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EXECUTIVE SUMMARY

The Master of Arts in Teaching – Earth Science Residency Program (MAT-ESRP), based in the American Museum of Natural History (AMNH) Richard Gilder Graduate School in New York City, is a collaboration between educators and scientists at AMNH and school districts in the Bronx, Brooklyn, Queens, and Yonkers. The cohort-based, 15-month, 36-credit program is designed to prepare and retain highly effective Earth science teachers to serve diverse student populations, in high-need schools. Each cohort begins with a Museum Teaching Residency at AMNH, followed by a year of residencies in high-need schools. The program concludes with an AMNH-based Science Practicum. After completing the residency program, graduates are supported by the MAT-ESRP’s two-year New Teacher Induction Program as they begin their teaching careers at high-need schools. This external evaluation report covers Year 2 (October 1, 2020 – September 30, 2021) of AMNH’s 2019–24 TQP grant to expand and innovate the residency program. The primary aims of the TQP project are to (1) expand the Earth science residency, mentoring, and induction program; (2) refine supports for culturally responsive teaching in the teacher preparation curriculum; and (3) integrate Computational Thinking (CT) into the curriculum. The TQP grant supports residents in Cohorts 10, 11, and 12, and provided second-year induction activities for an earlier cohort.

Horizon Research, Inc. (HRI) is conducting the formative and summative external evaluation for the TQP grant. The evaluation takes a multimethod, multi-source approach to understand tradeoffs the project must negotiate as well as accomplishments and challenges. In Year 2, evaluation methods included observations of meetings and program activities, interviews, surveys, and document and web resource reviews, as well as analysis of AMNH-collected data. HRI also conducted a review of literature on incorporating CT in courses for future teachers.

The MAT-ESRP has much to celebrate as Year 2 draws to a close. Although program faculty and staff continued to work remotely and classes (as well as schools) were online for much of the time, Cohort 9 residents progressed through the program, graduated, and are now teaching. The program also continued to support school-based mentors and recent graduates throughout Year 2. And, despite nationwide low application rates to teacher preparation programs, the program successfully recruited Cohort 10.

MAT-ESRP also made progress on goals to integrate CT and expand the program. As planned, instructors for two focal courses piloted CT innovations, and evaluation data indicate that they see abundant opportunities to integrate CT with their existing content. A new partner school was added, which allowed greater choice for residents and expanded the program’s capacity. The program also piloted a new effort to expand induction mentoring capacity, pairing new teachers from Cohort 8 with alumni teaching in NYC schools. Feedback on the pilot from peer mentors was very positive, highlighting the alumni’s strong sense of connection to the program and AMNH and benefits to the mentors’ own teaching practice.
INTRODUCTION

The Master of Arts in Teaching – Earth Science Residency Program (MAT-ESRP), based at the American Museum of Natural History (AMNH) in New York City, is a collaboration between educators and scientists at AMNH and school districts in the Bronx, Brooklyn, Queens, and Yonkers. Horizon Research, Inc. (HRI) is conducting the external evaluation for AMNH’s 2019–24 TQP grant to expand and innovate the residency program. The primary aims of the TQP project are to (1) expand its Earth science student-teacher residency, mentoring, and induction program in high-need schools; (2) refine supports for culturally responsive teaching (CRT) in the teacher preparation curriculum; and (3) integrate Computational Thinking (CT) into the curriculum. The project has secured the services of Dr. Irene Lee of MIT as a consultant for leading the CT integration.

The Earth science teacher preparation program is based in AMNH’s Richard Gilder Graduate School. The cohort-based, 15-month, 36-credit teacher residency program is designed to prepare and retain highly effective Earth science teachers to serve diverse student populations, including English language learners (ELLs) and students with special needs. Each cohort begins with a summer-long Museum Teaching Residency at AMNH. Program participants are then assigned a fall semester residency followed by a spring semester residency in the partner schools, which are high-need public middle and high schools. AMNH also supports residency school mentor teachers through Mentor Academy sessions, held online or at the Museum, and meetings at the residency schools to provide a robust mentoring system for the residents. The program concludes with an AMNH-based Science Practicum: an immersive Earth and space research course during the second summer. After completing the residency program, MAT-ESRP graduates begin their teaching careers at high-need schools and are supported by AMNH’s two-year New Teacher Induction Program. The TQP grant will support residents in three new cohorts, as well as providing second-year induction activities for an earlier cohort.

In Year 2 (October 1, 2020–September 30, 2021), the TQP project experienced continued disruptions caused by the COVID-19 pandemic, including closures of the museum and schools. Project leaders and faculty adapted all elements of the program (courses, residencies, induction support, mentor support, and administrative processes) to meet COVID-related restrictions. Year 2 accomplishments include:

- Piloting of new and revised CT activities in two focal courses—Space Systems and Weather, Climate, and Climate Change—with guidance from Dr. Lee;
- Enrolling 15 new residents¹ for Cohort 10 despite nationwide declines in applicants to education programs;

¹ Sixteen were enrolled, but one resident decided not to continue shortly after beginning the program.
• Expanding the program by identifying and adding a new partner school;
• Piloting peer-to-peer mentoring sessions to expand capacity for induction support; and
• Adding new CRT supports.

**EVALUATION OVERVIEW**

The external evaluation includes both formative and summative components. This section of the report provides an overview, followed by a description of the Year 2 evaluation focus and activities.

**Formative Evaluation**

The formative evaluation questions align with the project’s key activities; Table 1 describes how the evaluation will address each question. As indicated by the data sources listed, the evaluation uses a multi-method, multi-source approach to addressing the questions.
Table 1  
Formative Evaluation Questions, Data Sources, and Timeline

<table>
<thead>
<tr>
<th>Formative Evaluation Question</th>
<th>Data Sources</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the nature, quality, and outcomes of the course revision process with respect to developing new CT components, refining CRT content, and developing additional guidance for supporting ELL students and students with special needs?</td>
<td>Document reviews, Meeting observations, Interviews with field test faculty and students</td>
<td>1–2</td>
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<tr>
<td>2. How do efforts to (a) attract diverse, well-qualified applicants and (b) select, enroll, and retain them as residents evolve, and how effective are those efforts?†</td>
<td>Demographic data for applicants and residents, Applicant survey</td>
<td>2–4</td>
</tr>
<tr>
<td>3. How do AMNH and school leaders function as partners?†</td>
<td>Annual one-on-one interviews with leaders from AMNH and from partner districts and schools</td>
<td>1–5</td>
</tr>
<tr>
<td>4. In what ways does the project attract, prepare, support, and retain school-based mentors, and how effective are those efforts?†</td>
<td>Teacher effectiveness data and subject area knowledge for mentor teachers, Observations of a sample of mentor program activities, Survey of all mentors, One-on-one interviews with project leaders from AMNH and a sample of residents, Focus group interviews with a sample of mentor teachers</td>
<td>1–4</td>
</tr>
<tr>
<td>5. In what ways and to what extent do clinical experiences focus on specific project objectives, including CRT and implementing CT activities?†</td>
<td>Observations of a sample of clinical experiences, One-on-one interviews with a sample of residents and mentors, Survey of all residents</td>
<td>3–5</td>
</tr>
<tr>
<td>6. In what ways and to what extent do enacted course experiences align with project objectives and support residents' clinical experiences?†</td>
<td>Observations of a sample of course meetings, Course evaluations, One-on-one interviews with a sample of residents, Survey of all residents</td>
<td>3–5</td>
</tr>
<tr>
<td>7. To what extent does the induction program, including professional development opportunities, meet newly inducted teachers’ needs?</td>
<td>One-on-one interviews with a sample of new teachers, Survey of all new teachers</td>
<td>2, 4–5</td>
</tr>
<tr>
<td>8. In what ways and to what extent do residents and new teachers benefit from working with school-based and faculty mentors and coaching activities?</td>
<td>One-on-one interviews with a sample of residents and new teachers, Survey of all residents and new teachers</td>
<td>3–5</td>
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<tr>
<td>9. In what ways and to what extent do residents and new teachers benefit from being part of a cohort?</td>
<td>One-on-one interviews with a sample of residents and new teachers, Survey of all residents and new teachers</td>
<td>3–5</td>
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</table>

† The wording of this question reflects changes made during Year 2 in collaboration with project leaders.

