeed, this was at least part of the reason why the AMNH MAT was founded in the first place.

One program leader offered some nuance to the difficulty with recruiting diverse candidates into the program:

> A lot of the people that feel that they want to get into teaching and particularly teaching in high needs areas as a social justice issue, they're not majoring in geology. They might be majoring in environmental science and engineering but coming out of those courses you often don't have the requirements that you need in geology. You don't have all of them. You have some of them. (Interview # 8, Program Leader)

What this program leader was suggesting was that prospective science teachers with social justice dispositions were more likely to be in environmental sciences, making them ineligible for the MAT program due to a lack of credits in the geosciences. What is important to notice here is that the AMNH MAT was keenly aware of why they were experiencing difficulty in recruiting diverse candidates to their particularly niched program.

Moreover, the museum MAT made efforts to ameliorate this problem. In the following excerpt from accreditation documentation, the AMNH MAT produced important data that revealed that despite the challenges with recruiting racially and ethnically diverse candidates, it had made progress:

> While recruiting enough qualified Earth science majors is challenging, recruiting a diverse student body in the field of Earth science entails even greater challenges: a 2009

> National Science Foundation (NSF) study documented that only 9% of Earth, atmospheric, and ocean science majors were from minority groups (https://www.nsf.gov/statistics/seind12/c2/c2s3.htm). However, the MAT program has been able to meet and overcome these challenges. In Cohort 4 (2015-2016), 33% of matriculated candidates came from groups underrepresented in science, which aligns with the program's future goals. Additionally, 64% of Cohort 5 (2016–2017) self-identify as a member of a minority group. (Institutional Document #8, *Standard 3 Summary,* CAEP Accreditation)

This reveals the intentionality with which the AMNH MAT approached recruiting for diversity- and that this effort was paying off, since the majority of the candidates in Cohort 5 identified as "a member of a minority group."

It is clear that the AMNH MAT program endeavored to attract, recruit, and retain a diverse cadre of earth science teachers, although they also recognized how difficult this was to do. Leaders of the MAT program recognized that diversity of teacher candidates was an important factor to consider when teaching mostly poor and minoritized students in New York's high need schools. In other words, preparing teachers from various backgrounds and contexts can be regarded a good start to helping residents learn that context not only matters in the classroom, but that the diverse contexts from where students come is as an asset and a resource to be recruited in instruction. In other words, the AMNH MAT's commitment to recruiting a diverse pool of candidates is an indicator that it considered the importance of preparing teachers for urban schools to debunk *context-neutral mind-sets and practices*, given that they themselves came from various sociocultural contexts.

However, efforts to recruit a diverse teacher resident cohort were important, but only partial, attempts to center race. Importantly, Milner (2020a) argues that "it is clear that teachers of color, because of their racialized experiences in the world, often have a deeper understanding of students of color, and are accordingly able to co-create learning opportunities that students can relate to and connect with" (p. 33). Goodwin and Keane (in press) take this one step farther, arguing that the rationale for diversifying the teaching profession "needs to include recognition of the importance of teachers from under-represented groups for *all* students…while also continuing to work to transform teacher education to better prepare and support *all* teachers to effectively teach and support *all* students" (p. 34). While this is the case, Gay (2018) and others have cautioned that pairing teachers and students of the same race "may be potentially beneficial, but it is not a guarantee of pedagogical effectiveness" (p. 240). What this means is that recruiting for diversity by itself will not do the work of preparing teachers to debunk *context-neutral mind-sets and practices* in their classrooms. According to Milner (2020a), efforts like this should be combined with coursework and fieldwork opportunities to examine the multiple viewpoints present when there is a diverse group of prospective teachers.

Importantly, there is more than one viewpoint here. For example, Philip and Brown (2020), building on previous scholarship about diversifying the teacher workforce (Villegas & Lucas, 2004), raise questions about an overemphasis on recruiting "teachers of color" as a solution to the problems that exist in schools. They refer to employing teachers of color as

> a narrow goal…[that] can divert attention from the comprehensive transformation of schools and society. While teachers of color may be recruited for their commitments and presumed shared experiences and identities with students of color, these very assets are likely to become liabilities in school contexts that are not aligned in philosophy, institutional culture, and pedagogical approaches. (p. 3)

In other words, recruiting for diversity all by itself will not do the work of transforming instruction in schools and creating greater opportunities for students from minoritized populations. Additionally, the commitment to recruiting and ultimately graduating teachers of color for urban schools does not in and of itself ensure that teachers know how to reject *context-neutral practices* and instead offer multiple ways to incorporate various cultures and contexts in their approaches to teaching and learning. Providing a teacher learning space that is comprised of people with multiple perspectives and experiences at all levels can effectively enhance prospective teachers' understanding of the impact school contexts have on people from different cultures, heritages and backgrounds. In order to do this, however, urban teacher educators must create ample opportunities for recognizing and disrupting mind sets and practices that are implicitly assumed to be *context-neutral.* In this way, I argue that the AMNH MAT was partially committed to developing urban teachers who were able to reject *context-neutral mind-sets and practices* because while it worked to bring diverse people into its program, it did not provide enough experiences to critically understanding and interrupt *context-neutral mind-sets and practices*.

Partnership with NYCDOE/ School Residencies. When asked how the AMNH MAT specifically prepared it residents for urban school contexts, one program leader cited the museum program's strong and committed relationship with the NYCDOE:

> The museum itself has a very deep relationship with the Department of Education in New York City. There's a lot of attention to what New York City Department of Education science department needs. There's a deep connection to the chancellor…lots of meetings with the chancellor, lots of trying to understand what the city and the DOE is interested in. And so I think…at that kind of institutional level, there's a very strong

> partnership…You don't see that in a lot of universities... And I think it was an intentional choice on the part of the program not to partner with many schools because then you wouldn't have this kind of close relationship…So I think there's a recognition that it's important to have people in that role who both know what's happening in our program and in the schools. And I think that's another way that there's a real intention to understand what people need and what the context is. (Interview # 1, Program Leader)

The first point to make here is that this program leader indicated that this strong partnership is unique, and that many universities do not offer this level of commitment to their prospective teachers. While this may be true, it is also the case that most nGSEs are not only tightly connected to their partner schools, but some of them are in fact *part of* the school/s where their prospective teachers will engage in residencies or student teaching. For instance, High Tech High GSE and Sposato GSE are both part of K-12 charter network schools; these are the schools where residents learn to teach and often go on to become teachers themselves. In this way, the AMNH MAT's efforts to partner with the district falls in line with other nGSEs.

There is a second point to make here as well. Partnering with a district as large as NYCDOE is not an easy task; there are many offices, administrators, and policies to understand and navigate. That the AMNH MAT was able to forge a strong partnership in such a large district is an example of its long-standing reputation of working on behalf of the public. And in the case of the MAT program, this partnership attempted to *reject context-neutral mindsets* because the program leaders had knowledge of the district's priorities and policies and were able to incorporate them into its coursework and fieldwork as needed. In this way, the MAT program modeled for its residents that they were to be educators "working in service *with* the community…to improve individual circumstances and ultimately the human condition" (Milner, 2020a, p. 59-60).

Not only did the museum MAT have a strong relationship with NYCDOE, but its faculty seemed aware of the importance of acknowledging and understanding the multiple and varied social contexts within New York City itself. Milner (2020a) argues that this is important when considering opportunity-centered teaching because "social contexts have a huge bearing on human development and opportunity structures, for both educators and students" (p. 55). For instance, when I asked faculty what it meant to prepare residents for the context of New York City, a trend in their responses was that there were many overlapping contexts within the city itself, and that this was important for residents to grasp:

> I think you can make an argument that that might mean something different in the Bronx than it does in Brooklyn. So, I think a big part of that is context matters, so that's the context of your classroom, that's the context of the individual students that make up any individual class, understanding the history of their area, trying to get to know the students. I think a lot of our preparation for the high needs context is getting people to think about those things, and I think that is backed up not just by the words, but... If you look at the unit planning tool and the lesson planning tool, they'll say, 'Hey, you need to include this thing called the context for learning,' which is explicitly sort of talking about those things and it's getting the teacher candidates to sort of exercise those muscles to say, 'This is what this means to think about planning lessons and educative experiences for people, is to consider these things.' (Interview # 8, Program Leader)

This excerpt reveals a nuanced understanding that context knowledge matters a great deal when learning to teach in a particular area. This demonstrates that the program was working to prepare urban teachers who "are able to grasp how communities are classified and what they might encounter" (Milner, 2020a), p. 59), which was a way to position context as important, rather than assuming a *context-neutral* approach.

Based on my interviews with MAT residents and program graduates, the importance of learning about the context of New York City schools resonated with them. One program graduate reported that "I got a crash course in Regents…and everything that goes into that, and also the demographics and just how segregated the New York City school system…so I feel like it was a crash course, but I do feel like they tried to prepare us" (Interview #22, Program Graduate). Another resident felt that he now had "a better idea of, of segregation in schools and how the minorities don't have the resources that other privileged kids have and how that can affect your learning. I knew about that but having all those discussions and every session gave me like a better insight" (Interview #17, Resident). These residents felt that there was value in understanding the context of New York City, which reveals that the AMNH MAT connected residents to the place and people where they would engage in teaching- the school residencies.

A final point to reemphasize here is that AMNH MAT residents spent ten months in two different NYC partner schools. As I mentioned in Chapter 5 and elsewhere in this dissertation, this unusually extensive time in two different urban schools was one way the AMNH MAT reinvented the "field" in the fieldwork aspect of the residency model. This program arrangement intended to help residents *reject context-neutral mind-sets and practices* in that the museum emphasized the importance of residents learning how to acclimate, understand, and work within two different school contexts and from two different mentor teachers. The very fact that these teaching residencies were part of the museum MAT's core structures suggests that the program valued learning within and across urban school contexts. Also, because residents were coached and advised by the museum's senior specialists, highlighted at length in Chapter 5, they had many opportunities to learn techniques that helped them foster their ability to *reject context-neutral mind-sets and practices* in their own instruction and interactions with students. This experience was crucial to residents' understanding of urban teaching, which was best pointed out by one resident, who indicated that "90% of the learning that I've done has been in the residency schools" (Interview #21, Resident). Here is another example that best represent this trend in the data:

> I think the best way that I learn about [urban contexts] is by being in the residency schools. I don't think my classes necessarily give me any of that… I need to see it; I need to be in it. That's why I'm here because they allow me to do that. They'll me about all the diverse city, and like look at the school report card. But at the end of the day, those are just numbers that don't have much meaning unless I can experience what they actually mean…So to me, my classes are cool. But the residency is much better. (Interview #20, Resident)

The AMNH MAT's strong partnership with NYCDOE afforded it the ability to work closely with four partner schools. This provided valuable experiences for the teacher educators and the residents because the partnership focused on understanding the multiple and varied contexts within New York City schools in an effort to bring this context into the coursework and the fieldwork of the program.

However, as the resident quoted above pointed out, the residency experience was the best opportunity to understand teaching in the urban school contexts, with the program's courses not centralizing these issues as much. As I suggested in my analysis of the literature, much of current research on urban teacher residencies found that simply adding more exposure to and time in urban schools is not enough to ensure that prospective urban teachers are prepared for classroom complexities. There are many issues related to the role of mentors in urban settings (Gardiner & Salmon, 2014; Garza et al., 2018; Goodwin et al., 2016; Kolman et al., 2017; Roegman et al. 2016; Wasburn-Moses, 2017), and there are many questions about whether science preparation programs actually incorporate the cultures, communities, and contexts of urban schools (Marco-Bujosa et al., 2020; Mensah et al., 2018; Rodriguez, 2015). This fact was highlighted by one program leader, who acknowledged that,

> we recognized, and this was more of an understanding that we developed over time…that just by placing the teachers in these schools where there are high needs schools, and they're working with mentors who are having generally speaking positive outcomes, it doesn't necessarily mean that our residents will learn them. (Interview #7, Program Leader)

That she acknowledged this tension speaks to the fact that museum MAT understood the heavy responsibility of preparing residents for urban schools and that the school residency, though necessary, was not *sufficient* to accomplish this task.

In closing, this section demonstrates that the AMNH MAT made efforts to prepare residents for urban schools, including helping them r*eject context-neutral mind-sets and practices*, but these efforts were limited and partial. The program's commitment to recruiting candidates of color was limited in the same way that many teacher preparation programs that aim to diversify the workforce are limited: recruiting candidates of color is one part of ameliorating the many-pronged problem of inequities in schools. In the case of the AMNH MAT, as with many other teacher preparation programs, this commitment to recruiting for diversity was not necessarily combined with multiple other robust and specific efforts to *reject context-neutral* *mind-sets and practices,* such as offering seminars to help residents discuss and reflect on their classroom and school experiences- beyond the monthly meet-ups in schools, or offering multiple, even overlapping ways to incorporate school interactions in science pedagogy and practice in coursework assignments. More of these combined efforts is needed to prepare teachers who can join others to disrupt current systems that are not working for young people of color.

