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Science and Service: Teacher Preparation at the American Museum of Natural History

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ABSTRACT

This article examines how the MAT program in Earth Science at the American Museum of Natural History was conceptualized and enacted within its institutional context. We argue that the program was completely consistent with the museum's public and democratic institutional logic, as reflected in funding, staffing, location, and regulation. Further, we suggest that learning to teach was conceptualized as a process combining informal science learning with professional learning at the nexus of multiple communities of practice. Together, these arguments show that science teacher preparation at the AMNH was a natural outgrowth of the museum's commitment to educating the public in a democratic society.

Editor's note

This article is part of a special issue of *The New Educator* on the topic of teacher preparation at new graduate schools of education (nGSEs) (Cochran-Smith, Carney, & Miller, 2016). This term refers to the small, but growing phenomenon in the United States of new graduate schools that prepare and endorse teachers for certification and award master's degrees, but are not university-based or formally affiliated with universities as knowledge brokers or degree-granting bodies. The issue draws on data and analyses from a larger Spencer Foundation-funded study of teacher preparation at nGSEs. The issue's first article locates nGSEs within the context of larger policy, political, and professional trends and describes the larger study. This is followed by four articles, including this one, each of which offers a theorized profile of teacher preparation at one nGSE. The issue concludes with an article that offers a multiple-case perspective by looking across the four profiles.

As part of the larger study, the four cases were chosen for in-depth analysis not only because of their "instrumental" (Stake, 2006) value as instances of the phenomenon of teacher preparation at nGSEs, but also for their "intrinsic" individual interest (Stake, 2006) – that is, their high visibility, media attention, and/or institutional and programmatic innovations. Thus, each case profile in

this issue, which is intended to capture the essence of the individual case, analyzes how teacher preparation is conceptualized and enacted in relation to its institutional environment, including its practices, structures, environmental rules, traditions, and beliefs. Because each case site was selected in part because it was different from the others and was intrinsically interesting, the authors of these four articles use different, situationally-relevant theoretical frameworks, concepts, and analytic tools to construct the profiles in addition to the frameworks of the larger study. The four analyses are not intended to speak with one voice or echo one interpretive line; rather, they vary according to the unique aspects of each case. It is important to note, however, that although each of the four profiles is designed to stand alone, each is also linked to all the articles in the issue. Readers will gain the richest interpretation of what makes teacher preparation at nGSEs make sense to their participants and what the controversies are regarding this new phenomenon by reading across the articles in the issue.

Established in 2012, the Master of Arts in Teaching (MAT) Program in Earth Science at the American Museum of Natural History (AMNH) now prepares about one third of New York state's earth science teachers. The AMNH MAT is the only teacher education program in the United States wherein a museum, rather than a university or other higher education organization, grants the teaching degree, and it is the only teacher preparation program that is organizationally and physically embedded among the exhibit halls and artifacts of a museum. The establishment of the program reflects the rapidly changing organizational landscape of teacher education in the United States. The program's museum location and organizational structure, its full funding of teacher candidates through public and private grants, and the premium it places on science content knowledge make it an information-rich case for analysis. As elaborated in Cochran-Smith ([this issue](#)), this article offers a "theorized profile" of the AMNH MAT, drawing on case study data and analyses underway for the larger study. Detail about the design of the larger study is laid out in some detail in the first article of this issue (Cochran-Smith, [this issue](#)). Data sources include: interviews with participants; observations of key learning contexts, including courses, meetings with residents, school-based experiences, museum- and site-based experiences; collection of program materials, including syllabi, assessment protocols and tools, assignments, website information; and institutional documents, including internal and external evaluations, grant proposals, and funding reports. To identify patterns in the data, standard qualitative analysis procedures were used, especially Erickson's (1986) framework for building propositions using multiple data sources and triangulation.

The purpose of this article is to provide a theorized profile of how the leaders of the MAT program conceptualized and enacted teacher preparation within the unique organizational and institutional context of a museum.