Summative Evaluation

The summative evaluation will focus on project outcomes and impacts. MAT-ESRP’s goals include specific targets for persistence in the program, certification, high-need school placement, and teacher retention. The project also aims to positively impact graduates’ preparedness as Earth science teachers, including their preparedness to use CRT practices and implement CT activities. HRI will collect data on each of these outcomes (see Table 2 for details).
### Table 2
**Summative Evaluation Questions, Data Sources, and Timeline**

<table>
<thead>
<tr>
<th>Summative Evaluation Question</th>
<th>Data Sources</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did the project achieve its recruitment target of 72 residents, 24 of whom identify as Hispanic and/or non-white, for the MAT-ESRP program?</td>
<td>Demographic data for residents who enroll in the program</td>
<td>3–5</td>
</tr>
<tr>
<td>2. Did the project achieve its preparation, certification, and high-need school hiring target rate of greater than 90 percent and its 3-year retention rate of greater than 80 percent?</td>
<td>Certification/licensure outcomes (Performance Measure 1), Program graduation results (Performance Measure 2), One-year persistence rate among any residents that do not graduate in 14 months (Performance Measure 3), Hiring rate (high-need LEA and overall), One-year employment retention (Performance Measure 4), Three-year employment retention (Performance Measure 5)</td>
<td>3–5</td>
</tr>
<tr>
<td>3. What is the impact of the MAT-R program on residents’ preparedness to (a) teach science effectively to high-need underserved students, including ELL students and special education students; (b) use CRT practices; and (c) implement CT activities?</td>
<td>One-on-one interviews with a sample of residents and new teachers, Survey of all residents, AMNH faculty observation scores, Mentor teacher observation scores</td>
<td>3–5</td>
</tr>
<tr>
<td>4. What is the impact of the MAT-R program on graduates’ preparedness to use CRT practices and implement CT activities, and to teach underserved students, including ELL students and special education students?</td>
<td>One-on-one interviews with a sample of new teachers, Survey of all new teachers, Hiring principal surveys</td>
<td>4–5</td>
</tr>
<tr>
<td>5. What is the impact of MAT-R program graduates on high-need schools’ performance in Earth science?</td>
<td>Results of quantitative comparisons of Earth Science Regents performance in schools with and without MAT-R program graduates, conducted by project partners at NYU (Performance Measure 6)</td>
<td>4–5</td>
</tr>
</tbody>
</table>

### Year 2 Evaluation Activities

In Year 2, HRI focused on formative evaluation questions 1–4 and 7. Evaluation activities, organized by question, are shown below.

1. **What are the nature, quality, and outcomes of the course revision process with respect to developing new CT components, refining CRT content, and developing additional guidance for supporting ELL students and students with special needs?**
   - Meetings with project leaders periodically by videoconference
   - Observations of a sample of MAT-ESRP faculty meetings by videoconference (including one of the meetings with Dr. Lee)
   - Interviews with faculty regarding course innovations
   - Review of literature on CT in teacher preparation courses
   - Review of documents related to courses targeted for innovation

2. **How do efforts to (a) attract diverse, well-qualified applicants and (b) select, enroll, and retain them as residents evolve, and how effective are those efforts?**
   - Review of the admissions portal
   - Observations of MAT-ESRP admissions meetings by videoconference
• Survey of individuals who had shown interest in applying to the program (a copy of the survey is included in Appendix A)
• Review of Cohort 10 demographic data

3. How do AMNH and school leaders function as partners?
• Meetings with project leadership
• Review of documentation regarding partner school expansion

4. In what ways does the project attract, prepare, support, and retain school-based mentors, and how effective are those efforts?
• Observations of sessions of the 2020–21 Mentor Academy and initial sessions of the 2021–22 Mentor Academy

7. To what extent does the induction program, including professional development opportunities, meet newly inducted teachers’ needs?
• Observations of peer-to-peer meetings through videoconference
• Interviews with five peer mentors at the conclusion of the school year in June and July 2021.

In addition to this annual report, HRI shared results and findings from the faculty survey with the full faculty in February 2021 to set the stage for a faculty conversation about CT innovation. HRI also summarized a review of literature conducted at the project’s request (see Appendix B).

The remainder of this report is organized by the evaluation questions above and concludes with a summary and recommendations for the project to consider.

**FINDINGS**

**Developing New CT Components, Refining CRT Content, and Developing Additional Guidance for Supporting ELL Students and Students With Special Needs**

Infusing CT in program courses is a defining element of the TQP grant, and Year 2 saw continued work on this front. Project leaders also continued to refine the program’s emphasis on CRT and supporting ELL students and those with special needs, areas that are long-term hallmarks of the program. This section of the report discusses project work and evaluation findings in each area.

**Developing New CT Components for Focus Courses**
In Year 1, Dr. Lee provided an introductory seminar for program faculty on computational thinking for 7th–12th grade science teaching and learning to support the program’s goal to make CT more explicit in its coursework. In Year 2, the program planned for CT innovations to be
piloted in two courses: *Space Systems* and *Weather, Climate, and Climate change*. Accordingly, Dr. Lee met with the instructors for *Space Systems* and, separately, with the instructors for *Weather, Climate, and Climate Change*. The goal of each meeting (referred to as a sandbox session) was to continue the work begun in Year 1, but with a course-specific focus. During these meetings, faculty discussed how they already addressed aspects of CT in their course content and explored new approaches for more explicitly attending to CT, including the types of existing course activities that could be used to highlight CT.

In addition, to enhance CT understanding across the program, other Year 2 activities included:

- The first faculty meeting in Year 2 focused on CT. After a brief introduction, faculty divided into four small groups to discuss ways they were already incorporating CT and explore possibilities for additional integrations. Each group reported highlights of their conversation to the full faculty.
- At the beginning of Year 2, the project asked HRI to review literature on incorporating CT in teacher preparation courses. The initial search identified 50 articles. However, on closer inspection, only 13 were relevant. HRI synthesized guidance from these articles in a January 2021 memo (see Appendix B).
- The project identified an online course on CT and recommended it to program faculty and alumni, offering to pay the $75 registration fee. This 15-hour course—Introduction to Computational Thinking for Every Educator, offered by ISTE—is designed specifically for K–12 teachers and teacher educators. The project plans to offer the course to mentor teachers as well.
- As mentioned above, HRI presented results of the Year 1 faculty CT survey at a faculty meeting in February at the project’s request. Faculty discussed the results and implications for their courses.

Several Year 2 evaluation activities attended to CT. HRI interviewed instructors for the two focal courses (*Space Systems* and *Weather, Climate, and Climate Change*) and observed the sandbox meeting for one of the courses. HRI also observed the full faculty meetings focused on CT mentioned above. The sections below summarize findings from these activities in three categories: opportunities for infusing CT, challenges, and needs.

**Opportunities for Infusing CT in Space Systems and Weather, Climate, and Climate Change**

The interviewed focal course instructors were enthusiastic about the potential for infusing CT in their courses, despite also identifying challenges. As one put it:

> I think my own understanding of computational thinking is the biggest challenge. . . . I mean I’m totally down with it. It meshes really, really well with the national Next Generation Science Standards in terms of some of the practices and crosscutting concepts.
Instructors also see the content of their courses as rich with opportunities to connect with computational thinking. For example, one course heavily emphasizes computation, and both use modeling extensively. Two instructors commented:

*We’ve done like an energy budget jigsaw, like the Earth’s energy budget—so, what comes in, what goes out, where do things get spread around—and there’s numbers all over that. . . . We do a bunch of activities where each week the residents present a website that’s designed to present weather and climate information. A lot of that is very much computationally oriented, and so that’s like an opportunity there. We have a guest lecturer come in from NASA GISS, and we actually do an online version of a climate model . . . so that’s a perfect opportunity right there. That’s a pretty substantial activity. We do an activity using another model called Daisyworld that’s pretty famous in terms of climate feedback kind of stuff. So that’s another opportunity.*

*Groups of three [residents] will explore one of the 9–12 [NGSS] performance expectations. So usually in the first week, that is exploring the science and engineering practice, the second week exploring the DCI, and then moving on to eventually build performance assessments around it. Now this year, what I’ve done is I’ve also added in to look for a way to think about what that performance expectation looks like through the lens of computational thinking. . . . And what I’ve done is I’ve linked that assignment to the K–12 CS Framework so that they can actually work from the actual CS standards as they exist and think about how they can mix the CS standard with the performance expectation.*

Although the courses have rich opportunities, prior to 2020–21, instructors did not have reasons to lift out the CT aspects, but they see substantial potential for highlighting existing CT-related content. One instructor noted that conversations with Dr. Lee were helpful in this realization:

*We’ve had some useful discussions with [Dr. Lee] on how she and her colleagues have incorporated computational thinking into courses at different levels. And that’s actually been very helpful in conceptualizing . . . [that] most of what we can do is simply make explicit things that were already implicit.*

Another instructor described how the conversations with Dr. Lee led to a new CT strand in the course:

*Through [the meeting with Dr. Lee], I was connected to this article, to this ISTE site, and then was able to find this article that we can use in the class. . . . So what we’re going to do with this is going to be reading in the first part of the course, and then one of the things that that we do is we have quizzes, like sort of pre-course quizzes, that are open book open for 45 minutes, but one of the questions in the first quiz addresses these four elements of computational thinking. . . . As the course goes on and we do these activities*
that have the potential to make computational thinking more explicit, we will refer back to this article and ask them to think about the activities that we did in terms of these four dimensions.