Additionally, the AMNH MAT's partnership with NYCDOE and its school residencies worked to provide opportunities for the residents to engage with the particular context of New York City. This *context-specific teacher preparation* (Matsko & Hammerness, 2014) helped residents learn the state regulations and requirements as well as learning how these impacted the local context of the city, and the students and classrooms in particular. The school residency was perhaps the strongest example of the museum MAT's efforts to prepare its residents for creating opportunities for young people in urban schools to learn and grow. Because this experience was deeply supported by the advising and coaching of the senior specialists, analyzed at length in Chapter 5, it was not simply an "add-on," to the project of learning to teach, but a major component. However, as this and other sections of this dissertation have pointed out, residents' questions, issues, and concerns that arose in their school residencies were not wholly taken up in the coursework, making an uneven approach to preparing them for urban schools. In this way, my findings match that of other researchers examining urban teacher residencies: in the field of teacher education, there is a great deal of tension and uncertainty about how to comprehensively and honestly approach preparing prospective teachers for the complexities and opportunities in urban schools. This was perhaps best pointed out by one program leader, who shared her own tensions with this issue:

I wish I could say that preparing teachers to be effective in high needs classrooms, that

> there was a recipe to do that, because if there was [we] would be in a different place. So, I think ultimately teachers who are enthusiastic about their science, or the science that they're teaching, and enthusiastic about the kids, those two enthusiasms together will go a long way. (Interview #7, Program Leader)

This leader's honest account of the struggle to prepare strong and competent urban teachers once again points to the AMNH MAT's *centralized and continually reinforced* efforts to prepare good science teachers and its *less central and more limited* approach to preparing effective urban educators in that she clearly believed that a science-enthusiastic teacher would go "a long way" to be "effective in a high needs classroom."

Conclusion

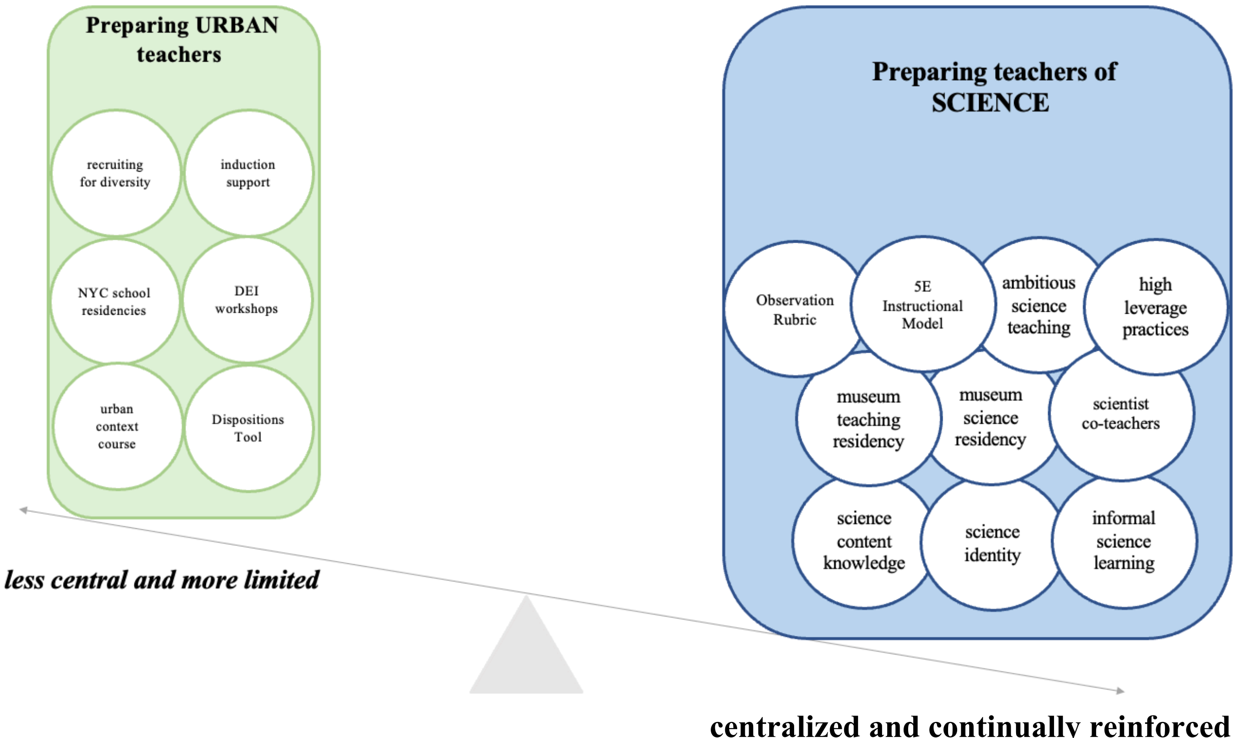
Using Milner's (2010; 2020a) opportunity gap framework as a guide, this chapter identifies and describes the AMNH MAT program's approach to preparing *urban* teachers. My analysis suggests that while working from good intentions and offering some innovative features, the program was not "deliberate and consistent" in its efforts to "center opportunity" in Milner's sense in the predominantly urban classrooms where its graduates would go on to become teachers of record.

Throughout this dissertation, I have offered a multitude of examples that demonstrate that the museum MAT emphasized science knowledge, identity, and teaching practices, in terms of both the quantity *and* the quality of the science teacher preparation programming. I have argued that this aspect of its teacher preparation was highly coherent and could be seen in many aspects of the program, from the underlying assumptions involved in how learning to teach was conceptualized to the main features of program enactment. In this chapter I have shown that the

MAT program's preparation for urban school contexts was less emphasized in that the breadth *and* the depth of opportunities to engage in introspective and interrogative practices to prepare for urban school contexts was not prioritized in the same way that science teacher preparation was. Certainly, the AMNH MAT included some interesting and provocative programming designed specifically to prepare teachers for urban schools consistent with Milner's (2010; 2020a) principles for mitigating the opportunity gaps that young people experience in schools. However, I also argue that these endeavors only partially addressed the key ideas that are necessary for learning to teach in urban school contexts. Figure 20 illustrates the final argument of this dissertation: while my analysis suggests that there were many useful design elements, tools, and arrangements in the AMNH MAT program designed to prepare teachers for **urban** schools, these efforts were *less central and more limited* when compared to the program's powerful and coherent efforts to prepare teachers of **science**, which were *centralized and continually reinforced.*

Figure 20

AMNH MAT's approach to preparing teachers for urban schools



Confronting race is at the heart of Milner's (2020b) argument that it is "our social, psychological, moral, intellectual, and civic responsibility" (p. 157) to help prospective teachers learn the skills, knowledge, and dispositions necessary to address opportunity gaps in curriculum and classrooms. *Rejecting colorblindness*, for instance, is about acknowledging the different race-based opportunities and obstacles each individual has experienced. It is also about acknowledging the danger in *not* making race central, especially in classrooms where multiple races, ethnicities, and heritages are represented. In order to make this point, Milner (2020a) asserts that:

> teachers with a color-blind mind-set may not recognize how their own race and racial experiences shape what they teach, how they teach it, and how they assess what is being taught…The result is that students very often learn from a curriculum dominated by [w]hite contributions and [w]hite norms to the exclusion of contributions from other racial and ethnic

> groups. Moreover, students are learning something based on a null curriculum- what is *not* included in the curriculum. What is absent in the curriculum is actually present in student learning opportunities. At the heart of what is and is not emphasized in the curriculum is teachers' racial identity-who teachers are, how they represent themselves to others, and how they come to see themselves as people who benefit from or are discriminated against due to matters associated with race in society. (p. 31)

In this final section, I draw attention to Milner's (2020a) reference to Eisner's (1994) now well-known construct- the "null curriculum," a concept that allows us to focus on the impact of what students *do not* get the opportunity to learn either in the explicit curriculum or in implicit messaging around the curriculum. Conceptualizing and enacting the project of learning to teach is an enormous undertaking. All teacher preparation programs have the formidable task of making decisions about the courses and practices, tools and assessments, and arrangements and commitments they make central in the preparation of teachers and about the courses, tools, and arrangements that are left out of or peripheralized in their programming. Although many of these decisions are mission-driven, they are also influenced by local school district or community needs, state-level requirements regarding the licensure and certification of teachers, and the larger political and policy climate.

Like other teacher preparation programs, the AMNH MAT was mission-driven, working to mitigate the critical shortage of earth science teachers in New York's urban, high needs schools. Also like many other teacher preparation programs, the museum-based urban teacher residency did not fully provide in its programming the depth of self-critical reflection and understanding of the impact of racism and poverty on schools, schooling, and classrooms necessary to prepare urban teachers. This was reflected in the fact that there was only one course dedicated to centering the historic and current impact of race and racism in schools and classrooms, while most of the other courses centered on science content and practices. This was also shown by the fact that, when asked to describe how the AMNH MAT prepared them for teaching in urban schools, many of the residents pointed to peripheral programming, such as workshops or non-evaluative tools. They did not point to the multitude of science content and science pedagogy courses offered at the museum, the museum- and science-based residencies, and the major evaluative tool used throughout many aspects of the program, the Observation Rubric. What this means is that the programming that was left out of the AMNH MAT's project of learning to teach—its null curriculum—had primarily to do with urban classrooms per se. That is, while residents received the message loud and clear that deep science content knowledge, science identity, and specific science instructional practices were required for good teaching, they did not receive such a clear message about the necessity of creating multiple, varied, and intellectual spaces of opportunity in urban classrooms, in the sense that Milner (2010; 2020a) suggests.

CHAPTER SEVEN

Overarching Findings and Implications

To understand the nature, quality, and impact of teacher preparation at the AMNH MAT, this dissertation posed two major questions: To what extent does an institution with the rich history of the American Museum of Natural History infuse its long-standing beliefs about **science** learning and public service into a teacher preparation program? And How and to what extent does the museum conceptualize and enact science teacher preparation for the specific context of **urban** high needs public secondary schools? At the broadest level, this case study analysis of teacher preparation at the MAT program in Earth Science at the AMNH concludes that the museum's mission of disseminating science knowledge in service of a more science-literate and science-conscious public was instantiated in a teacher preparation program that cohered around a *centralized and continually reinforced* vision of preparing **science** teachers but had a *less central and more limited* approach to preparing **urban** teachers.

This analysis concentrated on understanding how the program conceptualized and carried out the project of learning to teach, especially learning to teach science in urban school contexts. An important point to make here is that the AMNH MAT was not only a museum-based science program *but* was *also* an urban teacher residency program that focused on preparation of secondary earth science teachers for New York's high-need schools. As this dissertation shows, the program required residents to complete four different residency experiences—two related to science and two related to urban teaching. To understand this complex program, I used three theoretical frameworks to guide my analysis of the extensive programming offered at the AMNH MAT.

First, in using Cochran-Smith and Lytle's (1999) conceptions of the relationship between knowledge and practice in teacher preparation, I found that the AMNH MAT took a "knowledge-*for*-practice" approach to conceptualizing teacher preparation. That is, they worked from an approach predicated on the belief that there are specific pre-existing and research-based domains of knowledge created primarily by researchers *for* implementation in classrooms. The evidence for this was very clear in the key beliefs that animated the program: at its core, good science teaching depends on deep science content knowledge; teachers of science must develop and continue to explore their own science identities (and support their students' development of science identities); in order to reach all students, teachers should use research-based science teaching practices as well as high leverage culturally relevant science practices. Put another way, the AMNH MAT valued and prioritized science knowledge and research-based knowledge about the practice of good science teaching as the basis for work in classrooms.

Second, applying Lave and Wenger's (1991) and Wenger's (1998) conceptual framework for understanding learning within *communities of practice,* revealed that the museum MAT enacted the beliefs described above by socializing candidates into three overlapping and interrelated communities of practice. This involved a "complex social landscape" with multiple actors, namely residents, scientists, teacher educators, museum-based senior specialists, and school-based mentor teachers. Together, these actors supported the residents as new members of the community of scientists, the community of good science teachers, and the community of New York City teachers, students, and schools. The idea behind enacting teacher preparation this way was that residents would leave the program with the overlapping identities of scientists and good science teachers for New York City schools. Planted firmly at the core of this approach was the idea that effective science teaching should be research-based, which the AMNH MAT carefully outlined in its Observation Rubric. As my analysis shows, this assessment tool was used pervasively in coursework and residency work to monitor and evaluate the residents' teaching performance.