Along these lines, this article makes two closely linked arguments. First, we argue that the MAT program was completely consistent with the museum's larger public and democratic institutional logic, as reflected in the ways the program was funded, staffed, located, and regulated. Second, we suggest that the leaders of the program conceptualized learning to teach as a process of combining informal science learning with professional learning at the nexus of multiple overlapping communities of practice brokered by key personnel. Together these two arguments suggest that science teacher preparation at the AMNH MAT was a natural outgrowth of the museum's deep commitment to educating the public, given its abundance of intellectual, material, and human resources, coupled with its outreach capacity and its willingness to risk entering the contemporary field of teacher education even at a time of intense accountability demands and competition.

Background of the AMNH MAT program

The AMNH MAT prepares earth science teachers for grades 7–12 in what New York State has qualified as “high-needs” schools (AMNH, “MAT Program Overview,” n.d.b., para. 1). The MAT program is housed within the Richard Gilder Graduate School (RGGS), which was established at the AMNH in 2006 to grant PhDs in Comparative Biology. Teacher candidates, who are referred to as residents, are fully funded for the 15-month program that includes two semester-long teaching residencies in two different New York City schools, one museum residency, and a science research practicum in the field. This residency structure makes the AMNH MAT somewhat different from many other university-based and non-university based residency models of teacher preparation programs, which generally offer teacher candidates the experience of working in one classroom for an extended period of time, often a full school year (Torrez & Krebs, 2020). AMNH residents receive a fellowship for the 44,750 USD tuition plus a 30,000 USD living stipend. Until 2019, program acceptance and funding were contingent on candidates' commitment to teaching in high-needs schools in New York State for four (now three) years upon graduation, during which time graduates from 4 of the program's 8 cohorts received a 10,000 USD annual salary supplement (MAT Program admissions e-mail, January 22, 2020). As of May 2020, seven cohorts totaling 109 graduates had completed the program; for some of these years, the number in the cohort constituted as many as half of the earth science teachers prepared in New York State.

Our analysis suggests that science teacher preparation in the form of the MAT program was what one key administrator referred to as a “natural outgrowth” (Interview #11, Administrator A) of the museum's educational mission. The program's co-founders wanted to strengthen the informal connection between science and education at the 150-year-old AMNH. Drawing on experiences with previous university partnerships as well as AMNH's myriad in-house

professional development programs for educators, the MAT program's founders designed a new teacher preparation program in response to a critical shortage of qualified earth science teachers in New York State. Prior to the inception of its own higher education programs, many of the museum's research scientists, known as curators, and its education faculty had served as adjunct faculty in nearby university science and education departments. But the founders of the AMNH MAT were unsatisfied with the siloed relationship they perceived at most universities between science departments and education departments – and they were strongly influenced by state and national policy discourses about the pressing need for earth science teachers (Interview #11, Administrator A; Interview #12, Administrator B). These factors were central in the museum's decision to apply for—and ultimately receive – a portion of the nearly 700 USD million Race To The Top funds that were awarded to New York State in 2010. A pilot MAT program was launched in 2011 with the degree awarded by the New York State Board of Regents, and then in 2015, the MAT program was formally housed within the existing Richard Gilder Graduate School at the AMNH with the degree awarded by the graduate school.

The competitive teacher education policy landscape in 2010 was highly accountability- and market-driven (Cochran-Smith et al., 2018). This made for an especially risky moment to enter the field of teacher preparation given federal and professional demands to show results and competition in an increasingly crowded field. Leaders of the AMNH MAT, however, felt that the museum's very short history as a preparation provider was a competitive asset. For example, after the AMNH MAT had been in operation only one year, the New York Department of Education mandated that all teacher preparation programs require candidates to pass the edTPA in order to be certified. One MAT program leader said, “And so for us, in a way, it was almost better than for universities because we'd only been at it one year. We were quite flexible because we were barely formed” (Interview #12, Administrator B). This senior administrator also noted that because faculty members were not entrenched in teacher education traditions, the program was able to be nimble in reshaping itself in response to initial feedback from graduates and shifting policy demands.

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 grants; and Race to the Top funding through New York State. At the same time, the museum has shown its own internal support for the MAT program by matching external grant funding because, as a key administrator suggested, “they see teacher preparation as the culmination of many different activities the museum is engaged in . . . even though it's very expensive” (Interview #12, Administrator B). Interestingly, despite the financial security of the AMNH MAT at the time of our interviews, there was a shared feeling among program administrators

that the existence of the program was contingent on historical circumstances that were always subject to change. That is, if curriculum requirements changed or if other local teacher preparation programs decided to emphasize earth science, then the need for the AMNH MAT program would likely diminish. This acknowledgment of changing contingencies speaks to the underlying logic of the program, as elaborated below.

