A Balancing Act in the Third Space: Graduate-Level Earth Science in an Urban Teacher-Residency Program

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ABSTRACT

This article describes a museum-based urban teacher-residency (UTR) program's approach to building subject-specific content knowledge and research experience in Earth Science teacher candidates. In the museum-based program, graduate-level science courses and research experiences are designed and implemented specifically for the UTR by active Earth and Space research scientists that account for almost half of the program's faculty. Because these courses and research experiences are designed specifically for the teacher candidates, they are different from many science courses and research experiences available to preservice teachers in a university setting. At the same time, the museum-based program is the only UTR, to our knowledge, to incorporate such a rigorous science curriculum, and this article considers some possible advantages and disadvantages of the program's approach. Because the museum-based program's science curriculum is balanced against the educational coursework and teaching residencies that necessarily form the program's backbone, the museum's approach to strengthening the teacher candidate's science background may also inform the faculty and administration of other UTRs in cases in which one of their program goals is to further expand their teacher candidate's content knowledge and practical subject matter experience. [DOI: 10.5408/14-058.1]

Key words: urban teacher residency, Earth Science teacher preparation, science course work for teachers, research experience for teachers

INTRODUCTION

In the United States (U.S.), urban teacher residencies (UTRs) have been called a "third way" (Berry et al., 2008a) or "third space" (Klein et al., 2013) in teacher preparation because they bring together positive aspects of traditional and alternative models but exist in a space outside of these two routes. A specific UTR is typically conceived with the needs of a particular school district or school districts in mind (Berry et al., 2008b). The UTR will then go about recruiting talented candidates, who typically have a college degree or career in the subject area they intend to teach, for the purpose of training them to be effective teachers through an interwoven mixture of graduate-level education coursework and mentored, clinical teaching experience (Berry et al., 2008a, 2008b). This training takes place in a relative short amount of time (<16 mo), meaning that teacher-candidate residents in UTRs undergo an intensive curriculum. To facilitate a professional learning community and foster lasting collaborations, teacher candidates in UTRs are trained in cohorts, receive stipends, and are supported in a professional-development capacity once they are hired as teachers of record upon leaving the program (Berry et al., 2008a, 2008b; Solomon, 2009 Coffman and Patterson, 2014). Strictly speaking, the UTR model is a relatively new and largely untested approach; to specify, the first UTR was founded in 2001 (Jagla, 2009), and as of April 2014, there had only been fewer than 3,000 graduates from the approximately 30 UTR programs in existence (Urban Teacher Residency United [UTRU], 2014). For comparison roughly 200,000 new teachers are entering the profession each year in the U.S. via all routes combined (Feuer et al., 2013).

Although there is variability across the structure and curriculum of individual UTRs (Berry et al., 2008a, 2008b; UTRU, 2014), nearly all have university partners. An exception is the American Museum of Natural Histories' (AMNH) Master of Arts in Teaching (MAT) UTR pilot program. This UTR was created to address a shortage of certified Earth Science teachers in the New York State (NYS) high-needs public schools and is the first museum-based UTR (Kinzler et al., 2012; Nadeau et al., 2013a; Kinzler and Macdonald, 2014). Another unique aspect of the AMNH-MAT program is that approximately one-half of its faculty consists of active research scientists in various Earth and Space Science disciplines at career-levels from postdoctoral to nearing emeritus. This science faculty is responsible for designing and implementing graduate level science courses and a research practicum that constitute approximately one-half of the AMNH-MAT program's curriculum and that are in addition to the educational course work and clinical teaching experience that are the backbone of other UTR programs. These science courses and research practicum are explained more fully in the program description that follows, but it is important to emphasize here that, although both include a pedagogical component, they are built around the level of scientific inquiry that would be expected of someone pursuing an MS degree in an Earth or Space Science field. However, because they are designed specifically for the teacher candidates in the UTR, they are also different from the upper-level science courses and research experiences typically available to teacher candidates in a university setting.

The relatively large amount of graduate-level scientific work in the AMNH-MAT program constitutes an as-yet untested approach in UTR teacher preparation. The impetus for making this science curriculum a large part of the

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AMNH-MAT program is that it would hopefully serve to expand and deepen the teacher candidate's knowledge and understanding of Earth Science ultimately making them better teachers (Kinzler et al., 2012). The effectiveness of this approach will ultimately be tested by examining student performance under graduates from the AMNH-MAT in relation to student performance under teachers from UTRs without a rigorous science curriculum. However, this will require several years of student performance data that are not currently available because the program is still in its pilot phase—the first AMNH-MAT cohort graduated in August 2013. The primary purpose of this article is, therefore, to describe the AMNH-MAT program's science curriculum with an emphasis on the programmatic mechanisms in place to balance science and pedagogy. The article then discusses some possible advantages of the AMNH-MAT approach to science, and finally, the article considers how the program might be replicated in other nonmuseum-based settings.

THE AMNH-MAT PROGRAM: BACKGROUND, STRUCTURE, AND FACULTY ROLES

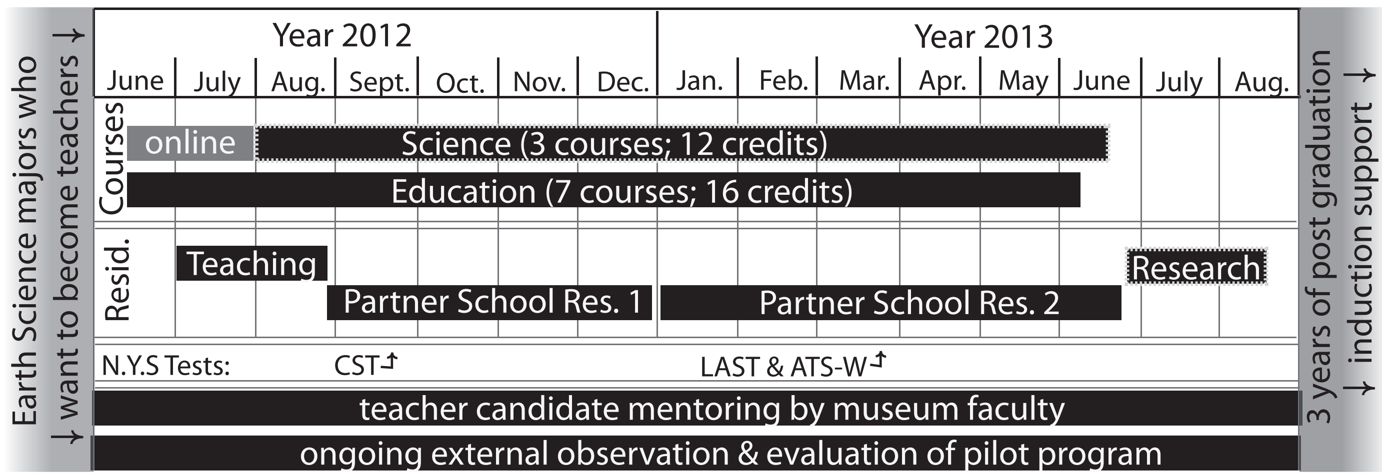
The 15-mo-long AMNH-MAT pilot program (Kinzler et al., 2012; Nadeau et al., 2013a; Kinzler and Macdonald, 2014) is certified by the NYS Education Department and Board of Regents to grant the MAT degree, and graduates of the program achieve initial NYS Earth Science certification via the "approved teacher preparation program" pathway. The pilot program is funded by a grant from the NYS Department of Education and a private donor (Kathryn W. Davis) to prepare 50 Earth Science teachers in two cohorts over 3 y. Teacher candidates in the AMNH-MAT program receive a tuition waiver and a $30,000 stipend but are required to make a signed commitment to teaching in high-needs public schools in NYS for a minimum of 4 y following graduation. To be considered for admission into the AMNH-MAT program and, per NYS requirements for initial certification, applicants must be U.S. citizens or legal residents, have either a BS degree in Earth Science or a related field, or a bachelor's degree in some other discipline with 24 credit hours in Earth Science and 6 additional credit hours in physics, chemistry, environmental science, or biology, and have a minimum GPA of 3.0. Many of those admitted have science course work (including graduate level), research experience, professional experience, and other skills beyond the eligibility requirement. Those with prior education degrees are not eligible for the program, but formal and informal teaching experience is commonplace among those admitted to the program.

In keeping with the residency model, all of the teacher candidates within a cohort follow the same path through the AMNH-MAT program (Fig. 1a). Formal mentoring for the teacher candidates is built into the program so that it occurs throughout the program and during a 2-y induction period following graduation. The 15-mo program is broken into three distinct residencies that run sequentially (5 credit hours each), with educational and scientific course work occurring continuously throughout the program. The first residency is 6 wk long, and during it, candidates gain museum-based teaching experience working as teaching assistants in the AMNH's existing youth initiatives and public outreach programs. The second residency is 10 mo long and is where the candidates gain student teaching experience working with a mentor teacher in the AMNH-MAT program's high-needs, low-achieving partner schools in the NYS and Yonkers school districts. During this residency, candidates typically spend Monday to Thursday at the partner schools and on Fridays and some Saturdays are at the museum taking classes all day. Following completion of this second residency, the teacher candidates embark on the 7-wk museum-science practicum residency. This practicum residency and the science course work, are further described below because these two elements of the program are the primary focus of this study. First, however, is an outline of the AMNH-MAT program's faculty structure.

The faculty structure of the AMNH-MAT program is unique and complex. This complexity is due in part to its drawing together a myriad of career educators and research scientists from the AMNH, as well as faculty and disciplinary experts from other institutions to prepare the teachers. Simply put, the AMNH-MAT academic faculty is composed of the program codirectors, scientific curators, senior specialists in teacher preparation (Contino and Cooke-Nieves, 2013), postdoctoral research and education fellows (Flores et al., 2012; Nadeau et al., 2012; Zirakparvar et al., 2013), and program adjuncts (Fig. 1b). The science courses and research practicum are designed and implemented by the postdoctoral fellows and curators. This unique partnership is described in Nadeau et al. (2012), Flores et al. (2012), Zirakparvar et al. (2013), and Zirakparvar (2014), but it is important to mention that both the curators and postdoctoral fellows have their own scientific research agendas, independent of the MAT program. The expectation, however, is that the teacher candidates gain exposure to the scientist's discipline specific expertise through the science courses and research practicum. Figure 2 is a schematic representation of how the various faculty contribute to the preparation of the teacher candidates over the duration of the program, with the various faculty roles defined in Fig. 1b.

THE AMNH-MAT PROGRAM: SCIENCE CURRICULUM

One unique aspect of the AMNH-MAT program is that its very inception represents a partnership between scientists and educators (Kinzler et al., 2012; Nadeau et al., 2012, 2013a; Pagnota et al., 2012). In this way, equipping the teacher candidates with a depth and breadth of scientific knowledge well beyond that which they need to pass NYS-level, content certification exams for their initial teaching certificates (in the case of AMNH-MAT cohorts 1 and 2, the Content Specialty Test [CST]) and subject-specific credit-hour certification is one of the program's goals. This is accomplished by giving active research scientists wide latitude in developing and implementing three, four-credit science courses and the research practicum. Although, as described in the next section, this wide latitude is not without boundaries. Additionally, an educator (either a senior specialist [Contino and Cooke-Nieves, 2013] or another AMNH-based PhD-level educator with teaching experience in a grades 7–12 classroom) is part of the teaching teams for the science courses and research practicum to guide the candidates in thinking about the graduate-level science within the framework of their own growing pedagogical knowledge. However, the depth of the topics, and sometimes the topics themselves, covered in the a



b

Title	Description of role in the AMNH-MAT program	Universal roles
co-director (n = 2)	Full program executive priveleges and responsibilities. Oversees all aspects of the program. Teaches courses and advises candidates. Oversees regular faculty meetings, reports to museum leadership.	-review of applications to AMNH-MAT program -prepare reports to external evaluators & board of advisors -perform cross-program curriculum and workload alignment -report to bimonthly full faculty meetings
senior specialist (n = 5)	Primary liason between AMNH and the partner schools. Co-teaches science and education courses. Advises candidates.	
postdoctoral fellow (post-doc) (n = 7)	Appointed to conduct scientific research (65%) at AMNH and support the MAT program (35%). Teaching post-docs (n = 3) co-teach science courses with curators and education faculty whereas practicum post-docs (n = 4) design and implement the summer two research practicum with curators and a senior specialist. The practicum postdocs also visit the partner schools in an educational outreach capacity.	
curator (n = 7)	Tenured museum scientists. Each curator works closely with a post-doc on scientific research. Curators also co-teach the science courses and particpate in the implementation and design of the summer two research practicum.	
administrative staff (n ~ 5)	Teachers at the AMNH-MAT partner schools who have been selected to mentor the candidates while they are student teaching. These mentor teachers particpate in professional development related to being mentors as part of the MAT program and work closely with the senior specialists in mentoring the candidates.	
adjunct and 'other' faculty (n > 10)	Perform a variety of roles including co-teaching education courses, technological support for the candidates, facilitating the summer one museum teaching residency, aiding with induction and professional development, candidate advising, supporting the summer two research practicum, etc.	
mentor teacher (n > 10)	Teachers at the AMNH-MAT partner schools who have been selected to mentor the candidates while they are student teaching. These mentor teachers particpate in professional development as part of the MAT program and work closely with the senior specialists in mentoring the candidates.	

FIGURE 1: (a) Generalized diagrammatic representation of the AMNH-MAT program timeline. This study is focused on graduate-level science courses (SCI 665, SCI 670, and SCI 675), which run sequentially, and the two summer research practicums. These elements of the program are highlighted by dashed lines on this figure and are also described in more detail in the text. (b) Description of faculty roles in the AMNH-MAT program.

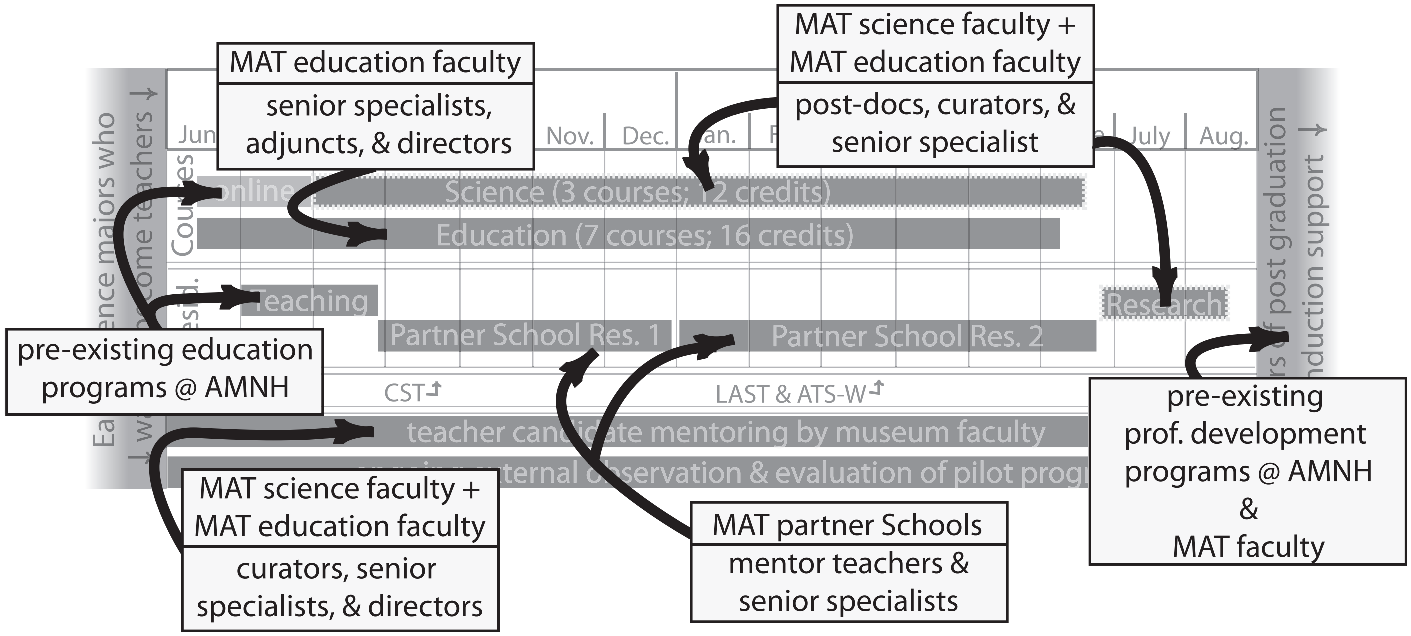


FIGURE 2: Schematic representation of how the various program faculty members contribute to the preparation of the teacher candidates. This representation is superimposed onto the program timeline depicted in Fig. 1a. Each of these faculty roles are defined in Fig. 1b.

courses and research practicum are not always directly related to the NYS Earth Science curriculum. This is because the NYS Earth Science curriculum is more general than the highly specific graduate-level Earth Science inquiry.

Each of the four-credit science courses (SCI665: Space Systems, SCI670: Earth Evolution and the Earth System, and SCI675: Weather, Climate, and Climate Change), which do not overlap but run sequentially (Fig. 3a), are cotaught by a museum curator, one or two postdoctoral research and education fellows, and a senior specialist. There are also two online science courses taken by the candidates at the start of the program (SCI651: Earth Inside and Out: Dynamic Earth Systems, and SCI652: The Solar System: Earth and Space Science), and a "swing" course (EDU/SCI660: Earth Science Literacy Journal Seminar), which are not discussed further in this article because they are not taught by active research scientists. For SCI675, SCI670, and SCI675, course meetings occur over nine 4-h sessions (Fig. 3a). Three hours of each session are typically a mixture of discourse-style lectures on a scientific topic and a graduate-level scientific-learning activity led by the curator and postdoctoral fellow. One hour of each session is usually devoted to the pedagogical application component, led by the education specialist (Fig. 3a). For these three courses, there are semester-long term projects, weekly assignments, online discussions, and readings related to both the scientific and pedagogical components. These three courses are not "methods" courses because their primary purpose is not to teach the candidates how to teach content. Instead, they are primarily designed as graduate-level science courses where one-quarter of the course time is devoted to pedagogy.

Following completion of the SCI665, SCI670, and SCI675 courses (the graduate-level science course work, or GSCW), the teacher candidates begin the seven-week long museum science research practicum residency (The clinical experience in the practice of science, or CEPS; Fig. 1). This residency is described in Nadeau et al. (2013b). The science practicum is led by a team of five curators and four postdoctoral fellows with expertise in various subdisciplines of geology, astrophysics, and paleontology. During the course of the practicum, the candidates work, in subdisciplinary groups led by these scientists, on a research project culminating in a final presentation and paper (Fig. 3b). These lectures are modeled after the type of talk given at a professional meeting and the type of manuscript that could be submitted to a scientific journal. All of the projects incorporate an aspect of hypothesis development, field and laboratory data acquisition, and preparation and revision of the final deliverables—all under close (8+ h/d) mentorship of the postdoctoral fellows and curators. Each project is, however, tailor-made for the research practicum. Therefore, the practicum is different than a research apprenticeship (e.g., Brown and Melear, 2007), or similar experience in which the teacher candidate participates in a scientist's ongoing research. There is a pedagogical component of the practicum focused on relating the practicum experience to future classroom practice, but, similar to the three science courses (SCI665, SCI670, and SCI675), the practicum is focused on graduate-level science work. Another component of the practicum involves taking the entire cohort to a variety of geologic outcrops and sites of interest where the candidates are encouraged to collect samples that will ultimately become part of their own teaching collections. These day trips happen throughout the research practicum experience and are tied to individual research projects.

THE AMNH-MAT PROGRAM: BALANCING SCIENCE AND PEDAGOGY

Even though the AMNH-MAT program science courses and research practicum take up roughly one-half of the program's total credit hours, this aspect of the program is