Finally, using Milner's (2010; 2020a) conceptual framework for analyzing urban teacher preparation, a framework he refers to as the *opportunity gap framework,* revealed that the Earth Science program at the AMNH MAT did not prioritize or center race and racism in its coursework, structures, and arrangements to the same extent that it prioritized science. Milner, outlines set of principles that ought to guide urban teacher preparation programs in order to create opportunities for young people to succeed in urban classrooms. Milner refers to these principles as *rejecting colorblindness* and *context-neutral mind-sets, debunking deficit mind-sets* and *the myth of meritocracy,* and understanding and knowing how to address *cultural conflicts* in classrooms. While the museum MAT offered excellent and innovative courses, support programming, and arrangements that were designed to prepare urban teachers, this work was limited in two ways. First, there were few opportunities in AMNH MAT coursework, workshops, and support programming wherein residents could do the deep, critical work Milner argues is necessary if teacher candidates are to learn how to *reject colorblindness, debunk the myth of meritocracy,* and understand the utility and value of *cultural conflicts.* Second, the single course aimed explicitly to prepare residents for urban contexts was primarily designed and facilitated by a single MAT faculty member, which differed greatly from the science content and science content pedagogy courses, all of which were co-designed and co-taught by AMNH MAT faculty. Additionally, all of the support programming designed to offer residents opportunities to explore their own positionalities and to center race and racism were created and facilitated by another single faculty member. This programming and these faculty members, along with the coaching and advising of the senior specialists during the school residency experience, offered the AMNH MAT residents some important opportunities to learn about urban schools and to examine some of their own assumptions and beliefs. However, my analysis also reveals that these opportunities were not as rich, robust, or prioritized in the museum MAT's conceptualization and enactment of the project of learning to teach as were the opportunities explicitly focused on science.

When the findings of this case study are considered collectively, they suggest somewhat of an imbalance. On the one hand, the museum MAT program was incredibly coherent in terms of the science teacher preparation it offered; in fact, some observers might consider the program a model for science teacher preparation in that it concentrated heavily on science content knowledge, it fostered the science identity of teacher candidates, and it reinvented the meaning of "field" in the fieldwork aspect of teacher preparation. Along these lines, the museum MAT offered three different types of fieldwork opportunities or residencies for all teacher candidates—teaching in the museum using museum exhibits and artifacts, doing field research in science in natural settings, and observing and engaging in classroom teaching. These occurred in four different locations for each resident—the museum itself, science field sites such as state forests and public parks, and two different New York City schools. On the other hand, however, my case study also suggests that the MAT program lacked what Milner (2020a) called "deliberate and consistent" coursework, structures, and arrangements that centered the impact of race and racism in schools and classrooms and prepared teachers to teach in complex urban classrooms. In this way, teacher preparation at the AMNH MAT, like many teacher preparation programs across the country that aim to prepare urban teachers, raises questions about what urban teacher education needs to do in order engage in antiracist pedagogy and practices. In order to better understand what these findings contribute to the larger field of teacher education research and practice, in the next section, I situate this study in the larger research project and in the larger field of teacher preparation.

Locating this Case in the Larger Study of nGSEs

and in the Larger Field of Teacher Education

This dissertation situates the MAT program at the Richard Gilder Graduate School at the AMNH within the larger context of newly-established, state-approved graduate schools of education that offer teacher preparation, endorse teachers for certification, and grant master's degrees. As I described in some detail in Chapter 1, the larger research project of which this case study is part has termed these institutions, which are located outside of universities, "new graduate schools of education," or nGSEs.[5] All 11 existing nGSEs have emerged since 2005, largely as a result of three converging trends in teacher education. The first trend, a paradigmatic shift in education policy, sometimes referred to as the "education reform movement" can be traced to *A Nation at Risk* (1983) (Mehta, 2013), when the federal government, think tanks, and private interest groups essentially began to prioritize outcomes—for students, teachers, and schools. This was supported by a deregulated teacher education field, which opened up many new routes into teaching. The second trend was the prevailing failure narrative, which was a harsh critique of university-based teacher preparation and state-level teacher licensure bureaucracy, including their presumably cumbersome, costly, and inconsistent policies and practices (Cochran-Smith et al, 2018; Fraser & Lefty, 2018). Finally, over the past two decades or so, venture philanthropists have made large-scale donations to fund new pathways into

[5] To read more about our cross-case findings, see the 2021 special issue of *The New Educator,* 17(1), Teacher Preparation at New Graduate Schools of Education, guest edited by Marilyn Cochran-Smith with articles by: Cochran-Smith, Keefe & Miller, Cummings Carney, Sánchez, Olivo & Jewett Smith, and Cochran-Smith, Keefe, & Jewett Smith.

teaching aimed at disrupting traditional preparation and, importantly, attached to accountability outcomes for teachers and for students (Mungal, 2016).

These three trends, taken together, prompted many teacher education reforms, including new efforts to “change the game” of teacher education by including new programs and pathways that offered “innovative” solutions to long-standing problems such as critical shortages of qualified teachers in particular content areas (namely, science, math, special education, and English as a Second Language) and shortages of qualified teachers of color. Teacher preparation programs at nGSEs arose partly in response to these shortages and market demands, although it should be noted that for some time teacher educators at universities have also been engaged in teacher preparation that centers social justice and equity (Cochran-Smith 2010; Ladson-Billings, 1995; Sleeter, 2011), and have worked to create more opportunities for candidates of color to enter into the teacher workforce (Villegas, 2007, 2008).

Not surprisingly, teacher preparation at nGSEs has proven to be controversial. On one hand, some policymakers, think tanks, private interest groups, and even the federal government have promoted nGSEs as new, promising pathways. On the other hand, some teacher education scholars and critics have raised questions about whether new graduate schools of education uphold or undermine the democratic ideals of education. For instance, arguing that racism and capitalism have worked hand-in-hand to perpetuate oppression, Anderson (2019) took aim at independent graduate schools like nGSEs, arguing that they were organized around the private interests of the philanthropists who were funding them, rather than working toward the public responsibility of creating more equitable schools and schooling for all.

Given this controversial context, the goal of the larger nGSE research project aimed to understand – *not to judge or evaluate* – how teacher preparation was conceptualized and enacted across four nGSE sites selected for in-depth case studies, including the Master of Arts in Teaching Earth Science Residency at the AMNH. The logic behind this goal is that it is necessary to understand a phenomenon before it can be appropriately critiqued or evaluated. One of the findings of our cross-case analysis of these four sites was that across nGSEs, there were very different but sharply-focused visions of good teaching that were often tightly coupled with, and supported by, multiple aspects of program enactment (Cochran-Smith, 2021; Cochran-Smith et al, 2021). We also found that all four nGSEs took up some similar strategies in order to enact their visions of good teaching (Olivo, 2021), such as "parallel pedagogies," which we defined as teacher educators themselves modeling the pedagogies they wanted their teacher candidates to enact in classrooms with school students. This was reflected in several of the observations I made at the AMNH MAT, which are referred to and analyzed in this dissertation. One example occurred when I observed two teacher educators modeling how to engage secondary students in a scientific "think-aloud" by sharing out loud themselves and then jotting down resident ideas, wonderings, and insights from an assigned reading about ocean acidification. The intention here was to demonstrate for the residents a technique for "eliciting student ideas," which was one of the practices the program encouraged (Observation #2, *EDU/SCI 660*). A second strategy we identified across all four of nGSEs we studied in depth was the invention of unique program design components, such as the AMNH MAT program's required four different residency experiences. A third strategy seen across nGSEs was inventing new program roles that privileged practice. This can be seen in the AMNH MAT's senior specialist role, which was unique in that other urban teacher residencies do not have this additional coach/advisor to act as a liaison between coursework and fieldwork. Clearly, the AMNH MAT, while unique in many ways, also shares commonalities with other nGSEs in terms of how teacher preparation is conceived and carried out.

There is another similarity among the four nGSEs case sites we studied that is worth noting here. As Chapter 1 pointed out, urban schools and districts tend to have substantial problems with teacher attrition (Ingersoll, 2001; Waddell, 2010), critical shortages in certain subject areas and specializations (Ingersoll & Perda, 2009; Partelow, 2019), and many instances of under-resourced schools (Strom et al., 2018). Because of these issues, many nGSEs have focused on preparing teachers for urban public schools and/or urban charter schools. One common approach is the residency model of teacher preparation, usually referred to in the literature as the urban teacher residency model. As noted, many of the existing nGSEs, including the AMNH MAT, utilized a residency model.

There is an important distinction to make here, however. While a number of nGSEs are affiliated with or in fact are *a part of* charter networks or charter schools (e.g., Relay GSE, High Tech High GSE, and Sposato GSE), the AMNH MAT program was one of only three nGSEs directly linked to urban *public* schools. In other words, while the museum MAT program received philanthropic funding from private foundations (as well as public funding) like its nGSE peers, the AMNH program did not do so in the service of the charter school movement. Rather, both private and public- funding for the AMNH program were attached to the mission of the museum itself: dissemination of science knowledge as a public good. Along these lines, improving the quality and quantity of earth science teachers in New York public schools was regarded as part of larger efforts to improve the public's science literacy and science curiosity.

Findings and Implications for Research and Practice

As I pointed out in Chapter 4, program coherence has been highly regarded in teacher education and referred to by some as a "holy grail" (Darling-Hammond, 2014, p. 550) of powerful programs because it offers prospective teachers an intentional and consistent experience when learning to teach. However, as some others have also suggested (Buchmann & Floden, 1991; Hammerness, 2006), this dissertation argues that tight coherence in and of itself is not necessarily a desirable goal. Rather it is important to examine what teacher preparation programs actually *cohere around*. Because coherence is a relative concept, it is largely dependent on a program's central belief about good teaching. For example, one program's ideas about good teaching as the use of automatic and highly prescribed teaching moves would not be well-received at another program with a project-based, student-centered approach, or at a program where deep content knowledge was central.

This suggests that it is particularly important to pay attention to what teacher preparation programs designed to prepare teachers for urban schools actually cohere around. These issues are especially important, given that urban schools have long been vulnerable to society's oppressive forces. Since 2020 these issues have been particularly emphasized, given the dual crises of the pandemic and the new racial reckoning in our country. Part of my analysis of the MAT program at the AMNH includes an answer to the question: What did the project of learning to teach actually *cohere around*? I found that at its core, the AMNH MAT was an incredibly rich and nuanced **science** teacher preparation program that also included some thoughtful programming designed specifically for the work of **urban** school teaching. In the next sections, I elaborate on these findings and describe their implications for research and practice.

A Unique Approach to Science Teacher Preparation

There is no question that the museum MAT program is unique in the country and indeed in the world. This means it would be incredibly difficult to replicate. For instance, one teacher educator pointed out the following: “I don’t want to use the word ‘boutique’…but it kind of is” (Interview # 4, Program Faculty). Indeed, like a boutique, the museum MAT had its own style, and in this way was in a kind of class of its own given its uniqueness in terms of the affordances offered by its exhibits and artifacts, its immense size, and its deep sources of private funding. None of these are typical features of teacher preparation programs. In addition, the program’s ongoing and extensive research about the program and its participants, conducted by both program faculty/leaders and by commissioned external evaluators was unusual. Even the program’s mission of public service contributes to its position as a genre of its own. The museum’s long-standing service to disseminate knowledge to the public was reflected in one program co-founder’s belief that the MAT program was a way to “make the institution [AMNH] responsive and responsible for the education, the science education of students in New York City…in particular, in those settings where access to museums may be difficult” (Interview # 4, Program Leader). This goal, no small feat, was tackled head on by AMNH faculty in their founding of the MAT program.

In fact, leaders of the AMNH also believed they were capable of accomplishing the goal of mitigating the critical shortage of earth science teachers in New York, hence working to create a more science-literate public. For example, one museum leader referred to the MAT program as a “type specimen” of teacher preparation (Interview # 5, Museum Leader). In science, a “type specimen” can be defined as the specimen, or a set of specimens, on which the description and name of a new species is based. In other words, this museum leader had the upmost faith that the

MAT program itself was a new “species” of teacher preparation that was capable of accomplishing its goal of changing how the public interacts with science by way of public school teachers.

There was also the idea that the AMNH was aptly-positioned for such a feat because of its knowledgeable faculty. As I pointed out in Chapter 4, an MAT program co-founder and leader commented that part of the work of the MAT program was “to help people be confident in their expertise…We really do place a high premium on expertise here in the American Museum of Natural History. We admittedly have hubris, and it has to do with the quality of this place” (Interview # 7, Program Leader). It was precisely this confidence in the quality and affordances of the museum as an institution that propelled it to launch its MAT program in the first place: the faculty did it because they believed they could successfully contribute to more and better earth science teachers in New York school.

AMNH MAT data over the past decade since its inception shows that they were right. The program has indeed mitigated the critical shortage of earth science teachers in New York State, and its teachers are remaining in the profession at a rate of 90%, which is higher than its urban teacher residency counterparts (Hammerness et al., 2020; Institutional Document #25, *Summary of Top Level Findings, 2019)*. In many ways, as this dissertation has shown, the museum’s conceptualization and enactment of project of learning to teach was indeed a prototype of sorts for the field of science teacher education writ large.

However, the “boutique” quality of the MAT program is an important point to examine further. It would be very difficult, maybe impossible, for any other science teacher preparation program to replicate the structures, arrangements, and programming of the AMNH MAT. Even given this reality, however, my analysis of this unique program reveals that it does have implications for the practice of science teacher education, particularly in terms of two key features invented by the AMNH. The first feature was its coherence around the development of a science teacher identity that included deep science content knowledge and a commitment to bringing informal science teaching and learning practices into schools. The second was the MAT program's reinvention of the "field" in teacher preparation fieldwork, which I take up in the next section.