Challenges with Infusing CT in Space Systems and Weather and Climate

HRI’s interviews and observations suggest three related challenges faculty face in efforts to integrate CT content in their courses: (1) uncertainty about how the program is operationalizing its definition of CT, (2) the sense that CT is an add-on (as opposed to an integration), and (3) the difficulty of adding content to courses that have already-packed syllabi. In the field more generally, lack of an agreed-upon definition for CT is a challenge (as noted in HRI’s literature review), and the field’s use of varied definitions and standards poses a challenge for MAT-ESRP. Despite efforts to reach consensus within the program (including faculty meetings and conversations with Dr. Lee), faculty have struggled with understanding the program’s CT goals for residents and integrating different views of what “counts” as CT. One faculty member noted:

I think actually the biggest challenge has been coming up with a workable definition of what computational thinking is and it’s not. And I would say that the greatest part of the conversations that we had with Irene, and that even the presentation, was around trying to come up with a common definition of what computational thinking is. And I actually still think we’re not completely there. And so what that has meant is that—I will literally come up with an idea for something and then be told it’s not computational thinking. And through one lens, it is not computational thinking, but through another lens, it could be thought of as computational thinking.

Focal course faculty also described their sense that, so far, CT feels like content they are being asked to add to their courses, which are already packed with concepts they need to address. This perception ties closely to the third challenge of course duration, as faculty already feel the strain of trying to address all their course content in the time available. One instructor commented: “If this course has to cover CT, something else has to go—and that something is science.” Another commented:

[CT] sort of feels like an add on to me. I want to try to make it as seamless as possible. In future years, it probably will be that, but this year, it kind of feels like this added thing we’ve been asked to do. . . . I think going forward, if this is going to be a focus of the program, as a faculty we need to do some more work [around CT], and I think that everybody knows that. That’s not a revelation.

Though not a prominent theme, residents’ backgrounds in mathematics and coding were also mentioned as a challenge. The perception that residents generally do not have strong backgrounds in these areas emerged from two sources: faculty members’ own interactions with residents and residents’ responses to a survey on the topic. The concern is understandable, given
that among the many definitions of CT, some stress mathematical modeling and coding. One instructor commented:

*We had visions of actually trying to build in computing modules, but given the low-level background that the students have, I think we’ll probably confine ourselves to basically discussions of things like, “How do you set up a physical model that steps through time while integrating a differential equation?” Since many of them also need to learn what a differential equation is, that may be as much as we can accomplish in this course.*

**Needs for Infusing CT in Space Systems and Weather and Climate**

Not surprisingly, one need faculty identified is a clear definition of CT that MAT-ESRP is addressing. Faculty expressed a need for more support if they are to effectively integrate CT content into their courses. They would appreciate models of how others have done this work in ways that did not add content and time. They would also appreciate time to work individually and with other faculty. The idea of working collectively to find solutions is particularly appealing, partly because of the combined expertise that could be brought to bear. As one faculty member put it:

*When we take this up as a faculty and kind of really dig in and have conversations as faculty, those are always really productive. I’m looking forward to being able to do something like that in the future. . . . We have a weekly workshop on Thursday mornings to do that, and this would be a perfect opportunity to do something like that there, to be able to kind of talk through with everybody else and getting their perspective on it and kind of reading some common literature, or whatever, and talk about some strategies for doing that. I’m sure that that’s kind of on the horizon.*

Another benefit of working together as a faculty is the potential for distributing the CT load across courses, minimizing the stress on any one course. One faculty member described the possibility of a CT progression across courses:

*Let’s say that Space Systems is the beginning of the continuum for computational thinking, and Weather, Climate, and Climate Change is the end of that. So now, instead of thinking about this as a nine-session progression, it’s an 18-session progression. . . . And so thinking about this kind of holistically as how our classes are working together to do this instead of, like, we are doing it and they are doing it.*

**CRT, ELL, and Special Education**

MAT-ESRP has historically emphasized CRT, ELL, and Special Education. The program devotes substantial coursework to each area. In Year 2, the Mentor Academy devoted substantial time to discussing the book *Make Me!* (Toshalis, 2015), which directly addresses CRT and relates to ELL and Special Education as well. Community building for Cohort 10 was grounded in CRT practices through the *Becoming a Science Teacher: Identity, Privilege & Power in the*
Classroom workshop series that took place over the summer. The series provided an authentic context for residents as they built community with each other while learning to apply CRT-informed practices. Additionally, the Collaborative Planning to Create Culturally Inclusive Science Classrooms 3-day workshop was held at the end of Year 2 as part of induction support for Cohorts 8 and 9. This workshop allowed beginning teachers to consider CRT practices that affirm student identity when planning for and implementing rigorous science instruction. The project also planned a new initiative for Year Three, when Mentor Academy follow-up sessions will set aside time for mentors with expertise in ELL and Special Education to share their expertise. Also in Year 2, the peer-to-peer mentoring program devoted time during induction activities for mentors and first-year teachers to discuss and expand their knowledge of CRT and ELL concepts. For example, during the May peer-to-peer meeting, participants brainstormed in breakout rooms, and one breakout room focused on the question “What are Culturally Responsive Teaching strategies and processes that you want to keep and build on?” Peer mentors (program alumni who are currently teaching) generated this topic on their own, suggesting they have internalized the program’s commitment to CRT and that it remains relevant to their work as teachers.

Attracting and Enrolling Diverse, Well-Qualified Individuals

The pandemic has affected every aspect of the project, including recruitment. Not surprisingly, other TQP projects have also struggled to recruit their target numbers. In Year 2, MAT-ESRP sought to attract enough applicants to enroll 24 residents for Cohort 10. Ultimately, 16 were admitted, with one deciding not to continue shortly after the program began.

The Application Process

To identify factors that might encourage or discourage applicants, the project asked HRI to survey anyone who had shown interest in the program. Working with project leaders, HRI developed a survey (see Appendix A) and administered it to 130 individuals, offering a $15 incentive for responding. Of the 130, 50 completed the survey. Most of the individuals who received the survey interacted minimally with the program. Thus, the low response rate (38 percent) was unsurprising but nonetheless suggests that caution should be used when interpreting results.

Table 3 shows the demographic characteristics of the respondents, both overall and by whether they completed an application. Similar to the middle and high school science teaching forces nationally (Banilower et al., 2018), most respondents identified themselves as female, but they are much more diverse in terms of race/ethnicity. For example, nationally, just over 90 percent of

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2 The project maintains records of those who express interest in the program. For example, the project collects contact information for anyone who attends an interest session.
middle and high school science teachers identify as White (Banilower et al., 2018), compared to 60 percent of survey respondents. No substantial differences are apparent between those who completed an application and those who did not. What appears to be a difference with regard to the “prefer not to answer” category for race/ethnicity is tentative at best given the small number of respondents who chose this category overall (N = 6).

As can be seen in Table 4, roughly a third of respondents reported they found out about the program through an internet search (30 percent), followed by the museum website (18 percent) and a current or former professor (16 percent). The fact that 1 in 6 respondents heard about MAT-ESRP through a professor may reflect the program’s outreach efforts in geoscience departments. Twenty percent of respondents selected “other” and were prompted to write a response. Among the 10 comments, two mentioned a LinkedIn advertisement, and two mentioned an email from their college department. No other way of hearing about the program was mentioned by more than one person.

<table>
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<th>Gender</th>
<th>Total (N = 50)</th>
<th>Did Not Apply (N = 34)</th>
<th>Applied (N = 16)</th>
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<tr>
<td>Black or African American</td>
<td>12</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Hispanic</td>
<td>16</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>Native Hawaiian or Other Pacific Islander</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>White</td>
<td>60</td>
<td>62</td>
<td>56</td>
</tr>
<tr>
<td>Prefer not to answer</td>
<td>12</td>
<td>6</td>
<td>25</td>
</tr>
</tbody>
</table>

† Percentages may add to more than 100 because respondents could choose more than one category.
Table 4
How Respondents Heard About the Program

<table>
<thead>
<tr>
<th></th>
<th>Percent of Respondents (N = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet search</td>
<td>30</td>
</tr>
<tr>
<td>Museum website</td>
<td>18</td>
</tr>
<tr>
<td>Current or former professor</td>
<td>16</td>
</tr>
<tr>
<td>Recruitment email</td>
<td>10</td>
</tr>
<tr>
<td>Academic advisor</td>
<td>10</td>
</tr>
<tr>
<td>Program graduate or current resident</td>
<td>6</td>
</tr>
<tr>
<td>Recruitment postcard</td>
<td>4</td>
</tr>
<tr>
<td>Social media</td>
<td>4</td>
</tr>
<tr>
<td>A different program at the Museum</td>
<td>2</td>
</tr>
<tr>
<td>Coworker</td>
<td>2</td>
</tr>
<tr>
<td>Professional organization conference or newsletter</td>
<td>2</td>
</tr>
<tr>
<td>Friend or relative who works at the Museum</td>
<td>0</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>20</td>
</tr>
</tbody>
</table>

The survey asked about several factors that could encourage or discourage—or even prevent—potential applicants from completing the application (see Table 5). For almost all factors, most respondents rated them as at least slightly encouraging. Three factors stood out because the majority of respondents rated them as strongly encouraging: the focus on Earth science, the museum setting, and the program location. For several others, at least two-thirds rated the influence as encouraging or strongly encouraging. These included the stipend/fellowship, the post-graduation support, and the focus on urban education and high-need schools. Two factors were rated by more than 10 percent of respondents as preventing them from applying: the GRE requirement (18 percent) and prerequisite science course requirements (16 percent). Three others were rated by at least half of respondents as slightly to strongly discouraging: cost of living (68 percent), application fee (61 percent), and time/effort required to complete the application (52 percent). Based in part on preliminary results from the survey, MAT-ESRP has already lowered the application fee from $50 to $10. The project also recently revamped the application portal, with a goal of reducing the time needed to apply.
### Table 5
Factors Encouraging or Discouraging Potential Applicants’ Decision to Apply to MAT-ESRP

<table>
<thead>
<tr>
<th>Factor</th>
<th>Prevented Me from Applying</th>
<th>Strongly Discouraged</th>
<th>Discouraged</th>
<th>Slightly Discouraged</th>
<th>Slightly Encouraged</th>
<th>Encouraged</th>
<th>Strongly Encouraged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on Earth science</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>16</td>
<td>68</td>
</tr>
<tr>
<td>Museum setting for program</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td>Program location (New York City)</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>26</td>
<td>52</td>
</tr>
<tr>
<td>Program stipend/fellowship</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>18</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td>Support offered after graduation</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>20</td>
<td>35</td>
<td>39</td>
</tr>
<tr>
<td>Focus on urban education</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>18</td>
<td>36</td>
<td>38</td>
</tr>
<tr>
<td>Focus on high needs schools</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>8</td>
<td>16</td>
<td>36</td>
<td>34</td>
</tr>
<tr>
<td>School residency requirement for program</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>4</td>
<td>20</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Program length</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>6</td>
<td>22</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>Teaching requirement after graduation</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>6</td>
<td>22</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Prerequisite science course requirements</td>
<td>16</td>
<td>8</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>GPA requirement</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>8</td>
<td>26</td>
<td>34</td>
<td>16</td>
</tr>
<tr>
<td>Cost of living</td>
<td>2</td>
<td>18</td>
<td>16</td>
<td>34</td>
<td>18</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Application fee</td>
<td>8</td>
<td>2</td>
<td>16</td>
<td>43</td>
<td>16</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Time/effort required for application</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>38</td>
<td>24</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>GRE requirement</td>
<td>18</td>
<td>8</td>
<td>22</td>
<td>28</td>
<td>14</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
Of those who responded to the survey, 68 percent reported that they did not complete an application. These individuals were shown a follow-up question asking about factors that influenced their decision. As shown in Table 6, one-fifth either could not commit to the three-year teaching requirement or made other plans before they finished the application (including two individuals who selected both options). However, the largest proportion (79 percent) indicated that some other reason influenced them. Of the 27 respondents who wrote comments, most described not meeting the requirements in some way, either in terms of courses, grades, or degrees. For example:

- I did not have sufficient undergraduate earth science credits.
- I did not meet coursework requirements given my humanities/social science degrees.
- I was missing one course which prevented me from applying.
- Not enough Earth Science credits.
- Didn’t have the required grades.
- Did not have degree in earth science.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percent Responding (N = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could not commit to the three-year teaching requirement</td>
<td>21</td>
</tr>
<tr>
<td>Made other work/school plans before completing application</td>
<td>21</td>
</tr>
<tr>
<td>Have prior education degree and/or teacher certification</td>
<td>0</td>
</tr>
<tr>
<td>Other reason not previously mentioned, please specify</td>
<td>79</td>
</tr>
</tbody>
</table>

The survey also asked about several aspects of the application process. More than 80 percent of respondents agreed at least somewhat with all statements except the single item that was negatively worded, suggesting applicants generally had a positive experience (see Table 7). Almost half strongly agreed that program representatives fully answered their questions, and more than two-thirds agreed or strongly agreed the information sessions helped them understand:

- what the program consists of,
- the application and admissions process, and
- funding and the post-graduation service requirement.

Respondents’ opinions about the speed with which the program responded to their inquiries were more varied. On the whole, just under two-thirds disagreed at least somewhat that responses
were slow, but 36 percent agreed at least somewhat with the statement, and 17 percent strongly agreed. The less favorable result for this statement should be interpreted with caution, as some respondents may have overlooked the negative wording of the statement.

### Table 7
**Respondents’ Opinions About the Application Process**

<table>
<thead>
<tr>
<th></th>
<th>N†</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program representatives provided full answers to my questions.</td>
<td>38</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>16</td>
<td>32</td>
<td>45</td>
</tr>
<tr>
<td>The information session helped me understand what the program consists of.</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>45</td>
<td>41</td>
</tr>
<tr>
<td>The eligibility/transcript review helped me understand if I was qualified for the program.</td>
<td>41</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>39</td>
<td>37</td>
</tr>
<tr>
<td>Deadlines for providing application information were clear.</td>
<td>48</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>13</td>
<td>44</td>
<td>33</td>
</tr>
<tr>
<td>The information session helped me understand the application and admissions process.</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>14</td>
<td>41</td>
<td>31</td>
</tr>
<tr>
<td>The information session helped me understand funding and the post-graduation service requirement.</td>
<td>29</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>21</td>
<td>38</td>
<td>31</td>
</tr>
<tr>
<td>I was kept up to date about the status of my application.‡</td>
<td>16</td>
<td>0</td>
<td>6</td>
<td>13</td>
<td>25</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td>Admission requirements were clear.</td>
<td>47</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>23</td>
<td>38</td>
<td>28</td>
</tr>
<tr>
<td>Steps for completing the application were clear.</td>
<td>47</td>
<td>0</td>
<td>2</td>
<td>11</td>
<td>21</td>
<td>43</td>
<td>23</td>
</tr>
<tr>
<td>Information on the program website was easy to find.</td>
<td>49</td>
<td>6</td>
<td>2</td>
<td>12</td>
<td>18</td>
<td>39</td>
<td>22</td>
</tr>
<tr>
<td>Program representatives were slow to respond when I contacted them.</td>
<td>41</td>
<td>20</td>
<td>27</td>
<td>17</td>
<td>12</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>

† Only those who did not respond “Not applicable” to the item are included.
‡ This item was shown only to those who completed an application.

Respondents who participated in an admissions interview were presented with a series of statements about the process. Again, the responses are quite positive (see Table 8), with three-fourths or more agreeing or strongly agreeing with all but one statement. More than half strongly agreed that the interview length was appropriate, interview questions related to their qualifications, they had an opportunity to ask questions, and interviewers answered their questions. The data for several statements suggest interviewees came away with a sense that interviewers took an interest in them as individuals. For example, more than three-fourths agreed or strongly agreed that (1) interviewers showed an interest in what they had to say and made an effort to make them comfortable during the interview and (2) they had an opportunity to describe
their science and teaching backgrounds, as well as other strengths they would bring to the program. A small proportion (23 percent) disagreed at least somewhat that they knew what to expect before the interview began.

### Table 8
**Respondents’ Opinions About the Interview Process**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Somewhat Disagree</th>
<th>Somewhat Agree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The length of the interview was appropriate.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>31</td>
<td>62</td>
</tr>
<tr>
<td>Interview questions were related to my qualifications.</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>I had an opportunity to ask questions.</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>38</td>
<td>54</td>
</tr>
<tr>
<td>Interviewers answered my questions.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>31</td>
<td>54</td>
</tr>
<tr>
<td>The purpose of the interview was clear.</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>8</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>Scheduling the interview was easy.</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>Interviewers showed interest in what I had to say.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>31</td>
<td>46</td>
</tr>
<tr>
<td>I understood the interview questions.</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>I had an opportunity to describe my science background.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>I had an opportunity to describe my teaching background.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>38</td>
<td>46</td>
</tr>
<tr>
<td>Interviewers made an effort to help me feel comfortable during the interview.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>I had an opportunity to describe other strengths I would bring to the program/classroom.</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>After the interview, I understood what the next steps for my application were.</td>
<td>0</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>I knew what to expect before the interview began.</td>
<td>0</td>
<td>15</td>
<td>8</td>
<td>23</td>
<td>38</td>
<td>15</td>
</tr>
</tbody>
</table>

† Only those who participated in an admissions interview are included.

In summary, survey data revealed findings in various aspects of the application process. Applicants were most likely to learn of the program through internet searches, the museum website, and faculty members at other institutions. Respondents identified several factors that encouraged them to apply. Among these were the focus on Earth science, the museum itself, and the stipend. Discouraging factors, some of which the program has no control over, included prerequisite science course requirements, the cost of living, the application fee, and the GRE requirement. Respondents rated many aspects of the application process positively, including program representatives and information sessions. Those who participated in an interview also gave it high marks.
The Application Review Process

In addition to attracting applicants, the project continued to refine processes for assessing applicants’ potential. For example, the program reviewed application and interview questions from several residency programs nationally and discussed the process at full faculty meetings. In observing admissions committee meetings, HRI noted the effort (and difficulty) in accurately assessing a candidates’ potential. For some, the committee had to weigh risks of accepting someone who might not succeed against the cost of rejecting someone who might. The task is particularly challenging because many applicants do not have prior experiences that relate closely to the goals of the program. For example, many applicants lack experience working with high-need schools and in teaching in general. Consequently, despite good intentions, some candidates realize during the program or during induction that teaching is not a good fit for them. In addition to the challenge of assessing potential, the committee realized that application reviewers may not be interpreting rubric ratings consistently, making consensus difficult.

To begin addressing these challenges, the admissions committee is revising the interview process to ensure it yields the best information possible. The committee discussed revising interview questions, making a clear distinction between those that are essential to the admissions process and those that are not. For example, the question “How did you find out about the program?” is helpful for the program but reveals little about an applicant’s potential for success. To address concerns about the rubric, the committee suggested that interviewers should meet before and after interviews to plan for and debrief interviews. These meetings could improve the flow of each interview and ensure that interviewers for a particular applicant agree on how to interpret the rubric. Providing time and space for interviewers to reach consensus on the interpretation of the rubric would also address the project’s desire for interviewers to have a shared understanding of the purpose and process for conducting interviews.

Developing Partnerships With Residency Schools

With the goal of increasing the number of residents in Cohort 10, the program decided to seek new partner schools where they could be placed. Through its Year 2 efforts, the program added one school, increasing the number of partner schools to five. The process started with museum faculty identifying local middle and high schools where alumni teach. A group of faculty members discussed this list of 59 possible schools during several meetings until a few candidates emerged. After conversations with building principals, South Bronx Preparatory was brought on as the new partner school. This addition enabled a change in the way residents are matched with schools. Each year, residents are given information about the schools where they could be placed and asked to rank their top two choices. With the addition of South Bronx Prep, residents were asked to rank their top three choices. This increase ensured that every resident was placed at one of their three choices.
Attracting, Preparing, and Supporting School-Based Mentors

MAT-ESRP successfully attracted enough school-based mentors for both Cohort 9 and Cohort 10, and the program’s strong connections to schools and mentors are evident in the number of repeat mentors. For example, the majority of mentors for Cohort 10 also mentored in previous years. Additionally, several Cohort 10 mentors are program alumni and eagerly volunteered for the role.

Due to the pandemic, all sessions of the 2020–21 Mentor Academy (for Cohort 9) were held virtually. HRI observed the first two days, one session in the middle of the year, and the final session held in June. The first two days of the 2021–22 academy (for Cohort 10) were held in person in August, and HRI observed both remotely. The first day of the academy was exclusively for new mentors, and the remaining sessions were for all mentors. Residents attended a portion of the second day and were asked to join the January session, when they had the opportunity to meet their new mentors for the second residency placement.

Observation data make it clear that the program aims to actively engage mentors with tools and structures the program uses with residents. For example, during the first day of the 2021–22 academy, program leaders acquainted new mentors with three tools they will use throughout the year: the observation rubric, mentoring language, and the collaborative assessment log (CAL). Throughout the day, program faculty demonstrated how to use the tools and provided many opportunities for mentors to practice using them in different situations. Mentors seemed well acquainted with the tools by the end of the day and had additional time to practice using them the following day.

The second day of the 2021–22 academy, which all mentors attended, had five goals:

1. To use mentoring tools for evidence-based conversations about teaching and learning;
2. To understand and use the observation rubric and dispositions for teaching and learning tool to support resident development;
3. To make mentoring plans for the 2021–22 school year using feedback from the previous year;
4. To use the museum for learning and reflection; and
5. To begin to build collaborative trusting relationships with and among residents.

All goals were evident in the day’s activities, which began with time for the mentors to explore The Hall of the Universe within the museum. Throughout the day, program faculty continued to model ways to use each tool and provided opportunities for mentors to practice using the tools in different settings, including with their resident. For example, mentors and residents completed a CAL together focused on expectations for the coming year. This allowed new mentors time to practice using the CAL (which was new to them) with their residents in a conversation that was not focused on the resident’s teaching. Time was also built into the schedule for program faculty to share feedback from previous mentors and residents so current mentors could think about their plans for the upcoming year. Finally, time was set aside for mentors to meet their residents and work through activities together to prepare for the upcoming year.
Observations of the 2021–22 academy reflect the program’s commitment to continuous improvement by incorporating feedback from previous mentors. For example, prior academies were exclusively for mentor teachers, and the mentors recommended adding time to meet with their residents. This year, as mentioned above, mentors met with their residents during Day 2 of the academy, and all future sessions during the school year will include time for residents to attend. Another change to this year’s academy was time for specialist mentors (ELL and special education teachers) to share their expertise with other mentors.

**Induction Support for Recent Graduates**

MAT-ESRP faculty provide ongoing induction support for recent graduates. In Year 2, the program piloted a yearlong peer-to-peer mentoring initiative that paired alumni currently teaching with Cohort 8 members who opted in. During regularly scheduled online meetings, pairs of mentors and mentees participated in reflection-based activities. Toward the end of the year, interest-based groups were offered that allowed mentors and mentees to interact with other pairs during sessions. Between regularly scheduled meetings, mentor-mentee pairs communicated as needed. Based on the success of the pilot, MAT-ESRP plans to pair all Cohort 9 members with a mentor.

HRI observed the meetings and interviewed five of the peer mentors. When asked why they took on the added responsibility, mentors talked about maintaining a connection to the program and giving back. Said two:

*Anytime we’ve ever done anything with the museum, I’ve always really enjoyed it. Now that year three induction is over, I wanted to continue some kind of connection with the museum.*

*I wanted to make sure I supported the program like they supported me throughout all these years because I’m still very active with the museum people at the MAT-ESRP program.*

In addition to contributing to the program, mentors enjoyed the experience. As two described:

*We did some problem solving around specific concerns that my mentee had, which I think was helpful, but I definitely tried to take a backseat and let my mentee drive the path of the mentorship.*

*Knowing that my mentee was comfortable being open, honest, and sharing what was going on in their life or classroom . . . it is that relationship building and digging deeper, what made [a lesson] not work and reflecting on that, just having the openness I have found to be great.*
Peer mentors also thought they grew as teachers through the experience. Two commented:

> I benefitted a lot. . . . I learned a lot from my mentee in the ways that they think through problems because they think very differently from me. It was a mutual learning experience, and we were able to share resources, which was great.

> When we looked at certain lessons, . . . I realized some new things I could do with those lessons. Even though I was the one trying to give my mentee a resource, it also gave me a chance to look back at it again.

Mentors offered a range of support to their mentees. For example, responding to the stress one mentee expressed, the mentor referenced a chart illustrating emotional peaks and valleys of being a first-year teacher and helped the mentee relate this to their experiences. The same mentor provided instructional support when the mentee shared concerns about curriculum pacing and preparing students for the upcoming Regents exams.

Mentors said they felt prepared for their roles because of their previous experiences with the program and use of the CAL rubrics. Two commented:

> I think the program models [effective mentoring practices] really well. Senior specialists in the program are good at being mentors. They never tell you the answer. They’re just going to try and guide you there. . . . Most of my work [as a mentor] was guided by my own experiences with faculty.

> One of the first things we were told was to use a template every time we met with [mentees]. I thought that was really helpful when I did not know where to start. I think [the CAL] was really helpful for fostering where we wanted to go and making some things come up organically.

HRI observed that peer-to-peer mentor meetings were structured to proactively address the needs of new teachers. For example, during the May and June meetings, time was spent having new teachers consider how they would bring closure to their school year in terms of both content and relationships. Mentors shared some of the difficulties they experienced with this the time of year, such as saying good-bye to students and retiring/resigning colleagues. Because mentees had experienced neither, providing structured time to prepare for intentionally ending the school year likely addressed a need mentees did not realize they had.

The flexibility of peer-to-peer mentor meetings allowed mentors and mentees to choose topics that would serve their needs. For example, during a March meeting, one mentor stated that the focus of the meeting was student work. When the mentee responded that discussing student work would not be as helpful as working through a CAL, the mentor shifted the focus of their time. Similarly, at the suggestion of peer mentors, meetings later in the school year used breakout
rooms, which allowed for small group discussions on various topics (as opposed to always meeting in mentor-mentee pairs). During the last two monthly meetings, mentors generated the breakout room topics and led the discussion in those rooms. Mentees were able to choose which breakout room they attended. The topics covered a wide range of mentee needs—e.g., being a working professional, instructional support, and emotional support. In interviews, mentors indicated that mentors’ input in the content of breakout rooms and mentees’ choice of which room to attend resulted in high levels of authentic participation. Said one:

*When we were brainstorming in focus groups, that was one of the most helpful things for me. We always preach student voice, student choice—and [breakout rooms] gave this cohort group a chance for that. I found it very successful because it was a lot more engaging because [mentees] came with interest to the group.*

Breakout rooms also addressed a need for structured meeting time that some peer mentors perceived earlier in the year. As two described:

*Some days I don’t think we really had a focus, so it was just us talking. It was nice, but I don’t know if it was helpful to either one of us.*

*The breakout rooms worked well because sometimes earlier in the year, when it was just [my mentee and me] for 45 minutes, we would run out of stuff to talk about.*

When asked to suggest improvements to the pilot program, some ideas mentors mentioned included (1) the pairing structure for mentors and mentees, (2) meeting mentees in person, and (3) opportunities for collaborating with other mentors. During the pilot, three mentors had one mentee, and two mentors had more than one. All mentors were asked to consider the implications of having more than one mentee in the future. Said two:

*For me, there wasn’t anything else [challenging] about having two mentees besides time management because there’s a strength in both of them needing help in the same thing, and there was also strength in them needing different things.*

*At some point, you may just get too many [mentees], and you no longer have time to make individual connections. . . . If you’re trying to help someone through what they’re struggling with, I think if you have more than two or three people, it’s going to [be] really challenging. My personal cutoff would be three [mentees].*  

In addition, some mentors discussed the intentional pairing of mentors and mentees using a strengths-based model. One commented:

*[The project] should think of the strength of the mentor and connect that strength to the place of growth for the mentee. For example, I’m really strong with my bilingual students. . . . So let’s say you have a first-year teacher assigned a bilingual class, and*
they’re freaking out, then [the program] should assign that [mentee] to me. I think finding the weakness or strength of the population as a whole for peer-to-peer is really important.

All mentors shared a desire to meet mentees in person, and some expressed interest in meeting mentees prior to the start of the school year. Said two:

For the mentees that are in the city, having a chance to meet up with them in person at the beginning of the year for anyone who can make it to the museum [would be good].

Meeting before the school year starts in August so that you can look at how they have their curriculum laid out for the year [would be good]. That was one thing I struggled with my first year.

Several mentors expressed an interest in increasing their interactions with each other. All enjoyed the breakout-room structure the program used during the end-of-year meetings, which allowed mentors to interact with other mentees and mentors, and they hope those opportunities continue. To have additional interactions with each other, mentors suggested mentor check-in meetings or changing the structure of meetings to allow two mentor-mentee pairs to collaborate during what was previously individual mentor/mentee pair time.

**SUMMARY AND RECOMMENDATIONS**

The MAT-ESRP has much to celebrate as Year 2 draws to a close. Despite formidable challenges imposed by the pandemic, the program made progress on all goals. Although program faculty and staff continued to work remotely and classes (as well as schools) were online for much of the time, Cohort 9 residents progressed through the program, graduated, and are now teaching. The Mentor Academy shifted online as well, and the program even discovered some advantages in the online approach. As a result, program staff were able to support mentors throughout Year 2. The program also piloted a new peer-to-peer mentoring initiative, pairing program alumni with Cohort 8 teachers for meetings throughout the year. And particularly important, the program successfully recruited Cohort 10, with 15 new residents beginning in June.

Throughout Year 2, the program worked to integrate CT into courses, one of the TQP project’s primary innovations. Program leaders arranged for instructors of two focal courses to meet with Irene Lee and discuss course revisions. Discussions during full faculty meetings were also devoted to the topic. In addition, the program identified a short course on CT and offered to pay the registration fee for faculty and alumni. At the project’s request, HRI produced a review of literature on incorporating CT in courses for future teachers.
Course instructors for the two courses targeted for CT innovation see abundant opportunities to integrate CT with their existing content. They also identified challenges, including (1) uncertainty about how the program is operationalizing its definition of CT, (2) the sense that CT is an add-on (as opposed to an integration), and (3) the difficulty of adding content to courses that have already-packed syllabi. They would appreciate more time to work on integration individually and with their faculty colleagues.

As noted above, the program successfully recruited Cohort 10. At the project’s request, HRI surveyed those who had expressed interest in the program about factors that encouraged and discouraged them in deciding whether to apply. The survey identified several encouraging factors, including the Earth science focus, the museum setting, the location, and the stipend. It also identified factors that discouraged applicants, some of which the program has no control over (e.g., the GRE requirement). Two factors the program does control have already been addressed: the application fee has been lowered from $50 to $10, and the application portal has been revamped to speed the completion process. The program also continued to refine the process of evaluating applications. For example, program leaders consulted with other programs about their application process. They also revised the interview process to focus on the most important information for making acceptance decisions.

Despite the pandemic and associated challenges with recruiting, the program planned for expansion. A new partner school was added, which allowed greater choice for residents and expanded the program’s capacity. The program also piloted a new effort to expand mentoring capacity, pairing new teachers from Cohort 8 with alumni teaching in NYC schools. Feedback on the pilot from peer mentors was very positive. They appreciated the opportunity give back to the program and stay connected to the museum. They also felt the experience benefitted them as teachers, as they heard new and different perspectives on problems they encounter in their own teaching.

Again, the program has much to celebrate. In the spirit of a critical friend, HRI offers the following for consideration as the program seeks to continue improving.

➢ **Consider creating time for faculty to work together to decide how to address CT competencies in their program activities.**

Faculty believe they have the expertise collectively to create strategies for helping develop residents’ CT understanding and preparedness to support students’ CT understanding. They also recognize existing structures they can use for this work, including faculty meetings and workshops. The focal course faculty would also appreciate time to problem solve together about what integrating CT in their courses would look like, recognizing that they feel their courses are already overburdened with content for the time available.
➢ Consider a CT progression across the two courses targeted for CT innovation. One faculty member discussed the possibility of using an agreed-upon definition and competencies to construct a progression across MAT-ESRP courses. Advantages include greater coherence and the potential of multiple courses sharing the load of developing residents’ CT capacity. Such a progression could also be a significant contribution to the field. MAT-ESRP is unique in many ways, but other STEM-focused teacher preparation programs exist and would benefit.

➢ Consider intensifying efforts to build college/university connections in the Earth sciences as a means of expanding the applicant pipeline. The program already advertises through AGU and GSA (e.g., through advertisements and booths at conferences), as well as recruitment efforts through LinkedIn, alumni, direct mailings, and additional strategies. The fact that 1 in 6 people who responded to the applicant survey heard about MAT-ESRP through a current or former professor suggests these efforts are bearing fruit. They are also strategic, as applicants who hear about the program through a professor are more likely than others to meet the Earth science requirements for admission. The program might explore ways to build more connections with faculty in the Earth sciences. One approach would be to convene a focus group of such faculty from other institutions and ask their advice on effective ways to recruit applicants.

➢ Consider matching peer mentors based on mentor strengths and mentee needs when possible. The peer-to-peer pilot was a success by all accounts, both in the outcomes and in generating ideas for future iterations. Mentors suggested taking their strengths and the new teachers’ needs into account when creating the pairings. Clearly, such an approach would require gathering information from both groups, but the effort may pay off in outcomes for mentees. Interviewed mentors also seemed comfortable being paired with more than one new teacher but cautioned against pairing with so many that the mentors could not meet the needs of their mentees.

References


APPENDIX A
APPLICANT SURVEY
MAT-R Faculty Computational Thinking Survey

This survey asks about your experience applying to the American Museum of Natural History’s Master of Arts in Teaching Earth Science Residency program. Each person who completes the survey will receive a $15 check as a gesture of appreciation. The survey should take about 20 minutes to complete. Horizon Research, Inc., (HRI) is conducting this survey as part of an external evaluation of the program. HRI will report results of the survey to the Museum, but individual survey responses are accessible only to researchers at HRI. Your name will not be included when HRI reports results. Although there are no anticipated benefits for you personally, your responses may improve the application and admission processes at AMNH and other teacher preparation programs.

The last question on the survey asks for contact information so that we can send your check. Your response to that question will be separated from all other information you provide.

Survey questions

1. How did you hear about the program? (RQ 1a)
   [Select all that apply]
   a. Recruitment postcard
   b. Recruitment email
   c. Museum website
   d. A different program at the Museum
   e. Program graduate or current resident
   f. Friend or relative who works at the Museum
   g. Current or former professor
   h. Academic advisor
   i. Coworker
   j. Professional organization conference or newsletter [fill in]
   k. Social media [fill in]
   l. Internet search
   m. Other, please specify [fill in]

2. How did each of the following affect your decision to apply to the program? (RQ 1)
   [Rate on a scale of “Prevented Me from Applying,” Strongly Discouraged,” “Discouraged,” “Slightly Discouraged,” “Slightly Encouraged,” “Encouraged,” “Strongly Encouraged”]
   a. Focus on Earth science
   b. Focus on urban education
   c. Focus on high needs schools
   d. Program length
   e. Program location (New York City)
f. Museum setting for program

g. School residency requirement for program

h. Teaching requirement after graduation

i. Program stipend/fellowship

j. Cost of living

k. GRE requirement

l. Prerequisite science course requirements

m. GPA requirement

n. Application fee

o. Time/effort required for application

p. Support offered after graduation

3. *Did you complete an application to the program? [Yes/No]*

4. [For those who answered No to Q3] Did any of the following influence your decision to not complete an application to the program? (Select all that apply) (RQ 3)
   a. Could not commit to the 3-year teaching requirement
   b. Made other work/school plans before completing application
   c. Have prior education degree and/or teacher certification
   d. Other reason not previously mentioned, please specify: [fill in]

5. Please rate your agreement with each statement about the application process:
   Scale: Strongly Disagree, Disagree, Agree, Strongly Agree; include a “Not Applicable” option

   a. Steps for completing the application were clear. (RQ 2b)
   b. Deadlines for providing application information were clear. (RQ 2b)
   c. Admission requirements were clear. (RQ 2c)
   d. Information on the program website was easy to find. (RQ 2b-c)
   e. The information session helped me understand the application and admissions process. (RQ 2b-c)
   f. The information session helped me understand what the program consists of. (RQ 2d)
   g. The information session helped me understand funding and the post-graduation service requirement. (RQ 2d)
   h. Program representatives were slow to respond when I contacted them. (RQ 2d)
   i. Program representatives provided full answers to my questions. (RQ 2d)
   j. The eligibility/transcript review helped me understand if I was qualified for the program. (RQ 2c)

   k. [For those who answered “Yes” to Q3] I was kept up to date about the status of my application. (RQ 2d)

6. *[For those who answered “Yes” to Q3] Did you participate in an admissions interview? [Yes/No]*
7. **[For those who answered “Yes” to Q6]** Please rate your agreement with each statement about the interview process:
   
   Scale: Strongly Disagree, Disagree, Somewhat Disagree, Somewhat Agree, Agree, Strongly Agree (RQ 4)
   
   a. The purpose of the interview was clear.
   b. Scheduling the interview was easy.
   c. The length of the interview was appropriate.
   d. I knew what to expect before the interview began.
   e. Interviewers showed interest in what I had to say.
   f. Interviewers made an effort to help me feel comfortable during the interview.
   g. I understood the interview questions.
   h. Interview questions were related to my qualifications.
   i. I had an opportunity to describe my science background.
   j. I had an opportunity to describe my teaching background.
   k. I had an opportunity to describe other strengths I would bring to the program/classroom.
   l. I had an opportunity to ask questions.
   m. Interviewers answered my questions.
   n. After the interview, I understood what the next steps for my application were.

8. **[For anyone who responded Strongly disagree, Disagree, or Somewhat Disagree to length question]** Was the interview: [Choose one: Too long  Too short] (RQ 4)

9. **[For anyone who answered “Yes” to Q3 but, based on the participant spreadsheet, was not accepted]** Please rate your agreement with the following statements: (RQ 5)
   
   a. I received the admission decision in a timely manner.
   b. I understand what would have made my application more competitive.
   c. I feel the admissions process was fair.
   d. I know who to contact with questions about the decision process.

10. **[For anyone who answered “Yes” to Q3 and was offered a residency but, based on the participant spreadsheet, declined or dropped]** What were your reasons for choosing not to enroll in the MAT program? (RQ 5)

11. **[For anyone who answered “Yes” to Q3 and, based on the participant spreadsheet, completed an application but was not accepted OR who was offered a residency but declined]** Would you be interested in reapplying to the program in the future? [Choose one: Yes/Maybe/No] (RQ 5)

12. How was your application/admissions process affected by COVID? (RQ 2a)

13. Please describe any part of the application/admissions process that went particularly well. (RQ 2a)

14. Please describe any part of the application/admissions process that was particularly challenging. (RQ 2a)
15. Do you have additional thoughts about the application/admissions process you would like to share? (RQ 2e)

[new page]

16. With which gender identity do you most identify? (select one) (RQ 6)
   a. Female
   b. Male
   c. Transgender Female
   d. Transgender Male
   e. Gender variant/non-conforming
   f. Not listed [text box]
   g. Prefer not to answer

17. What is your race/ethnicity? (select all that apply) (RQ 6)
   a. American Indian or Alaska Native
   b. Asian
   c. Black or African American
   d. Hispanic
   e. Native Hawaiian or Other Pacific Islander
   f. White
   g. Prefer not to answer

18. The following information will be used to send your check. Responses to these items will be separated from all other information you have provided.
   a. Please enter your name as it should appear on the check:
   b. Please enter the address to which we should mail the check: (Street 1, street 2, city, state, zip, country?)
APPENDIX B
LITERATURE REVIEW
The American Museum of Natural History (AMNH) is currently preparing the ninth cohort of Master of Arts in Teaching Residency Program (MAT) residents. With support from its 2019–24 Teacher Quality Partnership Program (TQP) grant, AMNH intends to increase its focus on computational thinking (CT) within the MAT coursework and activities. As part of the external evaluation of the TQP grant, Horizon Research, Inc. (HRI) conducted a literature review about preparing pre-service teachers for instruction related to CT. In particular, we aimed to identify what is known about preparing pre-service teachers to address CT in discipline-specific contexts.

This memo contains a description of how the literature review was conducted, the main findings, and examples of how others have incorporated CT into pre-service teacher education. The final section includes formative feedback about developing CT innovations for the MAT, informed by this review.

**Literature Review: Identifying Related Peer-Reviewed Literature**

During fall 2020, HRI evaluators conducted a widespread search of recently published literature, with the aim of identifying works that discuss CT within pre-service teacher education. The initial search was conducted using Google Scholar and university library catalogues, using key words and phrases such as “computational thinking in teacher education,” “pre-service teachers and computational thinking,” and “teaching computational thinking.” We identified approximately 50 works as potentially relevant to the Museum’s plans. However, many of these works addressed in-service professional development related to CT, as opposed to activities for pre-service teachers, or CT activities in general education or computer science courses rather than discipline-specific education courses.

HRI evaluators then read abstracts and coded each piece of literature to indicate its relevance. Thirteen articles were deemed highly relevant and selected for full review. The following findings and recommendations are largely based upon those 13 published works.

**Key Findings**

Our review revealed a gap in the literature related to CT within pre-service education programs. There is a substantial body of literature related to in-service professional development activities targeting CT skills, but very little related to pre-service activities. This gap suggests there is an opportunity for AMNH to share about experiences with incorporating CT into pre-service teacher education courses.
Our review revealed that researchers and educators used a wide variety of definitions for CT. Many of the works loosely characterized CT as the set of skills that computer scientists frequently use in solving computational problems. Csizmadia and colleagues (2019) summarized approaches others had used for defining CT: “it is a set of skills to help solve problems (Wing, 2006), it is a thought process (Aho, 2012), or it is a problem-solving process (Voogt, Fisser, Good, Mishra, & Yadav, 2015)” (p. 44). They went on to define CT as a set of thinking skills falling into the categories of abstraction, algorithmic thinking, decomposition, evaluation, and generalization; these skills originate from computer science tasks but are distinct from computer science. In addition to the many definitions of CT found in the literature we reviewed, the Next Generation Science Standards (2013) and K-12 Computer Science Framework (2016) also provide definitions of CT specifically intended for K-12 classrooms.

Several of the articles argued for merits of including CT into pre-service teacher education and for situating CT in discipline-based activities, as AMNH is doing. For example, Chang and Peterson (2018) describe teachers’ use of educational technology as greatly influenced by their experience within their preparation program, warning that many teacher education programs lack essential training and support. They note that many scholars have argued for integrating CT skills into other disciplines and existing courses (such as math and science), rather than trying to make the time for a separate computer science curriculum. Similarly, Sengupta and colleagues (2019) note that preservice teachers often have no prior experience in computational modeling and programing. They suggest incorporating CT through computational models related to science: “Rather than learning computer programming as a separate discipline, as Yadav, Stephenson and Hong (2017) also argued, we believe that in their science-methods courses, preservice teachers could be introduced to computational thinking through computational models” (Sengupta et al., 2019, p. 180).

In works that described specific CT activities for pre-service teachers, educators incorporated CT in various ways, ranging from hour-long interventions to entire courses devoted to learning the skills. Very few of the interventions were discipline based, in contrast to the MAT’s inclusion of CT in science content courses. However, some of the single- and multi-day lessons took place in content courses or were designed for pre-service teachers to explore ways they could align the CT skills within a subject area.

The literature also mentioned many challenges related to incorporating CT into pre-service teacher education. In a synthesis article about previous work and expert opinions, Li (2020) outlines two challenges that educators and researchers are facing that are relevant to the MAT’s work. The first challenge is gaining buy-in from all stakeholders, including faculty, students, administration, and mentor teachers. The experts Li consulted agreed that “helping them [stakeholders] understand the significance of CT for its democratic value” (p. 7) can increase buy-in. The second challenge was that faculty members may not be prepared to incorporate CT into programs. Experts recommended that online and blended professional development (with
many different types of faculty members) could be used to increase faculty members’ understanding of computational thinking skills.

**Examples of Computational Thinking in Pre-Service Teacher Education**

In this section, we present short descriptions from the literature illustrating a variety of ways that pre-service teacher education programs added CT activities to their curriculum.

Sengupta and colleagues (2019) investigated how pre-service science teachers can be exposed to CT and modeling through computer simulations and games. The two-day intervention took place in an education methods course for pre-service teachers in a two-year, post-degree program specializing in secondary science. The pre-service teachers work in groups of two or three on altering parameters for simulations or games that the researchers had created. The first day, the pre-service teachers worked on a Lunar Lander simulation and game, and the second day they worked on a Bird-Butterfly-Flower simulation. Both activities were framed as “playful pedagogical exercises” (Sengupta et al., 2019, p. 185), and the pre-service teachers were asked to engage with the activities from the perspective of their future students. After engaging with the activities, the pre-service teachers were asked to work with their partners to redesign the activities to address challenges they faced or deepen understanding. The pre-service teachers in this example did not have extensive coding experience but were able to manipulate simple code as part of the CT activity.

To introduce CT to K–8 pre-service teachers, Zha and colleagues (2020) created a flipped learning unit in an undergraduate Educational Technology Course. The pre-service teachers were assigned out-of-class readings and tutorials in a block programming application called Hopscotch a week before the in-class component. During the 75-minute class, they were given an individual quiz and then were allowed to discuss and submit the quiz in teams. Then, in pairs, the pre-service teachers did a CS and language arts activity in which they created a digital story in Hopscotch to explain an idiom. Although the approach—a single activity in an education course—seemed to go well, the researchers noted that there was some pushback from the pre-service teachers: “[S]ome students still held a stereotype that they were not trained as a CS major, and thus, CT should not be their field of teaching. This belief possibly prevented them from developing a positive learning attitude toward CS/CT” (Zha et al., 2020, p. 19). This example suggests that motivating interest in CT among the pre-service teachers is an important element of their preparation.

Bean and colleagues (2015) found that participating in three 2-hour CT exercises with ties to music, art, and literature content increased pre-service teachers’ self-efficacy related to CT. The intervention was intended to address a concern that teachers may not focus on CT due to demands for testing performance. The three exercises used Scratch (an introductory block programming language aimed at children) to explore music, animation, and shapes, and the pre-service teachers were tasked with identifying standards associated with each exercise. For example, in Scratch Music, the students programmed a song, which taught them sequences,
events, operators, and parallelism. Although some testing and debugging skills were also used, the activity as a whole was very different from traditional coding exercises. In Scratch Play, students adapted a one-page script into an animation, and in Drawing Shapes, they used Scratch graphics to draw shapes. Finally, the pre-service teachers had an in-class discussion about how Scratch can enhance learning in their future classrooms. Evaluation showed that pre-service teachers enjoyed the experiences and increased their self-efficacy in computational thinking. The authors noted that linking CT and other content was beneficial: “This approach comes with additional benefits: it emphasizes the nature of CT as a process to be utilized rather than an end unto itself while also grounding the use of CT within the student's pre-existing sphere of experiences” (Bean et al., 2015, p. 2).

Chang and Peterson (2018) described incorporating CT into two educational technology courses for Master’s of Education students, along with some junior- and senior-level undergraduate students. Computational thinking was embedded into these courses through a short introductory lecture about CT, an hour-long exploration of stations that included robots and “unplugged” CT activities using board games and books, and an extension project consisting of reflection on CT in the classroom or identifying a CT resource. The researchers recommended strategies based upon their experiences: 1) provide practical/tangible examples of how pre-service teachers can use CT in their future classrooms, 2) allow pre-service teachers to experience CT from a learner’s perspective, 3) describe career opportunities for people who have computational thinking skills and share the importance of preparing students from underrepresented groups for computational related careers, and 4) make the activities purposeful by allowing pre-service teachers to learn relevant content.

**Recommendations**
Based on the literature review, we offer the following recommendations for the project’s consideration.

- *Establish a definition for CT as it will be understood in the MAT program and guidance for course instructors.*

The review revealed the variety of definitions for CT taken up by educators and researchers. Establishing a clear definition of CT for the MAT program will help guide instructors to move forward with innovating CT activities into the existing curriculum. Such a definition might use NGSS practices 2 and 5 as a starting point, supplemented by feedback from Dr. Lee and informed by the K-12 Computer Science Framework. Then, a backward design approach could identify additional guidance for course instructors: First, consider what residents should know and be able to do in relation to CT do upon completing the program. Then, consider what residents will need to learn during the program. Finally, consider what else faculty members will need to know to develop appropriate learning experiences across the MAT program.
Engage residents in discussion about the benefits of CT. Articles included in the review highlighted the importance of buy-in from all stakeholders, including the pre-service teachers. Consider engaging residents in discussions early in the program about the benefits of CT skills and how CT can be applied in their future teaching. These discussions could prepare residents for the CT activities that they will encounter during the program, prime them to think deeply about how these experiences can inform their teaching, and increase the likelihood of buy-in and excitement related to learning and practicing CT skills.

Use expert feedback. Irene Lee has met with the general faculty and with faculty members who are teaching the courses targeted for innovation, and we suggest that both types of meetings continue. This access to an expert in the field of CT skills is extremely valuable for the MAT program. Consider soliciting additional feedback from Dr. Lee on the draft definition of CT and on plans for engaging residents with CT. She may be able to provide feedback about what skills to focus on, the design of new activities or assignments that include CT, or the development of CT skills over the course of the program.

References
Items marked with an asterisk (*) were included in the literature review.