The institutional logic of the AMNH MAT program

This analysis of teacher preparation at the American Museum of Natural History is located at the intersection of two educational sub-fields, teacher learning in communities of practice and the study of educational organizations (see Cochran-Smith, [this issue](#), for details). The first part of the paper uses institutional theory to unpack key dimensions of institutional logic, while the second part of the paper theorizes conceptualization and enactment of teacher preparation by examining four overlapping communities of practice. Looking at the AMNH MAT as a single case through these two lenses is a way to get at the relationships between its institutional structures and logics, on the one hand, and its program practices, pedagogies, and tools on the other. In the following section, we analyze the AMNH MAT's institutional environment.

The MAT program's institutional history, organizational flexibility, and historical contingency all reflect key aspects of its institutional logic, a concept that proves helpful here to unpack certain dimensions of the program's structure. Institutional theorists suggest that institutional logic is the "central logic that guides organizing principles and provides social actors with vocabularies of motive and sense of self" (Friedland & Alford, 1991; Thornton & Ocasio, 2008). Along these lines, scholars have identified capitalism, state bureaucracy, and political democracy (Alford & Friedland, 1985) as broad institutional logics, or "socially constructed patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" (Thornton & Ocasio, 1999, p. 804). From the perspective of institutional logic, broad institutions are regarded as "supraorganizational patterns of activity" (Friedland & Alford, 1991; Thornton & Ocasio, 2008) ordered by certain logics.

In this article, we suggest that the AMNH MAT was guided by an institutional logic that was both public and democratic. Here, we use the word "public" the way museums do, by referring to the publicly-funded, open-access nature of museums and their service to educate the general public of museum visitors. We use "democratic" to connote broader discourses that promote democratic society through equitable democratic education. In the next sections, we use Heinze and Weber's (2016) research on organizational change in medicine as a framework for unpacking the dimensions of institutional logic, including an

institution's economic system, sources of identity, and sources of legitimacy, that guide teacher preparation at the AMNH MAT. Heinze and Weber (2016) examine the development of pluralism among institutional logics in existing organizations by comparing two different medical models to reveal how new logics take root in incumbent organizations; using their framework helps us examine how the AMNH's democratic and public logic shaped decisions regarding the MAT program's funding, staffing, and regulation.

Funding model

The economic system of the AMNH MAT is most apparent in its funding model, which program leaders called a "hybrid model" of public grants and private donations (Interview #12, Administrator B). The MAT program is part of the larger not-for-profit AMNH organization, which is classified on its federal tax return as a "museum" with "other school-related activities;" as an educational organization that receives "a substantial part of its support from a governmental unit or the general public" (AMNH, 2018). In interviews, program leaders noted that the ongoing support of the program through public grants such as Race to the Top and the Teacher Quality Partnership program demonstrated that the MAT program was regarded as responsive to public needs. In turn, this high-profile *public* support enabled the leaders of the AMNH MAT to appeal to the deep tradition of localized *private* philanthropy in New York by demonstrating that they were aligned with a local need for teacher quality.

As one program leader noted, AMNH is "a high visibility institution within th[e] landscape" of New York philanthropic giving (Interview #11, Administrator A). Another leader noted, "There are a variety of different types of philanthropic sources that are very interested in improving teacher quality" (Interview #12, Administrator B). Program leaders expressed confidence that their financial model would remain viable as long as the need to prepare earth science teachers for high-needs schools existed in New York State, even though the program was, in the words of one leader, "a huge revenue sink" (Interview #11, Administrator A). The underlying public logic of the AMNH MAT was evident in several aspects of the funding model: the program focused on preparing teachers for high-needs schools, measured outcomes in terms of educational impact, and prided itself on public appeal. These aspects of the funding model deemphasized financial profitability—or even viability—in favor of a logic that rewarded public accountability, service, and social impact.

Sources of identity

Heinze and Weber's (2016) second dimension of institutional logic, sources of identity, is helpful for considering the MAT program's physical location and staffing arrangements.