Because the museum MAT was deeply-centered on a set of core beliefs about science knowledge, science identity, and science teaching, its approach to teacher preparation offers the field a unique approach to science teacher preparation, one that tightly *coheres around* the very specific and important ideals of fostering teacher residents' science knowledge and science teacher identities. The purpose of this was to encourage prospective teachers to improve their abilities and willingness to see themselves as scientists and to use the affordances of museum resources to enhance their ability to bring informal science teaching and learning practices to the formalized setting of schools. One current program resident best captured the MAT program's level of coherence, pointing out that the AMNH MAT's mission was about "bringing science to the high needs schools with effective science teachers…they really want people that have experience doing science and not just people that want to be science teachers" (Interview #16, Resident). This resident highlights something crucial about the AMNH MAT: not only does it work to accomplish what it sets out to ("bringing science to the high needs schools"), it also fosters the notion that successful science teachers are those that see themselves as scientists ("people that have experience doing science"). As Chapters 4 and 5 have pointed out, this idea that a science identity enriches science teaching was seen throughout all aspects of the museum MAT's project of learning to teach.

I take this comment as a kind of "proof in the pudding"—the MAT residents felt that the program accomplished what it set out to do in terms of preparing earth science teachers who were confident in their subject matter and in their identities as scientists and were able to imbue this confidence in their students. This dissertation has shown the care and commitment of the museum MAT's faculty, particularly with regard to ensuring that the residents understood the science content and pedagogy the program taught in the program and to nurturing the residents' own love of science.

It is certainly the case that it would be difficult for any other science teacher preparation program to replicate the rich and nuanced experiences with informal science that were at the fingertips of the AMNH MAT faculty and residents as they engaged in the project of learning to teach. However, the AMNH MAT's model of teacher preparation offers insights for teacher education practitioners in that its tight coherence around science content, identity, and pedagogy was a solid foundation for its residents. In consideration of this model, for instance, science teacher preparation programs might work to create more opportunities to partner with museums to include more informal teaching and learning in K-12 classrooms, to provide prospective science teachers opportunities to work with scientists, and to help them see themselves as deeply connected to science. As research has shown, partnering with informal science institutions like museums, zoos, and other local science centers uncovers– both for teachers and for students— the possibilities that are offered in such places (Avraamidou, 2014a; Çil et al., 2016). In light of my findings here, science teacher preparation programs might consider museum-university partnerships as a way enrich prospective teachers' knowledge and ability to incorporate the affordances of museums into the formal space of science classrooms, which can make for powerful, effective instruction.

As it relates to broader research implications, my examination of the AMNH MAT offers insight and suggests opportunities for future research in terms of understanding the extent to which science teacher preparation programs in general foster a science identity in prospective teachers. To this end, an area for further research is understanding whether and to what extent a very strong approach to deepening the science content knowledge and science identity of prospective teachers, such as that found at the AMNH MAT, actually makes for stronger, more effective teachers of science, especially in urban schools. It would be valuable to have a deeper empirical understanding of the benefits for school students and their teachers of incorporating many master's level, science-specific courses and multiple experiences in science in teacher preparation programs.

Reinventing the "Field" in Fieldwork of Teacher Preparation

This dissertation has argued that in order to prepare science teachers for New York City schools, the AMNH MAT program recreated the residency model approach to teacher preparation by reinventing the concept of "field" in field experience. The residency model, which is now well-known, generally includes extended field experience in one classroom, often nearly every day over the period of a year with residents taking courses in the evenings, on weekends, or on one weekday (Berry, Montgomery, & Snyder, 2008). As I have described at length, the MAT residents participated in four field experiences, called residencies, which comprised three different kinds of field experiences, each of which was consistent with faculty and program leaders' beliefs about what it means to learn to be an urban science teacher and what social, intellectual, and organizational experiences support that learning. Residencies in two different schools focused on the practice of teaching science, one museum residency focused on informal science learning and the development of a science teacher identity, and the other museum residency involved doing science research in a field site.

The purpose of these residencies was to deliberately socialize prospective teachers into the communities of scientists, good science teachers, and New York City teachers, students, and schools. To facilitate teacher candidates' socialization into these three communities, the program created the unique role of senior specialist who worked to initiate the AMNH MAT residents into each of these overlapping communities for the purpose of becoming effective teachers of science in New York City schools. This reinvention of the "field" in the fieldwork of teacher preparation has implications for teacher education pedagogy and practice. My analysis of program enactment at the AMNH MAT suggests that achieving powerful field experiences requires that prospective teachers have ample space to practice what they are learning and to investigate their burgeoning identities as teachers of science. In this sense the AMNH MAT offers the field of science teacher preparation a model for strengthening prospective teachers' exposure to and experience with the myriad opportunities outside of formalized schooling that can contribute to strong instruction. For teacher preparation in other disciplines, reinventing the "field" might more time spent in libraries or with authors and artists for future English teachers, more time in engineering spaces or in biotech labs for prospective math and science teachers, or more time with historians for future social studies teachers.

The field experiences offered at the AMNH MAT were a design component unique to this program. In terms of broader research implications, understanding the nature, purpose, and practices of the AMNH MAT's unique field experiences has implications for teacher educators who wish to encourage, inspire, and foster a pool of committed and confident prospective teachers. Research that focuses on the types and amount of fieldwork in teacher preparation programs, and on how participants experience and understand them, can provide insight into the extent to which multiple opportunities and exposure to different types of "fields" actually contributes to strong teacher preparation.

The AMNH MAT's reinvention of the "field" can have implications for research on mentoring and mentoring structures as well. The kind of oversight support needed for learning in multiple field experiences involves careful planning, deep knowledge and experience, and dedicated faculty. Reinventing the "field" was possible at the AMNH MAT in large part due to the extensive support of the knowledgeable and experienced senior specialists. More research is needed to understand the value of this unique, additional layer of support in teacher preparation programs in order to determine how to successfully continue to reinvent the "field" in fieldwork.

Remaining Questions about Urban Teacher Preparation

When we began data collection for this case study in May 2019 as part of the larger nGSE research study, we lived in a different world. We finished gathering data in January 2020, just two months before the pandemic began, and life changed for everybody. And the world changed again two months after that in May 2020 when George Floyd was murdered. America is now experiencing the collision of two overlapping crises: the coronavirus and a new reckoning related to long history of racism in law enforcement, education, and all of society's major institutions. Some people would say we are facing the most difficult challenges humans have confronted in the last 100 years. There is a different sense of urgency now about the impact of race and racism on schooling and education, which is shared by many people, including many educators, despite acknowledgement that there has been a long history of racial oppression in schools and schooling. Many argue that it has perhaps never been as important as it is right now to ensure that teachers not only join with others to support democratic education and educational equity, but also that they actively work to disrupt and dismantle the oppressive systems and structures that reproduce inequity and to build new ones.

In the field of teacher preparation in general, there are many who are trying to understand and work towards more just pedagogy and practices, including and especially urban-focused teacher preparation programs in traditional university spaces, in alternate routes and pathways, and in teacher preparation at nGSEs, like the AMNH MAT. As I mentioned previously, during my data generation period, May 2019 to January 2020, the program was working on ways to make culturally responsive sustaining pedagogy more central to their programming. It should be noted that in the two years since this period, the AMNH MAT has been engaged in new efforts to center culturally responsive science practices. This can be shown in some of its recent conferences papers and presentations. For instance, a newly-formed group of AMNH researchers, comprised of AMNH faculty, MAT faculty, and program graduates, called the Culturally Responsive Education Professional Learning Group, conducted a qualitative research analysis of the culturally responsive science education practices of recent AMNH MAT graduates, using “stories from the field” as an analytic approach (Wallace, Howes, Culturally Responsive Education Professional Learning Group, 2020). Additionally, a group of AMNH faculty, MAT faculty, and MAT program graduates presented a poster at the national American Education Research Association conference in 2021. This poster session outlined ways some program graduates had experimented with the culturally responsive and sustaining strategy of centering “student voice,” or opportunities for students to talk about their scientific understandings and questions in their preferred language (Wallace et al., 2021). Clearly, the AMNH MAT is working to understand more productive ways to help its prospective urban teachers to see the cultural and linguistic backgrounds of students as assets to the science classroom.

There is much to learn about the work being done at the AMNH and other programs: What is being prioritized in the teacher education curriculum? What is peripheralized? Who makes these decisions, who benefits from them, who is left out, and what are the consequences? In this dissertation I have raised concerns about whether and to what extent urban teacher preparation in general is taking the kind of "deliberate and consistent" critical approach to cultivating Sealey-Ruiz's (2021) "interrupters of inequality" and focusing on Milner's (2020a) "opportunity-centered teaching."

I chose to use Milner's (2010; 2020a) well-known framework for unpacking urban teacher preparation because it is based on the belief that teaching must center opportunity and race as a way to powerfully position young people in schools, especially those who have been minoritized, as capable changemakers. Using his principles as guide for my analysis, I found that the AMNH MAT is in some ways a mirror for urban teacher preparation writ large. Like many programs around the country, it has recognized that it is not doing enough to engage its residents in culturally responsive teaching practices and has been working to improve this. Some MAT faculty struggled to engage in this kind of work, which was best pointed out by one program leader, who voiced concerns about preparing teachers for urban schools:

> Personally, for me, the question that I wrestle with in my own journey as associated with this is what does it mean to be educating people in a society that's built on the bones of one people with the blood of another? That's complicated and really messy, and what does it mean that we're not always preparing people that look like the students that are coming into these environments to teach them? So, not only is it a lack of earth science

> teachers, it's a lack of Black, Latinx earth science teachers as well. I think there is something to be said about having a social justice pedagogy or an environmental justice pedagogy, quite frankly, in an earth science classroom. That's personally, for me, where I would like to see more of the education go. (Interview #8, Program Leader)

Just as was the case for some faculty members, as I point out in earlier chapters, this program leader was grappling with the critical work of acknowledging historical racism in a museum-based teacher preparation setting.

A case study analysis of an innovative teacher preparation program in one of the nation's largest cities has important implications for urban teacher education research and practice. In terms of teacher education pedagogy and practice, the AMNH MAT's partial focus on the specific context of urban schools requires unpacking. Milner (2010; 2020a) argues that equitable classrooms center opportunities for students to be challenged, to see their knowledge and skills as assets on which to build their learning repertoires, to understand their place in the world and to see how they can contribute to a democratic society. Additionally, Brown's (2019) *disaggregated instruction pedagogy* is a conceptual framework specifically designed for teaching "city kids." His approach to pedagogy may be thought of as an example of Milner's theory enacted, as it involves the process of teaching science as both concept learning and as language learning by teaching using the following four steps: finding out what students know and how they describe it; teaching the scientific concept in the language students use; teaching the language of science, and; creating opportunities for students to explain what they know using both their own and scientific language. This approach to teaching science in city schools is predicated on Brown's (2019) assertion that "The point of teaching science is to provide young people with a lens that they can then use to change the world we live in. Science education is about speaking to everyone's strong suit and making sure science is among the things that feel like home" (p.10).

In this dissertation I have shown that the AMNH MAT program was partially aligned with Brown's point here. On the one hand, historically, the mission of the museum is to contribute to a science literate public. As an extension of this mission, as I have shown, the MAT itself is trying to "change the science conversation in schools" by preparing teachers who see themselves as scientists, and who will nurture a sense of science identity in their secondary students. On the other hand, however, throughout AMNH MAT pedagogies, practices, and experiences, there was less consistent and comprehensive emphasis placed on "making sure science is among the things that feel like home." In other words, the AMNH MAT brought its deep science knowledge to schools, but only partially brought the contextual knowledge of urban schools into its programming. A salient point to make here, as I also referenced in Chapter 4, is that Bang and colleagues (2017) argue that what is needed is for teachers to understand multiple ways not only to elicit students' responses, but to excavate, understand, and incorporate their sense-making strategies into the science practices and learning in the classroom. Taking Brown (2019) and Bang et al. (2017) into consideration, the museum MAT might consider more ways to incorporate student ways of knowing into its preparation of urban science teachers.

In this way, it might be difficult for students to associate science as feeling deeply close to them, since the MAT residents might not have received enough training to help students see the link between science and their everyday lives. AMNH MAT programming centers strong science pedagogy, but it does not always prioritize the people who make up the classrooms where strong science pedagogy is meant to be carried out. This case study analysis shows that although the AMNH MAT included some elements, tools, and arrangements designed to understand and honor “city kids,” these features were *less central and more limited* compared to the program’s *centralized and continuously reinforced* efforts to prepare effective teachers of science.