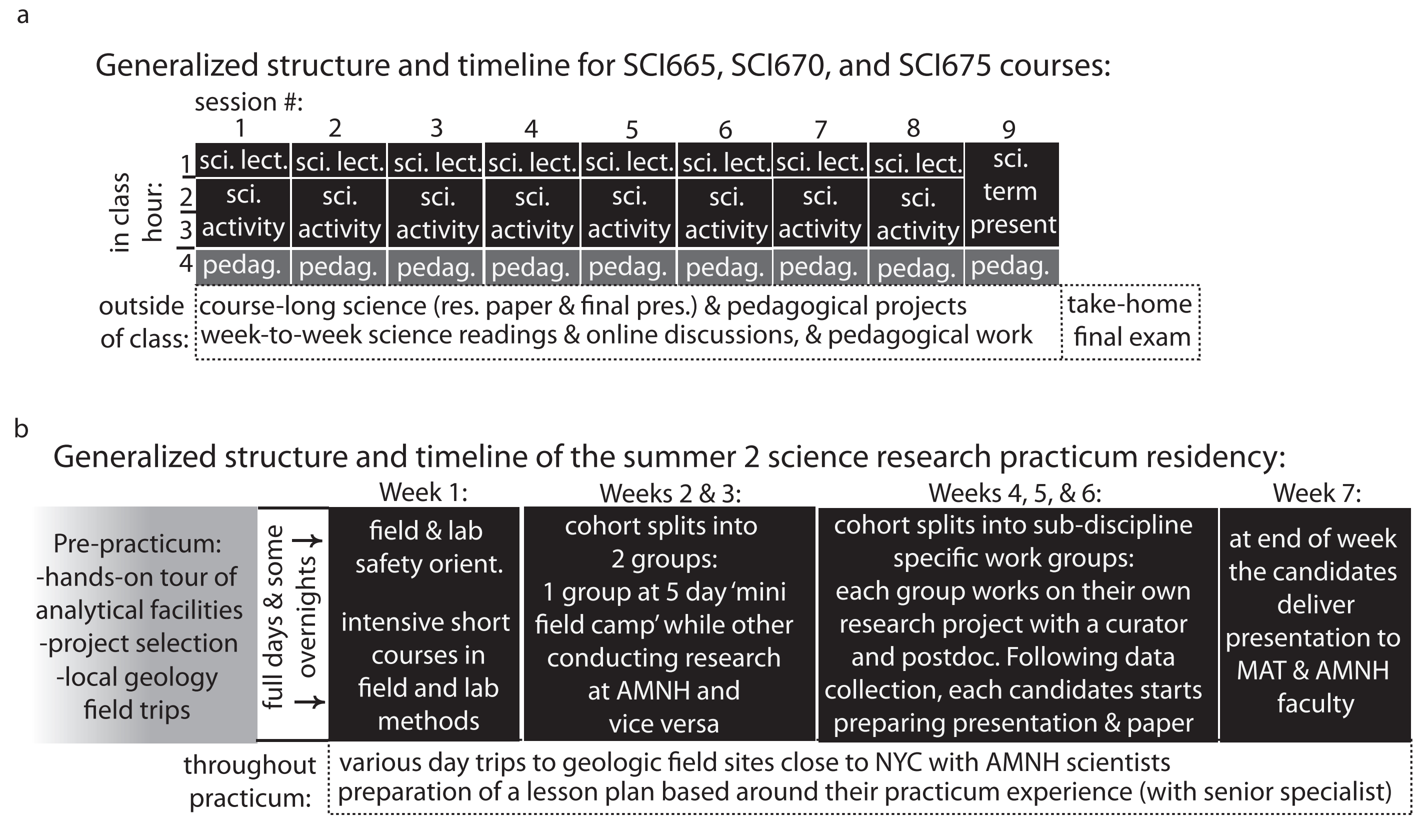


FIGURE 3: (a) Generalized structure and timeline of the individual science courses (with specific dates applicable to the first cohort). (b) Generalized structure and timeline of the research practicum.

necessarily balanced by the components of the program that are explicitly designed to train the candidates as teachers. This balance is achieved in two ways. The first way is by the required participation of science (and education) faculty in curriculum-mapping exercises. For the science courses and the research practicum, these exercises force the faculty to examine how each topic covered and activity assigned relates, in detail, to the program's learning and professional development goals for its candidates. Therefore, although certain topics covered in the science aspect of the program may not explicitly relate to the NYS Earth Science regent's curriculum, the faculty is held accountable to ensure that what they cover serves the purpose of satisfying at least one, and hopefully more, of the program's goals for the teacher candidates.

The second aspect of balancing the science and educational components of the AMNH-MAT program is the cross-program workload alignment. Similar to the curriculum-mapping exercises, course faculty are required to participate in the alignment process where the due dates and estimated time-burden of individual assignments from different courses are examined collectively to ensure that candidates are not being asked to devote a disproportional amount of time or mental energy to any single assignment. As part of this exercise, effort is also made to stagger major due dates for the assignments in different courses, so that there are no periods of severe academic duress because of many large assignments (e.g., term papers, presentations, etc.) being due at the same time or that interfere with major state-mandated certification exams. One key point about the two activities described above is that they happen in perpetuity such that there is a constant cross-engagement among the science and education faculty, as well as among the program's administrators, external evaluators, and the advisory board.

THE AMNH-MAT PROGRAM: TESTING THE SCIENCE CURRICULUM'S EFFECTIVENESS

The rationale for providing teacher candidates with science knowledge and experience beyond that which is required for state certification can be examined within the context of the development of the teacher candidate's pedagogical content knowledge (PCK). The definition of PCK has grown in complexity since the term was first introduced (Schulman, 1986), but it can still be thought of as a collection of a teacher's own knowledge, experiences, and reflections (Nilsson, 2008), which combine synergistically (Abell, 2008) in the classroom (Van Driel et al., 1998). Even though it is difficult (e.g. Nilsson and Loughran, 2012) to capture a teacher's development of PCK in practice, for a science teacher, an understanding of students' perception of science, knowledge of the science curriculum being taught, and ability to use science-specific instructional and assessment strategies could all be considered important aspects of PCK (Magnusson et al., 1999; Park and Oliver, 2007; Schneider and Plasman, 2011). Inherent in these are a teacher's own understanding of science and orientation towards science learning, which, for many teachers, are shaped by their own science background.

Regarding state certification, there is no universal requirement for new teachers to have authentic research experience, and the types of research experiences available (Yen and Huang 1998; Melear et al., 2000; Buck, 2003; Dixon and Wilke, 2007 National Science Foundation, 2007;) to preservice teachers vary greatly in their scope, design, and duration. In university-based teacher-preparation programs, future science teachers typically have a choice of which science courses they take to satisfy certification or graduation requirements. There are also currently many pathways to teacher certification (Grossman and Loeb, 2010), and measures of student success in science are constantly evolving (Pruitt, 2014), so it is difficult to describe how individual instances of student learning might relate to a teacher's experience during preparation (Feuer et al., 2013). Therefore, it is not often possible to *directly compare* the effects of specific research experiences and science courses in shaping the attitudes of new science teachers.

Despite this limitation, there is a growing body of educational research indicating that teachers pedagogically value research experience differently than they do traditional course work (Boser et al., 1988; Spiegel et al., 1995; Hemler, 1997; Office of Educational Research and Improvement [OERI], 1997; Gess-Newsome, 1999; Raphael et al., 1999; Melear et al., 2000; Schwartz et al., 2000; Gilmer et al., 2002; Westerlund et al., 2002; Varelas et al., 2005; Brown and Melear, 2007; Blanchard et al., 2009). It is almost universally accepted within the teacher-preparation community that a secondary-school science teacher's own science background affects the quality of his or her teaching, distinguishing teachers who have some authentic science-research experience and those whose science background is limited to course work (OERI, 1997; Silverstein et al., 2009). This is partly because science teachers with authentic research experience in their backgrounds are more likely to have a better understanding and appreciation for the practical and philosophical tenants of science (Duggan-Haas, 1998). The association is less clear for the role of science coursework in teacher preparation than it is for research experience. For example, it is interesting that a critical literature synthesis by Floden and Meniketi (2009) demonstrates a positive association between a teacher's resume of subject-specific course work and student learning, whereas Rice and Kaya (2012) found no association between a group of elementary-school science teachers' completion of advanced college science courses and their understanding of science concepts.

As mentioned in the "Introduction," the success of the AMNH-MAT pilot program and its science curriculum will ultimately be measured by the effect of the program's graduates on student achievement in NYS high-needs public schools (Kinzler et al., 2012). It is, therefore, not yet possible to study the effect of the program's science curriculum on their teaching, but that limitation is not unique to the AMNH-MAT program. In the literature, there are few analyses on the overall effectiveness, as measured by improved student achievement, of the UTR model. For example, the *Measuring UTRU Network Program Impact* statement for 2014 (UTRU, 2014) concludes, based on a within-network survey and publically available student performance data, that UTR-trained teachers outpace other new and, in some cases, veteran teachers in student achievement gains. The report also concludes that most UTR graduates are confident and knowledgeable practitioners with positive professional identities who will remain committed to teaching in high-needs public schools. In contrast, analysis of value-added performance data for graduates from specific UTRs indicates that UTR graduates were only equal and, in some subjects, less able to raise student test scores compared with other novice teachers in the same school district (Papay et al., 2012).

The reality is that, because of the relatively short time UTR programs have existed, there is still insufficient student achievement data to make any firm conclusions about their effectiveness. However, previously documented links between the way in which teachers perceive the pedagogical value of their own experiences with science and the way they eventually use those experiences in the classroom (Hong 2010; Pop et al., 2010; Miranda and Damico, 2013), which suggests that the candidate's scientific preparation as part of the AMNH-MAT pilot program will translate into effective classroom practice that contributes to student success in science. Future study of the effectiveness of the AMNH-MAT program's approach to science should revolve around two research questions. One question can be asked of the teachers so we understand how they are using the science knowledge and experience they gained at the AMNH. The second question is broader and seeks to know whether students of the AMNH-MAT perform better in Earth Science than students do who did not graduate from the AMNH-MAT program.

EXPANDING THE AMNH-MAT MODEL IN A CHANGING TEACHER-PREPARATION LANDSCAPE

As of 2010, only 159 teacher-preparation programs were recognized in the U.S. by the National Science Teachers Association (NSTA, 2010) as being able to document high-quality science standards for their teacher candidates. At the same time, prominent organizations, like the National Council for Accreditation of Teacher Education (NCATE, 2010), are calling for new teacher-preparation program designs to be explored on a wider scale. So, even though clinical teacher-preparation programs identified by the American Association of Colleges for Teacher Education (AACTE, 2010) as being on the cutting edge of their field understandably remain focused on ensuring that their candidates gain adequate classroom teaching experience before entering the profession, it may ultimately be necessary for science teacher-preparation programs to implement more-rigorous science curriculums. However, any teacher-preparation program wishing to incorporate a rigorous science curriculum will also have to balance it with the critically important components of clinical teaching and educational course work.

Future science teachers need additional practical experience with science, which can be provided in lectures and validation laboratories (Westerlund et al., 2002; NSTA, 2003; Windschitl, 2004; Anderson, 2007; Lotter et al., 2007; Miranda and Damico, 2013). For example, if a science teacher was to adopt the four dimensions of science literacy (to know and understand the natural world, to have the ability to generate and evaluate scientific evidence and explanations, to understand how scientific knowledge is constructed, and to participate in scientific practices and discourse) from the National Research Council (NRC, 2007) as learning goals for his or her own students, then it is clear that this teacher's own experiences in the practice of science will govern the attainment of these goals because three of the four NRC dimensions relate to the practice of science. That said, it is not uncommon for someone to graduate with a BS degree and no practical science-research experience (Roth, 1998).

The science curriculum of the AMNH-MAT program provides teacher candidates with graduate-level science course work and research experiences, and this model could, therefore, help ensure teachers are entering the profession with extensive content knowledge and practical experience in science. What follows is a consideration of how the AMNH-MAT model could be implemented in other settings with an emphasis on how to avoid two potential pitfalls so the science curriculum does not detract from education course work or clinical teaching experiences or expose teacher candidates to subject matter that is irrelevant to their future work as teachers.

UTRs can provide science teacher candidates with unique science research experiences and course work, which have the potential of being meaningful than those found in typical university-based, teacher-preparation programs. Career research scientists, which is the demographic capable of offering graduate science courses and research experiences, are typically appointed to colleges of science as opposed to colleges of education. The result is that future teachers often then find themselves in science classes or research settings among students seeking advanced science degrees. The risk is that these future teachers will then view their experiences in science research or course work as overwhelming, boring, or unrelated to their future classroom practice (Sadler et al., 2010). In a UTR program, however, science research experiences and course work can be tailor-made for the cohort of teacher candidates.

The key is that, in science courses and research experiences designed specifically for a UTR, teacher candidates will find themselves among their peers—they do not intermingle with students pursuing advanced science degrees, thus eliminating some of the potential pitfalls inherent in mixing future teachers and future scientists. However, when the science courses and research experience are designed by active research scientists (e.g., the AMNH-MAT model), there is still the potential for the teacher candidates to the view the UTR's science curriculum as unrelated to their future practice as teachers. It is ultimately up to the program's faculty (e.g., scientists and educators) to design the science curriculum in accordance with the program's science learning goals and up to the teacher candidates to make the link between the science curriculum and their own future practices.

As described, an educator (either senior specialist or other education specialist at the AMNH) is a member of the faculty for the three science courses and summer research practicum. The primary purpose of the educator's presence is to guide the candidates in making a connection between their graduate-level science work and their own growing PCK and professional identity. Additionally, the UTR model ensures that at the same time candidates are experiencing the science courses and research practicum, they are also being heavily indoctrinated in the teaching profession. However, graduate-level science topics and practice are necessarily much more specific and broader than the grades 7–12 curriculum that the teacher candidates are learning about or have taught in their residency placements. It is, therefore, not always possible to make an explicit connection between a graduate-level learning activity embedded in one of the course sessions, or a research project that is part of the research practicum, to classroom practice at the grade 7–12 level.

Because of the risk that the science component of the AMNH-MAT model will not provide the teacher candidates with knowledge and experience that is directly applicable to their work as teachers, a crucial aspect for any program wishing to implement a similar model is the implementation of safeguards to ensure that the science curriculum does not interfere with education courses and teaching experiences. In the AMNH-MAT program, this safeguard is a function of the faculty structure and the obligations of each faculty member to participate in the curriculum mapping and workload-alignment described. Therefore, any program, whether traditional or UTR based, that adopts a science curriculum modeled after the AMNH-MAT program needs an administrative structure that ensures collaboration among the education and science faculty.

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