The spaces and places where residents and faculty spent their time as part of the MAT program were by definition public in nature. During the school year, teacher candidates spent four days a week in high-needs public schools in New York City and Yonkers, working with mentor teachers while supervised by what AMNH MAT uniquely referred to as “senior specialists,” who are instructors, liaisons, advisors, and coaches. On Fridays, residents and program faculty convened at the AMNH for classes during which the residents regularly explored the museum’s exhibits and collections alongside members of the general public. During the two summer residencies that were central features of the AMNH MAT – one at the beginning and one at the end of the 15-month program – candidates spent time engaging members of the general public in the museum’s exhibits, teaching free summer courses for local public school students, and conducting original science research at public locations, including Central Park and nearby Black Rock State Forest. The physical and cultural immersion in some of New York’s most iconic public buildings and spaces represents a key part of the MAT program’s institutional identity.

Another crucial aspect of the AMNH MAT’s identity was the expertise of its faculty. All the educators who designed MAT program activities and taught courses held doctoral-level degrees either in education fields, such as curriculum studies and science education, or in earth science fields, such as geology, meteorology, and oceanography. Doctoral-level teacher educators taught or co-taught pedagogy, curriculum, or science content courses, supervised candidates in schools, and worked with school-based educators, drawing on their expertise and experience teaching in public schools, museums, and universities. The primary responsibility of the museum scientists who were involved in the AMNH MAT was not educating teachers but conducting original field research and curating world-renowned educational exhibits for the general public in order to promote knowledge of science in society. However, these curators also contributed to the MAT program by co-teaching courses with teacher educators. This unique staffing arrangement reflected the preparation program’s emphasis on expertise in earth science knowledge and research coupled with knowledge of pedagogy.

With respect to location and staffing, the MAT program also reflected the larger identity of the museum and its commitment to creating and maintaining publicly-accessible places that afforded open access to bodies of knowledge that support public consumption of science. Along these lines, a senior administrator noted the historical importance of the public schools as “an incubator for young scientists” to contextualize the AMNH MAT’s mission to “create the next generation of scientists . . . but also to have citizens who accept that you should listen to science for good reason” (Interview #11, Administrator A). At the center of the MAT program were people and places dedicated to the production and consumption of the kind of scientific literacy and knowledge that were presumed to be necessary for a democratic society. However, the

belief that was perhaps *most* indicative of the program's identity and its public and democratic logic was its leaders' comfort with teacher preparation not necessarily being a "permanent activity" (Interview #12, Administrator B; Interview #13, Administrator C) at the museum. As leaders noted, the program was "started to address a need that is considered to be temporal and contextual," and therefore subject to change (Interview #12, Administrator B; Interview #13, Administrator C). Although program leaders did not expect the teacher shortage in high-needs schools to diminish in the near future (Interview #11 Administrator A), their goal was to help eradicate the problem that made the MAT program necessary. In other words, the program was guided by what leaders believed was best for an equitable society, not by the program itself.

Sources of legitimacy

The final dimension of institutional logic drawn from Heinze and Weber (2016) has to do with an organization's externally-recognizable legitimacy established through regulation and accreditation. For the AMNH MAT, sources of legitimacy included local affiliations, external accreditation, and approval from regulatory agencies. Together, these associations lent external recognizability and legitimacy (Scott, 2008) to the MAT program and, at the same time, underscored the program's public and democratic logic.

Affiliation with long-established organizations and institutions lent legitimacy through association to the museum's young MAT program. Here it is important to restate that the MAT program was not simply *affiliated* with the AMNH, it was literally *embedded* in the museum's physical infrastructure. The RGS was physically retrofitted above the museum's publicly-accessible halls among the storage spaces for the museum's millions of specimens and cultural artifacts. Program offices were located in the annals of the museum, accessible only through the iconic Margaret Mead Hall of Pacific Peoples. Residents in the MAT program took classes in the Kathryn Davis West education room, but they also conducted observations in the Gottesman Hall of Planet Earth. Placing residents in public exhibits to practice scientific observation enhanced the program's curricular legitimacy because, as one senior administrator said, "There's immense emotional power in real things" (Interview #11, Administrator A). When teacher residents were not physically at the museum, they were in New York City's historically diverse public schools interacting with teachers and students. Partnering with high-needs New York City and Yonkers schools emphasized that part of the MAT program's legitimacy was that it served the public good.

Programmatic and state accreditation also contributed to the program's external legitimacy. The AMNH MAT is recognized by the National Science Teachers Association. In addition, like two other nGSEs (TEACH-NOW and Relay)

(Cochran-Smith et al., 2020), the AMNH MAT sought national programmatic accreditation from the Council for the Accreditation of Educator Preparation (CAEP) as a way to establish organizational legitimacy as a newcomer to the field; CAEP accreditation was granted in 2019. In addition, program leaders regarded the program's recognition from competitive and prestigious grant makers as "a kind of seal of approval, a high-quality seal of approval" that enabled the program to garner attention and support from funders, competitors and prospective candidates (Interview #12, Administrator B).

Taken together, affiliations, accreditations, and regulatory agencies reflected the efforts of the AMNH MAT to secure legitimacy in ways that were recognizable and prestigious in the larger organizational field of teacher education. Institutional aspects of the MAT program, such as the funding model, staffing arrangement, physical spaces, and external affiliations were consistent with the larger institutional and programmatic logic that emphasized public accessibility and democratic accountability. It was clear that MAT program leaders knew they had the support of the museum's senior most administration in undertaking teacher preparation. In interviews, program leaders characterized the museum's directors as believing, "teacher education ... [is] the most important thing we can do" (Interview #12, Administrator B). Overall, our analyses suggest that the program was conceptualized as a "natural outgrowth" of the museum's not-for-profit, public educational mission (Interview #11, Administrator A).

Learning to teach at the AMNH MAT program

We now turn to questions related to how AMNH MAT program leaders conceptualized and enacted the project of learning to teach. Building upon the public and democratic institutional logic of the museum, the program's approach to learning to teach incorporated four different learning communities within its unique museum and school-based residency model.

Conceptualizing the project of learning to teach

Our analysis of observations, interviews, and program documents suggested that there were several key beliefs and values, consistent with the museum's institutional logic, that guided the way program leaders conceptualized the project of learning to teach that animated the MAT program. One key belief, outlined in a chapter written by a group of museum and program faculty themselves, was that learning to teach science occurs in both formal settings, such as schools and classrooms, and in "authentic and participatory" informal settings, such as museums, zoos, and aquariums (Gupta, Trowbridge, & Macdonald, 2016, p. 178). Based on this belief, MAT program developers built many museum affordances into their coursework, including interactions

with museum curators, artifacts, exhibits, and dioramas. They felt that earth science teachers should develop identities not simply as schoolteachers, but as teachers of science (Gupta et al., 2016).

Secondly, MAT program leaders conceptualized learning to teach as a practice-oriented endeavor. A very clear example is the model of teacher preparation utilized by the MAT program – the urban teacher residency (UTR). This is an innovative approach to teacher preparation that combines coursework with engaging candidates in prolonged and rich classroom experiences working alongside experienced mentor teachers (Berry, Montgomery, & Snyder, 2008). As noted above, the AMNH MAT added considerably to the typical features of UTRs by requiring four residencies over the course of the 15-month program – two five-month school residencies in two different urban schools during the school year and two science residencies, one in the museum itself during the first summer of the program and one at an earth science research site during the second summer.

MAT program leaders and faculty also believed that an essential part of learning to teach was having a rich understanding of scientific knowledge. Along these lines, a teacher educator and co-founder of the MAT Program noted: “We place a high premium on expertise here” (Interview #3, Teacher Educator D). The program’s emphasis on scientific expertise was evident in many ways: the candidates recruited for the program were qualified in science content; PhD level, world-known museum curators co-taught courses with PhD or EdD level science teacher educators; science content courses on topics such as the solar system comprised half of the program’s coursework; and, program residents’ culminating projects were based on scientific field research that they conducted.

Finally, program leaders worked from the assumption that learning to teach is a social process, best accomplished in communities. One faculty member pointed out that teaching itself could be isolating: “Teachers have always been left alone in their room . . . we all know that’s not a very effective way to have someone grow and change and develop . . . we learn best from others” (Interview #7, Teacher Educator H). This belief was instantiated in many programmatic features including monthly-meet ups for residents and mentors, multiple and varied collaborative assignments, and regular induction meetings at which new teachers shared experiences.

Enacting the project of learning to teach

Our analysis revealed that AMNH MAT was a complex enterprise guided by the values outlined above. To examine how program leaders and faculty enacted teacher preparation, we use the concept of “communities of practice,” generally understood as “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). Communities of practice,

formed intentionally or unintentionally, are made up of practitioners with a shared area of interest who engage in joint activities to learn together with other participants, ultimately developing a shared repertoire of routines, strategies, and tools based on sustained interaction.

The leaders of the AMNH MAT enacted teacher preparation by placing residents at the nexus of four communities of practice: the community of residents in the program cohort, the community of practicing scientists, the community of what they referred to as “good science teachers,” and the community of New York City teachers, students, and schools. Together, these four communities created what Wenger-Trayner and Wenger-Trayner (2015) call a “living curriculum,” which means that 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 well as in the context of the learning experiences they had within and across communities of practice. The goal here was to generate a living curriculum that emphasized not only the importance of engaging with each other in the process of learning to teach, but one that also stressed the value of deep science content knowledge and research experience for the development of “good science teaching” in high-needs secondary classrooms.

Wenger (1998) suggests that there are three unique characteristics that make learning in a community of practice coherent: mutual engagement, joint enterprise, and shared repertoire. He also suggests that brokering by more experienced community members is necessary for beginners to make connections across communities. Each of the four communities of practice in which the MAT program residents participated can be theorized using Wenger’s characteristics. Given space limitations, however, in this article we zero in on each community of practice through the lens of one of Wenger’s characteristics.

The program cohort community: Mutual engagement

Reflecting its commitment to learning in communities, the MAT program utilized a cohort model, wherein residents remained together as a single, identifiable group that completed many aspects of the program together. According to its leaders, the program “aim[s] to attract individuals who are expert in earth and related sciences” and who come from diverse backgrounds. Consequently, the cohort was what Wenger (1998) called a “medley of people” (p.75) whose perspectives interacted to enrich the practice of learning to teach. Mutual engagement, a cornerstone of a community of practice, involves learning that occurs because “people are engaged in actions whose meanings they negotiate with one another” (Wenger, 1998, p. 73).

To illustrate, we focus on the Summer Science Institute peer feedback session, which occurred during the cohort’s first summer at the museum. During the institute, residents taught a day-long learning experience for museum youth immediately followed by feedback from peers. The 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 important thing was that because the MAT program created the space for beginning educators to negotiate the meaning of “good science teaching” together, 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). Residents were also encouraged to disagree and challenge each other’s perspectives, which led to richer conversations. Throughout the program, the cohort functioned as a community of practice wherein members were mutually engaged in connecting meaningfully to the knowledge and contributions of each other. Feedback sessions helped residents gain a deeper understanding of how to engage their students in science learning *because* the residents themselves were mutually engaged in learning from their own differences.

The community of practicing scientists: Joint enterprise

Because scientific expertise was central to the MAT program, residents often engaged with the museum’s curators and scientists in the enterprise of scientific research. 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 B). Wenger (1998) suggests that the joint enterprise of communities of practice is “their negotiated response to their situation and thus belongs to them in a profound sense” (p.77). As one museum curator who taught in the MAT program pointed out: “The integration with real practicing scientists is probably what sets [the program] apart . . . they’re actually looking at how science is done” by coming “up against the edge of knowledge” and gaining “a deep understanding [that] there isn’t a right answer” (Interview #2, Scientist A).

To encourage residents to work as practicing scientists, methods and content courses were co-taught by a museum scientist and a teacher educator. In a course on weather and climate change, for example, small groups explored how living organisms both alter and are altered by climate by using a simulation model with real data (Observation #1a). 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 #2, Scientist A). Wenger’s (1998) idea of joint enterprise as a central characteristic of communities of practice 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). The pedagogies used by the instructors in the MAT program imbued the residents with a sense of membership in the

community of practicing scientists who deal with the complex world of earth science where single right answers rarely exist.

The community of good science teachers: Shared repertoire

The MAT program offered many opportunities for residents to practice what AMNH MAT faculty referred to as “good science teaching,” which included using specific strategies such as “eliciting student responses” and “constructing scientific explanations.” (Observation #12). Wenger (1998) argues that over time, the joint enterprise of communities of practice creates resources that help participants negotiate meaning, such as routines, words, ways of doing things, stories, genres, discourse, actions, or concepts. These become the “shared repertoire” of the participants.

The MAT program used four key tools and assessments that exemplified its vision of good science teaching, and in turn helped residents develop a shared repertoire of practice: the Dispositions Continuum for Teaching and Learning Tool (Document #43), the AMNH Lesson Plan Tool (Document #44), the AMNH Unit Plan Tool (Document #45), and the AMNH MAT Observation Rubric (Document #42). The beliefs of the program faculty about what constitutes good science teaching were crystallized in the AMNH MAT Observation Rubric. In fact, this tool was pervasive in the program to concretize good science teaching, especially for observations of teaching either in the museum setting or in the school residencies. The Observation Rubric is a 19-page document with seven multipronged criteria of good science teaching. This expansive document includes 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 includes 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” (Document #42).

The Observation Rubric was the focus of a three-hour workshop that introduced residents to what program leaders and mentors considered to be the shared repertoire of good science teaching. The purpose of this session was to introduce the criteria of the Observation Rubric. During the workshop, residents had the opportunity to connect rubric criteria 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).

Importantly, as with many of the activities in which the residents participated, the activity described above 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). The MAT program invited its residents to form their identities as members of the community of good science teachers by utilizing

a shared dialogue. The MAT program deliberately built in a designated shared repertoire, which included ways of talking about, thinking about, and assessing their own lessons.

The community of New York City teachers, students, and schools: Brokering

As we have shown so far, the residents in the MAT program learned to teach through their membership in the intersecting communities of the MAT cohort, practicing scientists, and good science teachers. Residents were also socialized into the community of New York City teachers, students, and schools by spending four days a week in middle or secondary classrooms working with their earth science teacher mentors. Residents' practice-centered learning was facilitated by what the program called "senior specialists." It is important to point out here that the role of senior specialist is unique to the AMNH MAT, involving a much more extensive process of advising, coaching, and instructing residents than that offered by some university-based or non-university based urban teacher residencies. These two faculty members not only are PhD-level science educators who serve as instructors, but they also spend a significant amount of time in the school residencies observing the residents teach, coaching them in debriefing sessions, facilitating monthly meetings with mentor teachers and AMNH MAT residents, and overall "brokering" resident learning between and within their multiple communities of practice as they engage in the learning to teach experience. Senior specialists used the AMNH MAT Observation Rubric to observe resident-taught lessons and to debrief afterward. The monthly meet ups facilitated by the senior specialists focused on connecting science teaching practices introduced in courses to the pedagogical decisions and instructional activities that actually happened in classrooms, all of which were connected to New York State science learning standards and Next Generation Science Standards.

Wenger (1998) argues that members of a community of practice, particularly apprentices, need help from "brokers" to make connections from one component or characteristic of practice to another. In the case of the AMNH MAT, this term can be broadened to include the many ways in which the senior specialists helped the residents broker their learning both within and between communities of practice. For instance, senior specialists brokered the expectations, terminology, and context of New York City schools by helping residents connect them to the program's tenets of good science teaching. After one resident taught a lesson on contour maps in a tenth grade earth science course, the senior specialist focused on three of the AMNH MAT Observation Rubric criteria to make the point that more scientific terminology should have been explicitly taught to the students and that modeling should have been used as a strategy. Through the debriefing session, which was brokered by the senior specialist, the resident was able to make the connection between the key science teaching practices emphasized in the MAT program and her own

teaching experience in a NYC school (Observation #15). As Wenger (1998) asserts, “The job of brokering . . . involves processes of translation, coordination, and alignment between perspectives” (p.109). Senior specialists worked across the MAT academic courses and the residencies to connect the core aspects of each of these communities of practice for the residents as they entered into the community of NYC teachers, students, and schools.

As we have shown in the previous two sections, the specialized purpose of the AMNH MAT is to prepare earth science teachers who are committed to promoting quality educational experiences for students in New York State’s high-needs public secondary schools in keeping with the museum’s larger institutional goals and logics. The program’s purpose is an outgrowth of the bedrock democratic principles of the museum, as an historic public institution, whose efforts to bring science to the public stretch back over a hundred years. Along these lines, the museum’s MAT program has generally been well-received. In the final section below we comment on reactions and responses to the AMNH MAT in the context of reactions to teacher preparation programs at other nGSEs.

Reactions and responses to the AMNH MAT program

As the introductory article of this special issue shows (Cochran-Smith, [this issue](#)), the emergence of teacher preparation at nGSEs has prompted extremely mixed reactions in both popular and professional outlets over the last decade. In particular, nGSE teacher preparation programs that grew out of charter schools, that rely on school-based teachers without PhDs as faculty members, and that emphasize narrow and highly-prescribed teaching methods have been excoriated as part of the larger neoliberal “ed reform” movement that emerged in the 1990s to radically disrupt public education (and teacher education) to make room for “innovative” market-based reforms (Anderson, 2019; Philip et al., 2018; Zeichner & Pena-Sandoval, 2015).

Interestingly, the AMNH MAT has escaped criticism to a large extent, in part because the criticisms above are simply not relevant to the AMNH MAT. To the contrary, the MAT program is located in one of New York’s “beloved museums” (Quenqua, 2012), and it has received a great deal of positive attention. This positive response notwithstanding, there have been some mixed reactions to the MAT program, which speaks to the highly controversial nature of the phenomenon of teacher preparation at nGSEs. For example, as one of the founders of the MAT at AMNH noted (Interview #13, Administrator C), some university-based teacher educators in New York initially took issue with the fact that in 2011 the state awarded high-profile Race to the Top funds to two non-university start-up teacher preparation programs, one of which was the AMNH MAT. The *New York Times* (Otterman, 2011) covered this controversy in terms of the new landscape of

local independent teacher preparation programs in New York, naming Relay GSE and the AMNH MAT program as part of a nationwide shift toward independent and school-based preparation programs. Since that time, however, the *Times* has also published multiple flattering portraits of the AMNH MAT emphasizing the program's mission to serve local high-needs schools and the unique affordances of museum-based science teacher preparation (Pogrebin, 2015; Quenqua, 2012).

Interestingly, the press coverage of the AMNH MAT almost always zeroes in on its funding, including the Race to the Top funds it garnered and the substantial candidate funding package the museum offers to its residents, which is made possible by generous private grants as well as federal funds. As we have noted, our intention in this special issue of *The New Educator* is to present an even-handed discussion of teacher preparation at nGSEs, including reactions and responses. In this spirit, it is important to note that on one hand, the AMNH MAT program has received plenty of attention in New York City and state. Most of this has been praiseful, including applause for the museum's largesse in addressing the shortage of earth science teachers in New York (Quenqua, 2012) and for the MAT program's "distinguished faculty" (Education Update Online, 2018). On the other hand, there has been rigorous critique of the general shift in private and public funds away from teacher preparation in universities and toward supporting preparation in non-university private and public settings (Anderson, 2019; Cochran-Smith, [this issue](#); Zeichner & Pena-Sandoval, 2015).

Another concern about the AMNH MAT is one that our research team has heard at conferences and during presentations wherein we have described our research-in-progress about teacher preparation at nGSEs. Although we have not seen these issues in print, we sometimes hear concerns about the expenditure of vast resources on such a small program, which is not scalable as a strategy to improve teacher preparation writ large. Part of this critique is that other preparation programs cannot emulate the costly and allegedly unsustainable practices of the AMNH MAT, such as the interdisciplinary co-teaching model and the attractive stipend for teacher candidates. Some university teacher educators have wondered whether investing so much private and public money in what they refer to as a "boutique" program that serves a small cohort is appropriate, given the much larger number of teacher candidates prepared each year in public and larger university programs.

Again, in our effort to be even-handed, we emphasize that although relatively small in numbers, the AMNH MAT actually prepares a substantial portion of the earth science teachers in the state of New York. In addition, as we note above, MAT program leaders do not regard the program as a permanent activity of the museum or as one that is necessarily intended to be replicable by other museums, although they note that other museums could choose to develop teacher preparation if they were willing to address issues of

accountability. Rather AMNH leaders make clear that the museum entered the field of teacher preparation because doing so was consistent with the public and democratic mission and logic of the museum while also meeting an urgent need in the city and state. They perceived the MAT program not as a money maker for the museum (and, in fact, it is the opposite), but as a public service that exists to help meet a local need, which is subject to change if and when historical circumstances change.

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