At different points in this dissertation, I have also made the point that the AMNH MAT is one of many urban teacher preparation programs working to improve its efforts to center race and racism, particularly because teacher education in many places is largely a white space (Matias, 2016; National Center for Education Statistics, 2012; Sleeter, 2001). The field of teacher preparation requires much more critical, empirical analyses of the approaches, practices, and priorities of teacher preparation programming, particularly those programs with the goal of preparing urban teachers. Research of this kind requires applying critical conceptual frameworks, as I have done with Milner’s (2010; 2020a) work in this case study. In short, urban teacher educators need to know how to engage prospective teachers with the ideas, ideologies, and practices they will need not only to empower students, but to build new, more culturally and racially responsive structures in classrooms, schools, and in schooling in general.

Conclusion

This dissertation argues that the Master of Arts in Teaching Earth Science Residency at the American Museum of Natural History may be thought of as an exemplar of powerful program coherence around science teacher preparation. I have shown that the program’s coherence depended on an intricately interrelated set of beliefs and practices in terms of science content, identity, and pedagogy, which was done for the purpose of trying to “change the science conversation in schools.” Given the dearth of earth science teachers in New York’s urban, high needs schools, this goal was no small undertaking. MAT faculty, as I have shown in this chapter, believed that they had the resources and affordances to take on this challenge when they began preparing teachers in the MAT program in 2012. In fact, the depth and breadth of experiences, opportunities, and resources that prospective teachers in this program have received has undoubtedly enriched their understanding of science content, of themselves as scientists, and of science teacher practices. In this way, the AMNH MAT may be held up as a model of science teacher preparation. Ongoing exploration and examination of urban teacher preparation that tightly coheres around science content knowledge, identity, and pedagogy can help to strengthen the field, which can hopefully work to mitigate the ongoing critical shortages of science teachers, especially in urban schools.

This qualitative case study of teacher preparation has also shown that like many urban teacher preparation programs, especially those in primarily white spaces, there is work to be done at the AMNH MAT in terms of centering race and racism. I have noted in this final chapter that in some contexts in the United States, conversation about preparation for urban schools is changing to include the criticality of centering race- politically, socially, educationally, and in every other way.

The AMMH itself has demonstrated its commitment to centering equity. In January 2022, for instance, the museum removed its formidable and iconic equestrian statue of Theodore Roosevelt, which had greeted museum patrons since 1940 and was featured in a popular movie about the museum. In a *New York Times* article, museum President Ellen Futter reported that "the time has come to move it," responding to a "decades-long saga of protests by critics who argued that the equestrian statue symbolized the painful legacy of museums upholding images of colonialism and racism in their exhibitions" (Small, 2022). I observed another example of the museum's efforts to center equity during my multiple visits to the museum in the spring, summer and fall of 2019. While there, I noticed that some exhibits were being called into question, such as a diorama depicting an imagined 17th century meeting between Dutch settlers and the Lenape tribe, set in New Amsterdam (now New York City). Previously, the diorama had long stood unproblematized, with its barely-clothed, dutiful-looking indigenous people, including and especially women, meeting with the nobly-dressed and powerfully-armed Dutch traders. The museum responded to critics who deemed this portrayal an image of "cultural hierarchy, not a cultural exchange" (Fota, 2019) by adding 10 labels around the diorama that point out the reasons to reconsider the scene, identifying and problematizing its many issues. There is no doubt that the museum's efforts to center cultural and racial injustice and to understand diverse cultural perspectives impacted the MAT program, as I have shown in this dissertation.

This program is not alone. Many university-based graduate schools of education and nGSEs have undertaken various kinds of projects aimed at dismantling injustice in schools and diversifying the teacher workforce. However, much more work needs to be done to understand how teacher educators, particularly white teacher educators, can engage prospective urban teachers in the deep, self-critical work called for by Milner (2010; 2020a) and other scholars, especially Brown's (2019) disaggregated instruction pedagogy, Love's (2018) abolitionist teaching, Lyiscott, Caraballo and Morrell's (2018) anticolonial framework for urban education, Matias and Boucher's (2021) critical whiteness, Muhammad's (2020) equity framework for culturally and historically responsive literacy, Philip's (2019) principled improvisation, and especially, as mentioned throughout Chapter 6, Sealey-Ruiz's (2021) racial literacy.

This work is especially important given teacher preparation's goal of recruiting and preparing a more culturally and linguistically diverse pool of teacher candidates. If the demographics of teacher education faculty and leaders remain largely white, how will we work to nurture prospective white teachers and teachers of color who wish to be "interrupters of inequality" (Sealey-Ruiz, 2021)? Teacher education researchers and practitioners must continue to understand and enact programming that prioritizes race and racism, an act that itself will dismantle neutrality and position classrooms as places of intellectual diversity and endlessly curious young people.

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Appendix A

Observation Tool

	Key Focus Areas	Key Participants
COURSE NAME/NUMBER	• content and other knowledge residents need to have • practices residents must be able to learn • ways "practice" is talked about/taken up • TE instructional methods, strategies & activities • attitudes, values, beliefs about K-12 students & families and "high needs" schools • types of assessments discussed or practiced	(*e.g., teacher educators, scientists, senior specialists, mentor teachers, residents, etc.)*
COURSE NAME/NUMBER	• content and other knowledge residents need to have • practices residents must be able to learn • ways "practice" is talked about/taken up • TE instructional methods, strategies & activities • attitudes, values, beliefs about K-12 students & families and "high needs" schools • types of assessments discussed or practiced	
MONTHLY MEET UP/ WORKSHIOP	• ideas about what teachers should know to teach well • practices residents are engaged in/ ways "practice" is talked about/taken up • types of assessments discussed or practiced • faculty and residents program experiences • attitudes, values, beliefs about K-12 students & families and "high needs" schools • the role of teaching in culture and society	
SCHOOL SITE/ COURSE NAME	• ideas about what teachers should know to teach well • practices residents are engaged in/ ways "practice" is talked about/taken up • types of assessments discussed or practiced • attitudes, values, beliefs about K-12 students & families and "high needs" schools • ways K-12 students' cultures, backgrounds, and heritages are woven into instruction	

Event: Date & Time:
Observer: Participants (# of each):
Describe context/physical space:

	Ongoing Activities	**Commentary/Questions**
TIME STAMP (15-20 minute intervals)		

Emerging Themes/Topics/Trends

Appendix B
Description of Observations: AMNH MAT Case Study

#	Date	Description	Observer	Obs. Length	Artifacts?
1a	5/10/19	SCI 675: *Weather, Climate, Climate Change* (C7)	Marisa Olivo (MO)	3hrs	Y, related course materials
1b	5/10/19	SCI 675: *Weather, Climate, Climate Change* (C7)	Reid Jewett Smith (RJS)	*Same 3 hrs as 1a*	Y, related course materials
2a	5/10/19	EDU/SCI 660 : *Science Literacy Journal Seminar* (C7)	MO	2hr30mi n	Y, related course materials
2b	5/10/19	EDU/SCI 660 : *Science Literacy Journal Seminar* (C7)	RJS	*Same 2hr30mi n as 2a*	Y, related course materials
3	5/10/19	Monthly Meet-Up, Induction- Year 1 (C6)	MO	1hr30mi n	Y, related meeting materials
4	5/10/19	Monthly Meet-Up, Induction- Year 2 (C5)	Marilyn Cochran-Smith (MCS)	2hrs	Y, related meeting materials
5	5/13/19	Monthly Meeting at partner school, Bronx Early College Academy C7)	RJS	1hr30mi n	Y, related meeting materials
6	6/17/19	RES001: *Museum Summer Residency* (C8)	MO	2hrs15m in	Y, carts summer schedule
7	6/18/19	SCI 652: *The Solar System: Earth and Space Science* (C8)	MO	2hrs30m in	Y, related course materials
8	7/9/19	EDU650: *Foundations of Education in the Urban Context* (C8)	MO	3hrs	Y, related course materials
9	7/10/19	Observation Rubric Workshop (C8)	MO	2hrs	Y, related workshop materials
10	8/15/19	*Summer Science Institute*	MO	3.5hrs	Y, handout of

		Teaching in the Museum- lesson (C8)			instructions created by residents
11	8/15/19	*Summer Science Institute* Teaching in the Museum- peer feedback session (C8)	MO	1hr	Y, parts of Observation Rubric (9pp)
11	8/15/19	*Summer Museum Residency – Summer Science Institute (part of RES001)* Teaching youth in the Museum- peer/senior specialist/faculty feedback session (C8)	MO	1.5hrs, same session as above	Y, parts of Observation Rubric (9pp)
12	8/15/19	*Summer Science Practicum Research Presentations (culmination of EDU640)* Presentation of field research (C7)	MO	1hr	N
13	11/15/19	*EDU 620: Curriculum and Instruction for Teaching Earth Science in Secondary Schools* (C8)	MO	6 hrs	Y, related course materials
14-16	12/9/19	Observed 3 residents teach & senior specialist (NCN) debrief after their lesson	MO	7 hrs	Y, materials connected to lesson

Total hours: 40.25hrs

Appendix C

Semi-Structured Interview Protocol: Candidates and Program Graduates

This interview will be about your experiences as a candidate at this teacher education program as well as the beliefs and assumptions you have about education. All of the information in this interview will be kept confidential. Remember that your participation in this interview is completely voluntary: you can refuse to answer any question or end this interview at any time. This interview will be approximately 60 minutes and will be tape-recorded. Do you have any questions before we proceed?

Introduction

Background

1. Tell me a bit about yourself and your educational background.
    a. What were you doing before you started this program?
2. Choosing to be a teacher is a big commitment, which people make for lots of different reasons. Why did you choose teaching?
3. What do you see as the main purpose of teaching, and, even bigger, the main purpose of education?
    a. In your opinion, how does teaching fit into this purpose?
    b. Have you had experience in your time in the MAT program when you have seen these purposes being played out in practice? If so, could you share a story about this experience?

AMNH MAT Program

4. If you were recruiting somebody else to be in the MAT program, what would you say?
    a. **(optional)** Are there key stories or examples that you think represent the kind of experience people have in the program?
    b. Given your own educational background and your experiences in the MAT program, what would you say is the ideal way for a teacher to be prepared for a full-time teaching position?
5. What interested you in the MAT program at the museum?
    a. **(optional)** Would you mind sharing a story about your experience in looking into the MAT program and what other opportunities you were considering prior to accepting the MAT program's offer?
6. In your own words, what is the mission of the AMNH MAT Program?
    a. What parts of this mission are a good fit with your personal beliefs about teacher preparation in general?
    b. **(optional)** Are there any that don't fit well? If so, why? If not, why not?
7. Looking forward, what are your career goals/plans after you graduate from the MAT program?
    a. Where do you hope to work once you graduate from the MAT program? **(candidates only)**

b. Are there types of schools that you find yourself more or less attracted to based on your beliefs/educational values?
c. What do you hope to accomplish as a teacher once you graduate from the program? **/What have you accomplished as a teacher since graduating from the program?**
d. Do you see yourself staying in the classroom long-term, beyond the four-year commitment you signed on for?
e. **(optional)** Were there specific aspects of the MAT program experience that led you to this position?

Knowledge/Practice

8. What skills/practices/knowledge would you say are the most important for a good teacher to have?
    a. What do you believe a teacher should know, do, and be responsible for in his/her classroom and school?
    b. What are a teacher's most important professional responsibilities?
    c. Do these responsibilities look different depending on which type of school you are teaching in?
    d. Do you think there is a difference between what a teacher would ideally do and what a teacher can practically do? Have you had experiences at the MAT program that have shaped how you approach this question?
9. **(optional)** Describe the ways in which the MAT program **is preparing/ has prepared** you for your role as teacher.
10. What strategies and practices have you been taught or introduced to in your coursework at the museum?
    a. What would you say are the most important instructional practices you've observed in your residency classrooms?
    b. Which of these strategies **would you use as a full-time teacher/ do you use as a full-time teacher now**? Are there any strategies that you have observed/learned about that you **think would not be useful to you as a full-time teacher/ have not been useful to you now as a full-time teacher**?

Knowledge/Practice for Urban Contexts

11. Thinking a little bit about the schools for which you are preparing to teach/are currently teaching, which strategies, activities, and practices that **you are learning/have learned in the MAT program** have been the most useful to you in your own practice?
    a. Are there any courses in particular that you find useful for understanding your school community and culture?
    b. Do you believe that these tools are generalizable, to any school setting, or are the tailored particularly for the urban/ "high needs" schools for which you are preparing to teach/ **in which you currently teach**?

Residency

12. Can you describe a typical day in your residency**? Can you describe your experience in the school residencies overall?**

- **a.** What do you believe to be the most valuable learning experience for you so far in your residency**? /What was the most valuable thing you learned in your school residency placement?**
- b. Is there anything that is not working**/did not work** well for you in the school residencies?

13. What are you learning/**did you learn** about the school in which you teach, the community of which it is part, and NYC's school district in general? How do you think this will help you next year? How has this helped you as a teacher?

Co-teaching

14. The co-teaching model is unique to the MAT program's residency program. Can you talk a little bit about how this impacts/i**mpacted** your learning to teach experience?
    - a. Which features of this curricular model do you think work well?
    - b. Are there any that you think do not work well?

Justice (optional, time permitting)

15. How would you define equity or social justice as it applies to teaching and learning?
    - a. Can you relate this definition back to the mission and purposes you've laid out here? In other words, how do you think issues of justice/equity relate to the goals and practices of the MAT program?

Appendix D

Semi-Structured Interview Protocol: Teacher Educators and Scientists

This interview will be about your experiences in the MAT program, as well as your ideas about how teacher preparation should be carried out. All of the information in this interview will be kept confidential. Remember that your participation in this interview is completely voluntary: you can refuse to answer any question or end this interview at any time. This interview will be approximately 60 minutes and will be tape-recorded. Do you have any questions before we proceed?

Background and Introduction

- Tell me about your role in the MAT program, and how you came to do this work. What did you do before this?
    - What excites you about working here, and where do you see your biggest contribution?
    - Do you have any relationships with other teacher preparation programs/schools of education, or with teacher educators in general?

- What attracted you or interested you about working at the MAT program?
    - What have your prior experiences with graduate schools of education/teacher preparation programs been like? How does this program compare?

Museum

- What would you say were some of the fundamental reasons for creating this program at the museum?

- What is unique about this program? What makes it different from other teacher preparation programs?

Purpose of Education

- What do you see as the purpose of education in general and teacher education/teacher preparation in particular?
    - Can you give a story or anecdote that highlights what you mean?

- What would you say are the most important outcomes or goals you hope for in teacher preparation in the MAT program?

Knowledge/Practice

Knowledge

- What skills, knowledge, and practices are most important for teachers to develop?

- What attitudes, values, or beliefs do you hope residents develop during their time in the MAT program?

- What content knowledge should teachers have or develop? Either entering the MAT program, during the program, or prior to teaching?

- Given that there are many different takes on what an "effective teacher" is, what would you say makes an "effective teacher" and how is this cultivated?

Practice

- Thinking about the individual courses you teach/role you play in the MAT program, what activities/instructional strategies do you think are the most essential for the candidates to know and be able to do?
    - Why these activities over others?
    - Are there some that you deliberately do not emphasize?
    - How do these activities align with the MAT program goals?

- How do you know if residents have learned and are ready to put into practice what the MAT program intends them to?
    - What are some key assessments for your course(s)?
    - How are residents evaluated?

Urban/ "High needs" context

- What do you think residents should understand and know about working in urban or "high needs" schools?
    - Can you talk a little bit about the strategies, practices, and activities residents engage in to do this?
    - How is this facilitated? How do you know what candidates have learned?
    - Can you also talk a little bit about how it is determined that residents have learned and are able to apply this knowledge?
    -

Urban/"High needs"/residencies

- Can you talk about the school residencies of this program, and say a little bit about their role in preparing residents for urban/ "high needs" settings/students?
    - Can you describe a typical day and a typical week for the residents? What does four days in a residency school look like for them?

Co-teaching model

- How do you plan for essential activities with your co-teacher?
    - In other words, how do you and your co-teacher come to an agreement about essential ideas and pedagogical approaches?

    - Can you describe and maybe give an example or two about how you plan for your courses, how the syllabus is co-constructed, and how you make decisions about who will enact which instructional activities?

- When you reflect on your courses- is co-teaching sequential?
    - In other words, do you plan such that the students learn content at particular times in the course, and then pedagogy?
    - Or do you and your partner try to link content in together with pedagogy?
    - Can you give an example to illustrate how you handle this kind of planning?

- How do you and your co-teacher assess and evaluate the residents? Why did you choose these assessments**?**

- If you have worked with your co-teacher before, can you talk a little bit about if/how these assessments have changed from year to year? If this is your first year working together, how did you come to agreement on assessments? Can you describe this process?

Equity/Justice

- How do you think about the relationship between equity and teacher preparation?

- How would you define equity or social justice as it applies to your role here at the Museum?

    - Can you relate this definition back to the mission and purposes you've laid out here?
    - How do you think issues of justice/equity relate to the goals and practices at the Museum?

Appendix E

Semi-Structured Interview Protocol: Program and Museum Leaders

1. Say a little about own background, role at the Richard Gilder Graduate School, and your role as Dean in relation to the MAT program
2. **Mission**
    a. What is the mission of the Richard Gilder Graduate School?
    b. What is the mission of the MAT program at RGGS as you understand it as Dean?
    c. What need that prompted the development of the MAT program? (How do you construct the problem of teacher education?)
    d. Why did you decide to bring teacher certification under the same roof as the PhD in Comparative Biology?
3. **Affiliates and Partners**
    a. We know from your website that you are the only degree-granting museum in the Western Hemisphere and that there are many universities in New York City and New York State, so what was the rationale for having a graduate school in the first place?
    b. From your perspective as the Dean, what's the rationale for having a program in teaching since there are so many preparation programs and alternate routes in New York City?
    c. We know you are required by the state to pursue accreditation, what does accreditation does for the institution (of the graduate school, of the museum), besides fulfill a requirement?
4. **Funding**
    a. When I have talked about new graduate schools of education to groups of deans or education reform groups and mentioned your MAT program and its amazing student funding, people immediately question the sustainability. What makes it possible for you to offer this amazing financial arrangement to prospective teachers?
    b. What are the major sources of funding for the MAT program? Some people think that these new programs at new institutions have gotten more than their share of public and private funding. In our study, we've identified three kinds of funders: federal and state grants, private donors and funds from major foundations like Gates, Walton, and Broad. Can you talk about those in relation to the MAT program?
    c. How do you decide where to seek external funding?
    d. What kind of results do your grant makers look for? How do you manage these relationships? We know the major foundations are looking for particular kinds of outcomes, how do you manage that?
    e. We were really interested to see this fall that the MAT is now going to offer graduates $10,000 salary boost (check original language) for the first four years of their teaching careers. Where did this initiative come from? What's the source of that?

Appendix F
Semi-Structured Interview Protocol: Teacher Educator/Senior Specialist Focus Group

This interview/focus group will be about your experiences in the MAT program, as well as your ideas about how teacher preparation should be carried out. All of the information in this interview will be kept confidential. Remember that your participation in this interview is completely voluntary: you can refuse to answer any question or end this interview at any time. This interview will be approximately 45 minutes and will be tape-recorded. Do you have any questions before we proceed?

Teacher education pedagogy

Co-teaching model

- How do you and your co-teacher come to an agreement about essential ideas and pedagogical approaches?
- Do students learn content at particular times, and pedagogy at others, or are these linked together throughout?
- How do you and your co-teacher assess and evaluate the residents? Why did you choose these assessments**?**
- How do you think about the actual act of co-teaching? How do you decide who teaches what?

Collaboration across courses

- When you are planning or co-planning your course/s, how much do you consider the content in other courses?
- Do you think about where your course falls in the program, what they will learn in other courses, and how your course can complement other courses and/or deviate in important ways?
- As I understand it, your team of teacher educators worked together to revise the Observation Rubric. Is this a process the faculty engages in regularly? Can you describe any other explains like this process.
- How often do you get together as a faculty to look across courses, and plan out which key tools and assessments will go where? Who is generally present? Program leaders? Scientists? Senior Specialists?

Urban/ "High needs" context

- What do you think residents should understand about working in "high needs" schools?
- What are some specific strategies, methods, or practices you use to facilitate this learning? In other words, how do you and your co-teacher plan for this?
- Can you talk a little bit about the activities, discussions, and assessments residents engage in to learn to teach in "high needs" settings?
  - How is this facilitated?
  - How is this assessed?
  - How do you know residents can apply this knowledge?

Appendix G
List of Interviewees

Museum & Program Leaders

1. Co-Director and Co-founder of AMNH MAT program; Senior Director of Science Education; co-teacher of Earth Science Literacy Journal Seminar (interviewed 12/5/19)
2. Senior Director of Education at AMNH (interviewed 5/10/19)
3. Dean of the Richard Gilder Graduate School (interviewed 12/4/19)
4. Co-founder of AMNH RGGS MAT program (interviewed 12/6/19)
5. Senior Vice President, AMNH (interviewed 1/9/20)
6. Director of Educational Research and Evaluation, AMNH (interview 5/10/19)

Faculty & Staff

7. Co-Director and Co-founder of program (interviewed 6/17/19)
8. Manager of Teaching, Learning, and Technology (interviewed 5/10/19 and 6/18/19)
9. Teacher Educator (interviewed 5/10/19 and 6/17/19)
10. Teacher Educator/Senior Specialist (interviewed 6/18/19, focus group 7/9/19)
11. Teacher Educator (interviewed 6/18/19, focus group 7/9/19)
12. Curator and oceanographer and co-teacher of the weather and climate course (interviewed 6/17/19)
13. Teacher Educator/Induction faculty (year 1), Leader of the Mentor Academy and the Teacher Diversity, Equity and Identify programming in the MAT program (interviewed 6/18/19)
14. Teacher Educator/Senior Specialist (interviewed 7/9/19, focus group 7/9/19)

Residents

15. Resident 1, Cohort 8, AMNH MAT Program, 2019-2020 (interviewed 12/13/19)
16. Resident 2, Cohort 8, AMNH MAT Program, 2019-2020 (interviewed 1/13/20)
17. Resident 3, Cohort 8, AMMH MAT Program, 2019-2020 (interviewed 12/11/19)
18. Resident 4, Cohort 8, AMMH MAT Program, 2019-2020 (interviewed 12/17/19)
19. Resident 5, Cohort 8, AMMH MAT Program, 2019-2020 (interviewed 12/20/19)
20. Resident 6, Cohort 8, AMMH MAT Program, 2019-2020 (interviewed 1/19/20)

Program Graduates

21. Program Graduate 1, Cohort 4 of AMNH MAT Program, 2015-2016, Earth Science teacher at The James Baldwin School, New York City (interviewed 11/11/19)
22. Program Graduate 2, Cohort 4 of AMNH MAT Program, 2015-2016, Earth Science and Computer Science teacher at KIPP College Prep High School, Bronx, NY (interviewed 11/24/19)
23. Program Graduate 3, Cohort 2 of AMNH MAT Program, 2013-2014, Science teacher at Bozeman High School, Bozeman, MT (interviewed 11/18/19)

24. Program Graduate 4, Cohort 3 of AMNH MAT Program, Science teacher at White Plains Middle School, NY (interviewed 11/21/19)
25. Program Graduate 5, Cohort 7 of AMNH MAT Program, Earth Science & Environmental Science teacher at High School of Sports Management, Brooklyn, NY (interviewed 12/17/19)

Appendix H

AMNH MAT Program Observation Rubric

AMERICAN MUSEUM OF NATURAL HISTORY

AMNH MAT Program Observation Rubric

Standard I: The Resident understands the central concepts of the discipline and can make the subject matter meaningful to students.

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
1a	**Uses effective communication skills to demonstrate accurate content knowledge.**	Does not use effective communication skills or has inaccurate or incomplete knowledge of the important concepts of the discipline.	Uses somewhat effective communication skills that may confuse students or content knowledge of the discipline has minor errors.	Uses effective communication skills to demonstrate accurate knowledge of the important concepts of the discipline and how they relate to one another.	Uses effective communication skills to demonstrate deep knowledge of the important concepts of the discipline and how they relate to one another and across other disciplines. Students make connections between concepts.
	*Examples **may** include but are not limited to the following:*				
		- Makes serious content errors and does not correct them *- Does not correct errors made by students as appropriate to the lesson* *- Does not answer students' questions as appropriate to the lesson* *- Communication is unclear, inaudible, or otherwise inaccessible by the students*	*- Makes content errors but corrects them* *- Addresses errors made by students as appropriate to the lesson* *- Answers students' questions, however, answers are limited* *- Sometimes unclear with speaking, drawing, or writing* *- May not connect content to practices, crosscutting concepts, or anchoring phenomenon*	*- Demonstrates understanding of content and how concepts relate to one another within the discipline* *- Has varied explanations that address range of students' questions as appropriate to the lesson* *- Displays clarity in speaking, drawing, and writing* *- Makes connections among content, practices, crosscutting concepts and/or anchoring phenomenon*	*- Demonstrates understanding of the important concepts in the discipline related to an anchoring phenomenon, and how these relate to one another and across disciplines* *- Brings in personal examples and experiences doing and/or learning science related to the concepts* *- Has varied explanations that address range of students' questions as appropriate to the lesson* *- Students make connections among concepts as they build their conceptual understanding of the anchoring phenomenon* *- Displays clarity and creativity in speaking, drawing, and writing* *- Makes connections among content, practices and crosscutting concepts in relation to an anchoring phenomenon.*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
1b	**Adapts content to students' level of understanding.**	Does not adapt content level or complexity to students' level of understanding.	Attempts to adapt content level or complexity to students' level of understanding but is below/above students' abilities or scaffolds are not effective.	Adapts content level or complexity to students' level of understanding with appropriate and effective scaffolds.	Adapts content level or complexity to students' level of understanding with scaffolds that push students' thinking.
	*Examples **may** include but are not limited to the following:*				
		- Doesn't adjust content - Content level is too far above or below students' abilities - Representations, examples, or models have flaws that may promote misunderstandings of the content, have only superficial connections to the content, do not contribute to student learning, and/or are inappropriate in the context - Has not prepared any ways to break down a concept to make it accessible to students - Does not implement any scaffolds when needed	*- Adjusts content but content level is too far above or below students' abilities - Uses limited modes of representation (e.g., data visualizations, physical models, analogies, etc.) - Has prepared one way to break down a concept to make it accessible to students - Implements scaffolds, however, scaffolds not well designed or well implemented*	*- Content level is appropriate for students' abilities - Uses multiple modes of representation (e.g., data visualizations, physical models, analogies, etc.) that are appropriate in the context - Has prepared more than one way to break down a concept to make it accessible to students with different levels of conceptual understanding - Implements scaffolds that allow students to work successfully to understand the content (e.g., graphic organizers, explaining procedures, breaking down vocabulary, etc.)*	*- Content level is appropriate for students' abilities and encourages students to make their own connections - Uses multiple modes of representation (e.g., data visualizations, physical models, analogies, etc.) that are appropriate in the context and contribute to student learning - Students with different levels of conceptual understanding effectively help each other deepen their understanding - Scaffolds not only allow students to understand content, but allow students to learn autonomously*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

Standard II: The Resident understands how students differ in their approaches to learning and creates instructional opportunities that are adapted to diverse learners.					
	Criteria	**Unsatisfactory**	**Basic**	**Proficient**	**Accomplished**
2a	**Addresses students' different learning challenges, strengths, and socio-emotional needs.**	Does not address students' different learning needs.	Acknowledges and engages students with different learning needs but with inconsistent results.	Addresses students' different learning challenges, strengths, and needs, using a variety of strategies, with positive results.	Positions students to use their personal, linguistic, socio-cultural experiences to co-construct knowledge in a way that is beneficial to students.
Examples may include but are not limited to the following:					
		- Treats all students as homogeneous learners - Does not attend to varied needs of different student groups - Does not attend to race, culture, or class - Very little evidence of knowing students or their assets (e.g. names, linguistic preferences) - Does not set up opportunities/provide supports for students with different learning needs (e.g. ELLs, SpEd students, etc.) - Does not recognize contributions from students with different learning needs (e.g. ELLs, SpEd students, etc.)	*- Attempt at differentiation may not be successful - Attends to some needs of different student groups, however, some are being privileged over others during instruction - Attempts to take an asset-based view of students' backgrounds and cultural experiences - Attempts to set up opportunities/provide supports for students with different learning needs (e.g. ELLs, SpEd students, etc.) - Recognizes contributions from students with different learning needs (e.g. ELLs, SpEd students, etc.) but does not provide opportunities for them to show their thinking*	*- Uses a strategy to intellectually engage students with varied needs and strengths (e.g. ELLs, SpEd students, etc.) - Values all student groups equally - Shows evidence of an asset-based view of students' backgrounds and cultural experience by explicitly incorporating students' assets into classroom learning, - Sets up opportunities/provides supports for students with different learning needs (e.g. ELLs, SpEd students, etc.) - Recognizes contributions from students with different learning needs (e.g. ELLs, SpEd students, etc.) and provides opportunities for them to show their thinking*	*- Uses a variety of strategies to intellectually engage students with varied needs and strengths (e.g. ELLs, SpEd students, etc.) - Supports students to value other student groups' views equally - Shows evidence of an asset-based view of students' backgrounds and cultural experiences and supports students in incorporating their assets into classroom learning - Sets up opportunities/provides supports for students with different learning needs (e.g. ELLs, SpEd students, etc.) and integrates these students' thinking into the larger class discussion - Builds on contributions from students with different learning needs (e.g. ELLs, SpEd students, etc.) to the benefit of the class*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
2b	**Demonstrates high expectations for learning and achievement by framing clear learning goals.**	Makes no reference to learning goals or expectations for learning for the lesson, or does not exhibit high expectations for all students.	Refers to learning goals and/or demonstrates an understanding of the need for high expectations but does not follow through effectively.	Refers to learning goals and demonstrates high expectations for all students.	Prepares all students to be able to clearly articulate the goals and purpose of the lesson and how they personally can reach those goals by doing rigorous, high-quality work.
		*Examples **may** include but are not limited to the following:*			
		- Does not display or share learning goals/objectives - Expectations are not appropriately rigorous for students - Shows lack of faith in students' ability to reach learning expectations	*- Learning goals/objectives are articulated but not revisited during the class or in the wrap up - Expectations are appropriately rigorous for some students*	*- Learning goals/objectives are displayed and referenced throughout the class - Expectations are appropriately rigorous for students - Supports students in doing high quality work by asking questions, pressing for explanation*	*- Different students state the goals of instruction throughout the lesson - Students hold themselves and their peers to high expectations, for example, by asking questions, pressing for explanation, taking risks*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

Standard III: The Resident understands and uses a variety of instructional strategies to encourage student development of critical thinking, problem solving, and performance skills.					
	Criteria	**Unsatisfactory**	**Basic**	**Proficient**	**Accomplished**
3a	**Surfaces and responds to students' ideas.**	Does not attempt to elicit or respond to students' ideas or belittles students' ideas.	Attempts to elicit students' ideas but does not respond to them well.	Elicits students' ideas and responds to them in the instruction.	Elicits students' ideas, probes ideas, and responds to them within the instruction.
		*Examples **may** include but are not limited to the following:*			
		- Does not elicit students' ideas - Does not respond to students' ideas in the lesson - Makes fun of students' ideas -Does not make students' ideas visible	*- Asks questions/gives prompts meant to elicit students' ideas, but the question/prompts are not productive, limited ideas are surfaced, or the teacher gives the right answer right away - Attempts to respond to students' ideas in the lesson - Effort is made to make students' ideas visible*	*- Uses an observable phenomenon, models, or diagrams to elicit prior academic knowledge, misconceptions, and other knowledge in a whole class discussion - Uses a verbal or written assessment probe to elicit ideas - Explicit reference to students' prior experiences and understandings made during instruction - Tracks students' ideas with a routine/scaffold (e.g. KWL, POE, See Think Wonder, etc.) - Has students explain both correct and incorrect answers*	*- Uses an observable phenomenon, models, or diagrams to elicit prior academic knowledge, misconceptions, and other knowledge in a whole class discussion and includes references to individual students' backgrounds and ideas while discussing lesson content - Verbalizes how they are building upon students' ideas surfaced in previous lessons - Explicitly references students' preconceptions that were surfaced in prior lessons - Uses talk moves productively - Utilizes students' word choice in follow up questions or prompts - Probes for alternative interpretations of students' ideas risks*

☐ **Check if N/A**

Evidence and next steps:

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
3b	**Relates science to the personal lives, needs, and interests of students.**	Does not relate science content to the personal lives, needs, or interests of students.	Attempts to relate science content to the personal lives, needs, and/or interests of students but connection is weak or doesn't resonate with the students.	Relates science content to the personal lives, needs, and/or interests of students in a way that resonates with the students.	Relates science content to the personal lives, needs, and/or interests of students in a way that resonates with the students while connecting science content to broader societal issues.
*Examples **may** include but are not limited to the following:*					
		- Does not make connections between content and students' funds of knowledge (e.g., cultural practices, background knowledge, lived experiences) or current or local issues *- Does not put science content in context* *- Does not connect science to students' sense of "place" along physical, historical or sociocultural dimensions*	*- Asks questions/gives prompts meant to surface connections between content and students' lived experiences but with little success* *- Makes connections to students' funds of knowledge (e.g., cultural practices, background knowledge, lived experiences) but connections are not relevant or do not resonate* *- Attempts to address current and/or local events related to the content* *- Attempts to connect science with students' sense of "place" along physical, historical, and/or sociocultural dimensions*	*- Asks questions/gives prompts to surface connections between content and students' lived experiences* *- Makes connections between content and students' funds of knowledge (e.g., cultural practices, background knowledge, lived experiences) by, for example, incorporating resources and materials that reflect diversity in terms of race, culture, class, gender, etc.* *- Makes connections between current and/or local societal events and content* *- Makes connections between science and students' sense of "place" as physical, historical, and/or sociocultural dimensions*	*- Supports students in asking questions to surface connections between content and students' lived experiences* *- Elicits connections between content and students' funds of knowledge (e.g., cultural practices, background knowledge, lived experiences) including, for example, incorporating resources and materials that reflect diversity in terms of race, culture, class, gender, etc.* *- Uses issues relevant to students or school community to make science more culturally or linguistically relevant* *- Makes multiple connections between science and students' sense of "place" as physical, historical, and/or sociocultural dimensions* *- Connects content to value of science to society (why society cares)* *- Connects to societal impacts and/or moral/ethical beliefs pertaining to phenomena being studied*

☐ **Check if N/A**

Evidence and next steps:

AMERICAN MUSEUM OF NATURAL HISTORY

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
3c	**Uses questioning and discussion strategies.**	Does not ask questions to individuals or whole class or engage students in discussion.	Attempts to engage class in discussion and to encourage students to respond to one another, using questions and prompts or other strategies.	Successfully engages class in discussion, employing a range of strategies and questions to ensure that most students' voices are heard.	Successfully engages class in discussion, employing a range of strategies and questions to ensure that a variety of students' voices are heard.
	*Examples **may** include but are not limited to the following:*				
		- Does not ask students questions - Stifles discussion - Lectures for all or most of the lesson, prioritizes presentation of information over student engagement	*- Asks questions that are generally close-ended with answers seemingly determined in advance - Asks 'fill in the blank' questions - Student discourse is limited to responding to the teacher - Inadequate time may be provided for students to respond - Attempts to frame some questions designed to promote student discussion, but only a few students are involved*	*- Poses questions to students designed to promote student thinking and understanding - Creates a facilitated discussion among a variety of students, providing adequate time for students to respond - Engages in discourse strategies (e.g., elicits initial ideas, asks clarifying questions, supports students in elaborating their ideas, re-voices students' ideas, takes up student ideas, asks for other students' input, etc.)*	*- Asks a variety or series of questions or prompts to challenge students cognitively, advance high-level thinking and discourse, and promote metacognition - Creates a genuine discussion among most of the students, providing adequate time for students to respond, and stepping aside when appropriate - Engages in discourse strategies for the purpose of giving students ownership of class discussions. - Students formulate many questions, initiate topics, and make unsolicited contributions to discussion and/or lead discussions among their peers*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
3d	**Develops and manages diverse and effective student groups.**	Does not develop or manage student groups.	Develops and manages student groups, but group work is not beneficial to student learning.	Develops and manages diverse groups that engage in work that is beneficial to student learning.	Develops and manages diverse groups that engage in work that requires contributions from each individual in order for the group to succeed.
	*Examples **may** include but are not limited to the following:*				
		- No grouping of students is observed *- Allows students to choose their own groups to the detriment of learning*	*- Groups students* *- Students are put into groups that do not work (e.g., are distracting the class, are not working well together, etc.)* *- Students are not contributing to group work*	*- Creates purposeful groups (homogeneous or heterogeneous)* *- Encourages supportive interactions among group members* *- Students are contributing to group work but on a task that does not require collaboration to complete*	*- Creates purposeful groups (homogeneous or heterogeneous) based on students' strengths and needs* *- Encourages supportive interactions among group members to help individuals and the whole class see strengths that individuals bring to the task* *- Students in group are given explicit roles and responsibilities* *- Assigned task cannot be completed without each group member's contribution*

☐ **Check if N/A**

Evidence and next steps:

AMERICAN MUSEUM of NATURAL HISTORY

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
3e	**Engages students in doing science through the Science and Engineering Practices (NRC, 2012).**	Does not engage students in Science and Engineering Practice(s).	Engages students in doing science through the Science and Engineering Practice(s) to answer a question or solve a problem, but the question/problem or Practice(s) are not made clear to students.	Engages students in doing science through the Science and Engineering Practice(s) to answer a question or solve a problem and the question/problem and the Practice(s) are made clear to students.	Engages students in doing science through the Science and Engineering Practice(s) to answer a question or solve a problem and the question/problem and the Practice(s) are made clear to students, bringing in ideas about the nature of science by connecting what students are doing to how scientists use similar practices.
*Examples **may** include but are not limited to the following:*					
Science and Engineering Practices: • *Asking Questions and Defining Problems* • *Developing and Using Models* • *Planning and Carrying Out Investigations* • *Analyzing and Interpreting Data* • *Using Mathematics and Computational Thinking* • *Constructing Explanations and Designing Solutions* • *Engaging in Argument from Evidence* • *Obtaining, Evaluating, and Communicating Information*		*- Does not engage students in any Practices* *- The activity does not address a scientific question or problem* *- Talks at students instead of engaging them in active learning*	*- Engages students in one or more Practice, however, does not explicitly identify the Practice(s)* *- Scientific question or problem addressed by the activity is not made clear to students* *- Uses "cookbook labs" where students do not have to participate deeply, or the answer is spelled out for them*	*- Explicitly identifies the Practice(s) students are engaged in* *- Scientific question or problem addressed by the activity is made clear to students* *- Mentions types of scientists that engage in the Practice(s) and tools students are using in their scientific investigations*	*- Explicitly identifies the Practice(s) students are engaged in* *- Students can state the scientific question or problem addressed by the activity* *- Students' questions drive the investigation* *- Connects what students are doing to how scientists use similar Practices* *- Makes explicit connections to science as a profession* *- Makes sociocultural and/or historical connections*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

Standard IV: The Resident creates a safe learning environment that encourages positive social interaction, active engagement in learning, and self-motivation.					
	Criteria	**Unsatisfactory**	**Basic**	**Proficient**	**Accomplished**
4a	**Creates and maintains an effective learning environment that encourages enthusiasm for learning and engagement in science.**	Does not create or maintain an effective environment for learning. Students are disengaged and/or exhibit disrespect for the teacher.	Attempts to create and maintain an effective learning environment but is not able to exhibit firm control in all situations and/or student engagement and respect is inconsistent.	Creates and maintains an effective and respectful learning environment that encourages enthusiasm for learning and engagement in science.	Creates and maintains an effective and respectful learning environment that supports enthusiasm for learning and engagement in science, and students show self-motivation and ownership over the classroom learning environment.
	*Examples **may** include but are not limited to the following:*				
		- Students show disrespect for the teacher and/or each other *- No norms have been clearly established* *- Few students are intellectually engaged in the lesson (e.g., heads on desks, no hands raised, or questions asked, etc.)*	*- Students show respect for the teacher and/or each other* *- Has established norms but students are not aware of them or are not following them* *- Instruction is stopped to regain order* *- Students are not consistently intellectually engaged* *- Classroom environment is occasionally disruptive to student learning*	*- Students show respect for the teacher and each other* *- Students demonstrate that they understand classroom norms and are following them* *- All students are intellectually engaged in the lesson (e.g., raising hands, asking and responding to questions, actively participating in discussions and other activities)*	*- Students show respect for the teacher, each other, and visitors* *- Students demonstrate that they understand classroom norms, why they exist, and are following them* *- Students are engaging in self-directed learning* *- Students care about and support the learning of their peers*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
4b	**Uses instructional time completely and effectively.**	Loses significant instructional time under routine conditions due to poor planning and management.	Loses instructional time at transitions and/or at the beginning or end of class or the end of class is rushed.	Uses instructional time completely and effectively to allow for a clear beginning and end to the lesson.	Uses instructional time completely and effectively to allow for a clear beginning and end to the lesson while adjusting instruction to respond to students' needs or unexpected events.
	*Examples **may** include but are not limited to the following:*				
		- Lesson drags or is rushed *- Time is wasted* *- Does not include wrap up even though time allows for one*	*- Transitions are not smooth and some time is wasted* *- Class does not start on time or ends early* *- End of class is rushed or does not allow for lesson wrap up*	*- Transitions are smooth and no time is wasted* *- Class starts promptly with a clear beginning* *- Class ends on time and allows for a clear wrap up* *- Allows time during the lesson to conduct a formal assessment*	*- Transitions are smooth and no time is wasted, even when unplanned events occur that could be disruptive* *- Students themselves ensure that transitions and other routines are accomplished smoothly* *- Alters plan due to students' needs or unexpected event and still allows time for formal assessment and a clear wrap up*

☐ **Check if N/A**

Evidence and next steps:

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
4c	**Plans for and attends to material safety.**	Does not identify and address relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and attend to the safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials.	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and attend to the safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials. Effectively communicates safety precautions (verbally or in writing).	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and attend to the safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials. Effectively communicates safety precautions and their justifications to students (verbally and/or in writing).	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and attend to the safe and proper techniques for the preparation, storage, dispensing, supervision, and disposal of all materials. Students are actively involved in the construction and enactment of safe practices.
	*Examples **may** include but are not limited to the following:*				
		- Does not plan for safe handling of materials *- Does not address safety concerns with materials* *- Plans for safe handling of materials*	*- Plans for and addresses safety concerns with materials* *- Communicates safety with materials to students*	*- Plans for and communicates safety with materials with reasoning to students*	*- Plans for material safety and students communicate safety with materials with reasoning*

☐ **Check if N/A**

Evidence and next steps:

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
4d	**Plans for and implements safety and emergency procedures.**	Does not identify and address relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement emergency procedures and maintain safety equipment, policies and procedures that comply with established state and/or national guidelines. Ensures safe science activities appropriate for the abilities of all students.	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement emergency procedures and maintain safety equipment, policies and procedures that comply with established state and/or national guidelines. Ensures safe science activities appropriate for the abilities of all students and effectively communicates safety precautions (verbally or in writing).	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement emergency procedures and maintain safety equipment, policies and procedures that comply with established state and/or national guidelines. Ensures safe science activities appropriate for the abilities of all students and effectively communicates safety precautions and their justifications to students (verbally and/or in writing).	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement emergency procedures and maintain safety equipment, policies and procedures that comply with established state and/or national guidelines. Ensures safe science activities appropriate for the abilities of all students and students are actively involved in the construction and enactment of safe practices.
*Examples **may** include but are not limited to the following:*					
		- Does not plan for safety and emergency procedures *- Does not communicate safety and emergency procedures to students*	*- Plans for and communicates safety and emergency procedures to students*	*- Plans for and communicates safety and emergency procedures with reasoning to students*	*- Plans for safety and emergency procedures and students communicate safety and emergency procedures with reasoning*

☐ **Check if N/A**

Evidence and next steps:

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
4e	**Plans for and attends to the ethical treatment of living organisms.**	Does not identify and address relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement ethical decision-making with respect to the treatment of all living organisms in and out of the classroom. Emphasizes safe, humane, and ethical treatment of animals and complies with the legal restrictions on the collection, keeping, and use of living organisms.	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement ethical decision-making with respect to the treatment of all living organisms in and out of the classroom. Emphasizes safe, humane, and ethical treatment of animals and complies with the legal restrictions on the collection, keeping, and use of living organisms. Effectively communicates safety precautions (verbally or in writing).	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement ethical decision-making with respect to the treatment of all living organisms in and out of the classroom. Emphasizes safe, humane, and ethical treatment of animals and complies with the legal restrictions on the collection, keeping, and use of living organisms. Effectively communicates safety precautions and their justifications to students (verbally and/or in writing).	Identifies and addresses relevant safety concerns in accordance with the program safety checklist that demonstrates they plan for and implement ethical decision-making with respect to the treatment of all living organisms in and out of the classroom. Emphasizes safe, humane, and ethical treatment of animals and complies with the legal restrictions on the collection, keeping, and use of living organisms. Students are actively involved in the construction and enactment of safe practices.
		*Examples **may** include but are not limited to the following:*			
		- Does not plan for safety with animals *- Does not address safety concerns with animals*	*- Plans for and addresses safety concerns with animals* *- Communicates safety with animals to students*	*- Plans for and communicates safety with animals with reasoning to students*	*- Plans for safety with animals and students are able to communicate safety with animals with reasoning*

☐ **Check if N/A**

Evidence and next steps:

Standard V: The Resident uses effective media communication techniques and appropriate technology to foster active learning and supportive interaction in the classroom.					
	Criteria	**Unsatisfactory**	**Basic**	**Proficient**	**Accomplished**
5a	**Uses technology effectively to support learning.**	Use of technology disrupts classroom learning.	Uses digital technologies but addition of technology does not support classroom learning goals.	Uses digital technologies effectively to support learning and engage students.	Students effectively use digital technologies to construct their own scientific understandings.
*Examples **may** include but are not limited to the following:*					
		- Unprepared to use technology - Use of the technology significantly detracts from instructional time	*- Technology does not engage the students in the activity -Technology used to display content that does not support objectives*	*- Technology used to enhance instruction (e.g., peer response system (e.g. clickers) used to surface misconceptions and/or further learning, etc.) or display content (including natural phenomena, models, experts, video, images, etc.) - Uses technology to support learning of science concepts (e.g., make observations, access digital resources (such as Google Classroom), use models to run simulations, etc.) - Stops and starts video to use questions or prompts to engage students in discussion or written activity to deepen their engagement with the media*	*- Students demonstrate familiarity and competence in using technology in their science learning - Students actively use technology to engage in science practices (e.g., modeling, planning and carrying out an investigation, analyzing and interpreting data, constructing an explanation, asking questions, etc.) - Students produce media that communicates deep understanding of phenomena and related crosscutting concepts, disciplinary core ideas and/or practices*

☐ **Check if N/A**

Evidence and next steps:

Standard VI: The Resident plans instruction based upon knowledge of subject matter, state and national standards, students, and the community.					
	Criteria	**Unsatisfactory**	**Basic**	**Proficient**	**Accomplished**
6a	**Aligns science instruction with state standards appropriate to grade level.**	Does not make connections between science instruction and relevant standards.	Relevant state standards are incomplete or misaligned with science instruction.	Science instruction aligns with all relevant state standards.	Science instruction aligns with all relevant state standards and attends to future state standards.
		*Examples **may** include but are not limited to the following:*			
		- No standards selected	*- Selected standards include one NYS content and/or one process skill standard and/or one CCSS (but not one of each)* *- Selected standards misalign with lesson activities or learning experiences* *- Standards are not communicated (verbally or written) to supervisor*	*- Selected standards include two from NYS (one content and one process skill) and one from CCSS (Math or ELA)* *- Selected standards work well together and align with learning experiences* *- Standards are communicated (verbally or written) to supervisor*	*- Selected standards include two from NYS (one content and one process skill) and one from CCSS (Math or ELA) as well as a DCI, SEP, and CCC from NYS Science Learning Standards (NYSSLS, based on NGSS) and are communicated (verbally or written) to supervisor* *- All selected standards, including new NYSSLS, work well together and align with learning experiences*

☐ **Check if N/A**

Evidence and next steps:

Standard VII: The Resident understands and uses formal and informal assessment strategies, consistent with instructional goals, to evaluate and ensure the continuous intellectual and social development of the learner.					
	Criteria	**Unsatisfactory**	**Basic**	**Proficient**	**Accomplished**
7a	**Aligns goals, strategies and assessments.**	Lesson does not include or does not align learning goals, instructional strategies, and assessment.	All learning goals are not assessed by the proposed assessments or instructional strategies do not support students in meeting all learning goals.	All learning goals are assessed and instructional strategies support students in meeting all learning goals.	All learning goals are assessed and instructional strategies along with student self-assessments support students in meeting all learning goals.
*Examples **may** include but are not limited to the following:*					
		- Lesson does not include learning goals *- Instructional strategies do not allow students to complete assessment* *- Assessments do not assess proposed learning goals*	*- Lesson includes learning goals* *- Instructional strategies allow students to complete some but not all of the assessments* *- Not all learning goals are assessed*	*- All learning goals are assessed* *- Instructional strategies allow students to complete all assessments*	*- Student self-assessment is included and aligned with learning goals (e.g. a rubric is provided for students to self-evaluate or students compare their answer to the correct answer and self-assess)*

☐ **Check if N/A**

Evidence and next steps:

AMERICAN MUSEUM OF NATURAL HISTORY

AMNH MAT Program Observation Rubric

	Criteria	Unsatisfactory	Basic	Proficient	Accomplished
7b	**Uses a variety of assessment strategies to assess students.**	Does not informally or formally assess students.	Uses limited assessment strategies that do not allow for all students to effectively demonstrate achievement of learning goals.	Effectively uses a variety of assessment strategies (both informal and formal) that allow for all students to demonstrate achievement of learning goals.	Effectively uses a variety of assessment strategies (both informal and formal) that allow for all students to demonstrate achievement of learning goals and includes student self-assessment.
		*Examples **may** include but are not limited to the following:*			
		- Lesson does not include any assessment (formal or informal) *- Informal or formal assessments not used to check student progress towards learning goals*	*- Uses informal (e.g., verbal questions, etc.) or formal (e.g., writing, drawing, multiple choice, constructed response, etc.) assessment techniques during class* *- Assessments use close-ended questions that lead to convergent responses* *- Assessments do not allow for checking student progress in content understanding or skill development towards learning goals*	*- Uses informal (e.g., verbal questions, etc.) and formal (e.g., writing, drawing, multiple choice, constructed response, etc.) assessment techniques during class* *- Assessments include open-ended questions that lead to divergent responses* *- Assessments allow for checking student progress in content understanding and skill development towards learning goals*	*- Incorporates evidence from formative assessments in instruction as the lesson proceeds* *- Assessments include challenges that allow students to demonstrate their critical thinking* *- Assessments allow students to check their progress in content understanding and skill development towards learning goals (e.g. students are using a rubric to assess their work)*

☐ **Check if N/A**

Evidence and next steps: