Pivoting in a Pandemic:
An evaluation of the American Museum of Natural History educational programming
during the COVID-19 pandemic-related closure

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*For internal readers, appendices by program are also available upon request

AN UNPRECEDENTED CLOSURE

On March 13th, 2020 the American Museum of Natural History closed its doors to the public for the first time in history due to the public health emergency brought on by the COVID-19 global pandemic, alongside other New York City cultural institutions including the Metropolitan Museum of Art, the Museum of Modern Art, the Guggenheim, Carnegie Hall, the New York Philharmonic, the Metropolitan Opera, and countless smaller museums and cultural institutions (New York Times, March 12, 2020).[1] Just a few weeks afterwards, the New York City Department of Education followed suit, moving all in-person public school learning to remote learning and online platforms on March 23rd, 2020. News of the pandemic had surfaced in early January and February with reports of the novel coronavirus emerging in Wuhan, China. Over the course of February and early March, the public health dangers increased, the spread of the virus was not contained or even well understood, and during that short 6-week period, institutions throughout the country--and globally-- closed their doors in an effort to help contain the spread of the virus.

During this unprecedented time, museum staff in the education department were faced with the most unique and never-before experienced challenges, of trying to first adjust, and then re-define, re-invent the learning experiences, resources and materials for parents, children, teachers, families and the public. With no way to anticipate the length of time of the crisis, the potential impact it might have, nor the best ways to support, reach and work with families--themselves struggling to adjust to quarantining, remote school and remote work. While museum staff hoped the closure would be temporary and short-term, data about the virus was only in the early stages of being collected and analyzed, little was known about the nature of the spread of the virus. No clear pathway to re-opening existed--and so many unanswered questions were emerging.

Further adding to the challenges was the financial impact of the pandemic upon the museum, and in turn, on staff. The longer the museum remained closed, the more revenue was lost. As museum leadership--and that of other cultural institutions as well--

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[1] Based on archival research from the museum's Director of the Department of Library Services, Thomas Baione, who found that the museum has never been closed to the public in its history for more than a few days--with the possible exception of the period of time early in the museums' establishment when it moved in 1877 from the Central Park Arsenal to its current home at 79th Street. During the depression and World War II, some halls were closed or in rotation, but there was no time when the museum closed for a lengthy period. The museum has closed due to electric blackouts; Annual Reports show a closure for a day in 1965, 1977, in 2003, and for Hurricane Sandy for a period of three days from October 29-November 1st, 2012. The only other short-term closure was after 9/11, when the museum closed for the week after the terrorist attacks on the Twin Towers and the Pentagon (Baione, 2020).

had to take stock of the impact, between April and May, 2020, a set of measures were put in place to address the loss of revenue which included reducing staff time; and ultimately, furloughing and letting go of employees (New York Times, May 6, 2020).

Yet under these tenuous and uncertain circumstances, within a short few weeks--in some cases within days of closure--museum educators, designers, publishers and researchers pivoted quickly to design multiple new, online versions of programs, to address and redesign events that had always been in person (graduations, professional learning sessions, alumni events, hangouts) to be moved to remote, online platforms, and to design instruments and materials to document the experience. In this context of invention and creativity, museum staff were working at reduced time--between 60 to 80 percent time--and, in many cases, without some of their valuable colleagues who had been furloughed.

While the span from March 13th to September 9th (when the museum re-opened to the public) has been a period of remarkable strain, uncertainty, loss, and national tragedy, it has also prompted remarkable invention, creativity, collaboration, re-invention, and ingenuity. In this time scientific data about the virus, vaccines, virus prevention, and public safety has been discussed, debated, and examined. The pandemic has been a sharp reminder about the central role science plays in the daily, personal decisions about people's safety. And, the intersection of the pandemic with public education (both in and out of school) has played out in many important ways at the museum by shaping the role the museum can play in a medical crisis, as well as the role the museum can play in educating youth, families and children when in-person learning, and on-site learning, is no longer possible. In that context, the research and evaluation team at the museum (also on reduced time), with the support and participation of colleagues across education, undertook an evaluation to capture and examine, and learn from, the museum education departments work during the pandemic and the closure.

To that end, the purpose of this evaluation is multi-faceted: to document this critical moment in the museum's history in education; to capture some of the choices and decisions made during this remarkable and difficult time; to *reveal* the learning that occurred; to illuminate the creativity and work that took place; and to support further learning and examination that can help strategizing and work in the future--especially as we may continue to require new settings for learning and may be living in a new learning and museum environment even after the crisis has passed.

Research on Education in Emergencies

This evaluation draws upon two areas of research: 1) the education in emergencies literature and 2) evaluations that other museums and cultural institutions are engaged in during COVID-19. The education in emergencies literature is a body of research focuses specifically on schooling during prolonged crises; developed over the last 20 years, it has been led by researchers and practitioners in global development and humanitarian aid (for instance, a number of lessons come from researchers in countries including Sierra Leone, Liberia and Guinea affected by Ebola; but also from reviews of education during periods of armed conflict) (Hallgarten, 2020, Rohwerder, 2020; see also Kurde et al., 2017, Winthrop, 2020). This literature frames education as a critical part of a humanitarian response in a crisis. The literature on evaluations during COVID-19 is naturally new and emergent, but we pull major themes from this developing work as well in order to draw from scholarship and learning from similar institutions at this time.

Education in Emergencies. The scholarship in this area is driven by the commitment to ensure access to free, safe, public education to people affected by emergencies. It includes attention to the prevention of emergencies but also includes attention to supports for recovery as well as learning from a crisis to help prepare better and prevent new crises—or what one researcher called "amelioration, reparation and preparation" (Hallgarten, 2020). In relationship to the current COVID-19 crisis, researchers pointed to relevant lessons from this body of literature (Winthrop, 2020). A central lesson from the education in emergencies literature is that while schools often are provided with guidance on how to assess conditions for closure, safely disinfect, or what to do when a school community member is ill, the guidance "falls short" around conceptualizing educational settings as opportunities to educate the public about public health and disease. In the early stages of emergencies, mobilizing education networks to providing access to life saving information is an important role both in and out of school educators can play. While schools have long been places for sharing information about public health (such as the dangers of smoking), but there are opportunities in this crisis to partner with schools to share information about public health in this crisis related to strategies like handwashing, as well as more in depth education about becoming scientifically literate (Winthrop, 2020).[2] Early reviews of programming other science institutions offered through September suggested a focus upon the science of

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[2] Our research team conducted a brief review of the programming and education related specifically to educating the public about COVID-19, that review is attached as an appendix as well.

the virus and the history of pandemics, but not a focus upon how science changes over time and the process of scientific discovery related to public health crises (Hammerness, MacPherson & Wallace, 2020).

Second, findings from this literature suggest the importance of planning for months (not weeks) of remote learning experiences and school closures. Children and families need support around safety, well being and learning. Still, a key argument made in the literature is that schooling and educational experiences should continue to be aimed at long-term goals, not short term, stop gap solutions. Reviews of the literature from educational efforts in Ebola-affected countries also suggests that there is minimal evidence for paper-based educational supports during school closures; some for lower-tech supports (radio shows); and also limited evidence for online learning, screen based or tablet, or mobile based technology—however, the evidence base in this area is still quite small due and can get quickly out of date, due to the rapid changes in technology over the last several years and the circumstances around online learning have changed considerably even since very recent pandemics (Hallgarten, 2020).

Many epidemics differentially impact low income families and students (World Bank, 2020; WHO, 2009), and while most programs aim to improve both wellbeing and learning, the former may be especially important in disease-related emergencies. Educators are already writing about and bringing to the fore the many unanticipated consequences related to the move to remote learning during the COVID-19 pandemic. Much of the education in emergencies literature focuses upon the need that students have for continuity but also address well-being and the need for connection. During Ebola, for instance, children experienced not only social isolation but also post-traumatic stress. Programs offering psychosocial support seem be to especially effective in sustained impact. There is a stronger evidence base for informal programs offering psychosocial support. A small number of programs for informal learning that included psychosocial support demonstrated sustained impact; for instance, an arts program in Liberia that also included emotional support and attention to well being demonstrated positive impact on children's mental health (Hallgarten, 2020). In terms of changes in the emphasis in schooling there is only some empirical evidence that learning 'outcomes' were affected, but many educators warn that the reform process can be slowed and focus can shift (ACAPS, 2016).

One key finding from the Ebola-affected countries was the loss of hours of learning, which were substantial for Guinea, Liberia and Sierra Leone (486, 582 and 780, respectively) (Statista Research Department, 2015). A second key finding is that parents are underprepared to support children during homeschooling, and to support

their use of technology (UNESCO, 2020) which can widen the achievement gap (Nuzzo, 2020). Sometimes returning to school can cause challenges for children; attendance can decrease after a crisis even when it is safe to return.

Aside from the impacts of school closures, much of the literature also focuses upon psychological stress and trauma that children experience during a prolonged crisis. During Ebola, for instance, children experienced not only social isolation but also post-traumatic stress (Hallgarten, 2020); quarantined children have higher post-traumatic stress scores (Wang, et al. 2020).

Sometimes returning to school can cause challenges for children; attendance can decrease after a crisis even when it is safe to return. To help ameliorate these absences and attrition, scholars in this field advise a "multilayered approach" for children which might include various facets of programming and supports; from technical; to emotional; to educational to community building and maintenance of support networks.

Finally, a recommendation from this literature is that systemic data, evidence and evaluation are long term investments, yet many crises happen without researchers taking time to gather impact evidence. One area in particular that researchers studying the impact of Ebola found was a need for stronger data collection related to shifts in educational efforts during the crisis, which prevented any sustained support for later shifts or learning (Hallgarten, 2020). Scholars in this field argue for the development of richer bases of evidence for efforts so that educators, policymakers, and scholars can learn from them. Researchers in this area point out that making sure we can continue to learn about what is relevant, transferrable and adaptable for long-term crises relies upon ensuring we collect data even in the most precarious times, including disease-related emergencies. They underscore the essential role of evaluation and data gathering during unforeseen events.

Evaluations at museums and cultural institutions. During this unprecedented time, several large-scale evaluations were conducted across museums and cultural institutions in efforts to document and learn from the impact of the pandemic, as well as assess the extent of the outcomes on museum professionals, museums and other organizations, and the larger museum sector. Recent findings from an international survey indicated that 90% of museums worldwide, representing more than 85,000 institutions across 88 countries, closed due to the crisis illustrating the reach and spread of this truly global pandemic (UNESCO, 2020). A commonality across several emerging evaluations on museums during the pandemic is that data collection is conducted over periods of time to capture snapshots (e.g., the initial wave or closure period), followed

by additional periods to gather more recent data. As evaluation studies are recent and emerging, findings only on the first stage of the crisis are being released. A few studies were designed to focus on the initial impacts of COVID-19 on museums and cultural institutions and how they are adapting during this time (AAM & Dynamic Benchmarking, 2020; UNESCO, 2020), while another large-scale survey concentrates on the effects of COVID-19 on the public in terms of their experiences and responses, as well as how museums are serving their communities during this time with implications for future visitorship (LaPlaca Cohen & Slover Linett Audience Research, 2020).

In effort to document and illustrate the current and impending conditions of museums during the initial stage of the pandemic, three large-scale studies in May and June 2020 surveyed hundreds to thousands of museums both internationally (UNESCO, 2020; ICOM, 2020), across the United States (AAM, 2020), and regionally (Winikates, 2020). One of the objectives in surveying about the current state of museums was to not only assess the impact of the pandemic but also advocate for financial support for recovery. For instance, AAM's (2020) national survey of 760 museums captures current conditions, reopening plans, services provided to communities, and financial impact to provide documentation when seeking emergency economy relief funding from Congress. Findings indicate that a little less than half of the museums had taken actions to layoff of furlough between 20%-100% of their staff, with nearly two-thirds predicted further reductions in education, programming, and services in relation to staffing and budget difficulties (AAM, 2020). Only 41% considered reopening with reduced staff. In fact, one third of participating museums either confirmed or were unsure of "significant risk" of permanent closure without financial relief, and 87% had less than 12 months left in their operating reserve (AAM, 2020). Another international report suggests that educational programming and projects will be reduced in at least 80% of museums, and even more drastically in areas of Africa and Pacific where there could be an estimated 93% in reduction (ICOM, 2020).

Across studies, it is evident that many museums are quickly adapting to online environments to stay connected with communities and audiences. This shift was considerable, in light of findings about prior museum priorities: a survey of art museum directors launched in February, 2020, revealed that under 50% of museum directors considered providing digital experiences for audiences unable to visit the museum in person as a 'priority' (Sweeney & Frederick, 2020). Data suggest, however, that throughout the closure, 75% of participating US museums provided educational resources and programming online for children, parents and teachers (AAM, 2020). Examining how museums across the world are quickly adapting, particularly during lockdown, UNESCO (2020) documented 600 references to developing a digital

presence, noting online activities and programming ranging from using digital resources developed before the pandemic, to leveraging content and activities for social media networks, to new programming and virtual tours. ICOM's (2020) study reports an increase in online activities and programming in at least 15% of museums including digital collections and exhibits, live events, podcasts, newsletters, quizzes; a particular surge in social media is reported amongst nearly 50% of participating museums. Yet, the digital divide and inequities related to access is severely apparent with only 5% of museums in many African countries and Small Island Developing States able to provide online content (UNESCO, 2020).

In June 2020, LaPlaca Cohen and Slover Linett Audience Research released key findings from a special edition of a national survey designed to learn how cultural and arts organizations can address public experiences, perspectives, and responses related to the pandemic. Findings from the first wave, based on approximately 124,000 respondents from 653 participating cultural and arts institutions including 336 museums across the United States from April 29 to May 19, 2020 (LaPlaca Cohen & Slovett Linnett, 2020). The Culture Track study focuses on impacts of the pandemic, what respondents report doing remotely, what they miss most from cultural experiences, digital trends, and explores what respondents are looking for from arts and cultural organizations during this time and upon reopening. For instance, data show that 53% of respondents participated in one or more cultural activities offered virtually during this time (LaPlaca Cohen & Slovett Linnett, 2020, p.16). Amongst the top five online cultural activities that respondents participated in include recorded performances from before the pandemic, streaming live performances, children's activities (also what more than three quarters found most valuable), workshops or classes, and podcasts (LaPlaca Cohen & Slovett Linnett, 2020, p.16).

While the majority had not yet planned cultural experiences for after the quarantine, findings indicate that most respondents are looking for activities they consider 'fun and lighthearted' or 'beautiful'; with less interest in those that are social and participatory (LaPlaca Cohen & Slovett Linnett, 2020, p.16). Similarly, more than half of respondents want cultural and arts organizations to help their communities 'laugh and relax' and remain connected during this time, however there was notable interest in the role that museums and other organizations can play in educating children during school closures (p.25). Considering how cultural organizations can improve in the future, three of the most common responses included 'more fun,' 'support of local artists, organizers, etc.,' and 'friendlier to all kinds of people' (p.31). Implications from the first wave of the Culture Track study include four main foci for museums and cultural organizations to consider: 1) health and safety, 2) empathy and well-being, 3) inclusion, and 4) online

offerings as a 'virtual gateway' that may also attract broader audiences (LaPlaca Cohen & Slovett Linnett, 2020, p.33).

On an institutional level, many museums, cultural institutions, and informal science institutions are currently conducting evaluations and surveys during this time to learn more about experiences from communities, visitors, museum professionals, as well as transitioning ongoing studies to virtual formats (Online Experience Evaluation Group listserv created by Visitor Studies Association; cite webinars and newsletters). Similarly, many museums are collecting data on online educational programming and resources, particularly in relation to information about the COVID-19 pandemic. For instance, the Science Museum of Minnesota recently released a report from a study supported by an NSF RAPID grant designed to help provide information about the pandemic to families through online podcasts and resources to answer children's questions about the pandemic in hopes of easing their worries and uncertainties through increasing understanding and supporting conversations (Nelson et al., 2020). Webinars, web chats, and other virtual learning opportunities with researchers and evaluators across institutions have examined topics such as conducting community-based research, focus groups in-person and online, remote formative evaluation, and understanding visitors' behavior online. Several museums are also studying efforts related to equity and inclusion to learn more about visitors' perspectives and views of informal science institutions, understanding visitors' sense of belonging, changes toward equity, and museum-community conversations on STEM and racial justice, supported by recent NSF grants (e.g., CAISE website, Science Museum of Minnesota). However, as these efforts are still very new, not much has been written and released yet that is publicly available and accessible. Continuing to monitor the field over the next few months will help to further learning and understanding from museums and other cultural institutions about the shifts they are making and educational programming offered during this time.

Evaluation Goals

Building on the literature on education in emergencies which has underscored the importance of conducting research and evaluation even in a crisis - to help support later learning and enable strategic thinking post-crisis, as well as to plan for the future, and to account for a changed context post-COVID in museum settings. Further, in light of the evaluation findings thus far from similar institutions that suggests the central role our institutions can play in supporting cultural and educational experiences, providing connections and more inclusive experiences that help support and uplift residents at this time, we also sought to better understand the role our natural history museum can

play (as the evaluations from our partner institutions have looked at as well) in this particularly difficult time.

To that end, we undertook this effort to document the work of the education department. Our aim was to lay the groundwork for reflection and future work by gathering systematic data on our work in order to learn from the shifts and changes we made during this time. We also intended to examine any impacts on our audiences from the standpoint of participation, access and equity; and specifically, to understand how and to what degree our outreach to different audiences was sustained and any changes that might have occurred, during this time.

Finally, given the historic and deeply difficult and important period this has been for our institution and our city and nation, we also felt the historic and archival importance of documenting our work during this challenging time. In addition, even as we carried out this evaluation, the political and cultural contexts of the pandemic changed--over time, revealing racial disparities in impact of the virus; and, in May, after the death of George Floyd, and countless others, national protests in support of the Black Lives Matter movement began, and continue even as we write this report. Equity has been central to our research agenda, but the movement has also caused us to continue to ask ourselves how this work can be supportive of anti-racist pedagogies and efforts--while our questions did not focus upon these questions directly, we continue to look at the intersection of our work and our efforts to stretch outreach, to be more inclusive and to draw in and invite more communities and an even more representative membership, as our first evaluation question asks.

Across all our research, evaluation and programming, our work at the museum reflects a deep commitment to broadening access and increasing equity, and to that end, our evaluation looks at participation across all of our different audiences. Through this evaluation, we aimed to capture shifts in who we are able to reach with which types of programming, resources, supports, and efforts. This in-the-moment data collection is especially important to help us demonstrate--and then examine-- how the museum programs shifted to new platforms, how our colleagues continued to do their work under these changed circumstances; and in what ways we found challenges as well as solutions and opportunities.

To reach those goals, this evaluation focused upon three questions that cut across all our education programs--questions that also underscore our Strategic Assessment Initiative and reflect long-standing concerns and investments in our research work:

1. Question one: Who did we serve? Are there any notable trends in terms of which participants have been able to continue remotely with us, especially in terms of possible patterns around inequity, and which have not?
2. Question two: What are participants' experiences and what feedback did we get on their learning experiences during closure and the move to remote programming?
3. Question three: What shifts were we making in our work, and why?

Evaluation Methods

We built this evaluation on programs' previous data collection methods—not adding or creating new data collection requests. Rather, we situated this work into our current practice of data collection and analysis as captured in our current Strategic Assessment Initiative. We began collecting quantitative data on participation (*Question one*) using existing data collection approaches by program. We worked with program directors to gather existing data from surveys, program applications, and any other forms of assessment or feedback with us (*Question two*).

In many cases, however, we worked with program directors to either design new surveys or add questions to existing surveys that specifically addressed any changes in programs or experiences. In particular, when possible, we developed questions that could be asked in multiple programs--for instance, across many programs we included survey questions that asked participants to compare their experiences in person to remote programing. We held brief informal meetings with program directors' to learn about the shifts they are making as well as collect formal documentation of any shifts in the form of writing, strategy plans, and other important programmatic decision making (*Question three*).

While our data naturally do vary by program in terms of the degree to which programs gather information on specific demographics--some programs do not track that information; while others do--this is appropriate given the focus of the programs and depth of relationship with participants over time. Short-term, one day or one hour public programs do not gather substantial information on participants, while our long-term programs for youth and teachers have considerable depth of data, which is appropriate for the design and purpose of these programs. Readers will see that the depth of data collection and reporting, in turn, by program will also vary.

While data was gathered from each program, the research team engaged in several

check-ins with various programs, to touch base on shifts in programming, needs for additional surveys or assessments, and, to ensure the validity of the data. Each programmatic analysis--which are included in this report as individual appendices by program--was shared with program directors and colleagues for review, and to check for accuracy of data and overall reporting of programmatic work.

FINDINGS

Across all areas of work in education, as many programs as could, chose to offer some kind of remote version of their programming. A few programs were not able to offer remote or online versions of their in-person programming, but many of the programs we offered were revised to be offered online within weeks of closure. MAT and Urban Advantage, our two largest and most-in-depth programs for teachers, for instance, shifted to online completely (although MAT then moved to blended/hybrid in August). Gottesman offered a set of professional learning opportunities for teachers which were offered online rather than in-person. Most of the long-term and in-depth programs for youth, including Lang, Science Research Mentoring, and Saltz, moved to remote learning. Programs for young children and families similarly shifted online and offered learning opportunities remotely. Public programs also moved major programs, including Earth Fest, to online versions--and offered 39 online programs across six series. Furthermore, some of our programs and materials and resources (e.g. Seminars on Science, Coursera, Educator Guides, and OLogy) were already online and, thus, no changes were required to make these materials accessible.

A second key shift was the quick and immediate collaboration that occurred across programs; colleagues quickly reached out to different departments and colleagues across centers and programs for help, for resources, to leverage and garner materials from different areas within and across the museum--this was a clear finding across all programs. Many colleagues across education drew upon the expertise already inherent in some programs and centers using online or remote learning, by connecting with or seeking out colleagues with that expertise, or, in the case of those who regularly taught or designed online programs or courses, by sharing knowledge and practice with colleagues.

QUESTION ONE: PARTICIPATION PATTERNS ACROSS PROGRAMS?

Participation did not drop dramatically due to COVID-19/remote learning during the closure. While we were uncertain as to whether participation would change significantly when we moved to remote learning, we did not find that attendance dropped in programs that had to be offered online. For instance, attendance rates for teachers across 13 Urban Advantage courses that were offered online, were roughly 78%, similar to rates from other years. Attendance was also consistent for the UA elementary sequence. Similarly, analysis of youth program data did not reveal lower participation and hovered consistently around 85-95 percent.

On the other hand, in some programs that were designed to be in-person in the fall, participation did drop: for instance, in Science and Nature, approximately eighty families did not continue (out of about 300), due to concerns about in-person and reductions that had to be made in offerings. We are aware that participation in many of these programs may shift in the fall when school starts and teachers have multiple requirements, and an increased teaching load online. Coupled with the intense demand on educators to shift teaching online potentially for the entire year, we expect that we may see a shift in participation from educators come fall and winter.

In some cases, we found slight to considerable increases in participation increased with remote offerings. In some programs we did find some small increases in participation with remote offerings. For instance, an analysis of our youth programs showed that attendance in Lang during the program increased from in-person (87.5%) when shifted to remote (93.6%). Youth educators' observations shed light upon what they noticed about remote participation--noting that aside from connectivity challenges, which led students to drop in and out--they saw considerably good, to full, attendance:

> "I was also very surprised that our attendance is actually a lot better in a virtual space! One of the courses I just finished teaching …. Decode NYC, we got almost perfect attendance. So that's something that we don't see when we are in a physical space in a museum. Although there was almost perfect attendance, but we did have some students who dropped in and out because of connectivity issues. Still among those who signed in in the morning, we got almost perfect attendance."

> "Attendance rates were way better than in-person classes. Almost perfect attendance. We were competing with less other life events (less family vacations to interrupt class), less going on and they didn't have to commute, so almost no one was late!"

"In my classes there was almost perfect attendance everyday this summer. Kids are still hungry to do something. Camera engagement at around 70% which I think is amazing. Speaks to what we try to foster."

In MAT, as another example, attendance for the residents did not change and in addition, we found that attendance increased for both mentors and graduates slightly and one program (the CRE PLG) even increased the number of meetings to adjust for the pandemic and a need to come together.

At the higher range of positive shifts in attendance, public programs had some of the highest attendance at EarthFest at Home as compared to in-person programming. For instance, EarthFest corresponded with the highest single day of traffic on our website--eighty two thousand users logging on compared to twenty-four--many people were going to the page for the Earth Fest events. Across the seven programs, there were more than 8700 concurrent 'live' views, while the total views continue to grow. The new events such as the field trips (Field trip to the Moon, Field trip to Mars) after EarthFest, had the highest concurrent views.

Online public programs and resources all saw increased numbers and participation. For instance, there were 4.7 million Ology page views in Spring 2020 (March – July), compared to 3 million Ology page views during the same time period in 2019. As Table E.1 shows (see Appendix E), a huge jump in engagement in April drove this trend; we might hypothesize that this is the month when the world was locked down due to the pandemic. We were especially interested that Educator Guides and related PDFs (Teacher's Guides and Student Worksheets combined) have continued to be downloaded, even though educators were not visiting the museum. All the other Educator Guides and related materials have received 14,682 downloads since March 15. While this represents a 6.7 percent decrease from the same period last year (15,738 downloads) it is in fact, surprising that the materials are being downloaded at all: these are guides to specific halls, intended to be used in conjunction with a Museum visit. In terms of our online teacher education programs, Seminars on Science and Coursera also had slightly increased registrations and participation as compared to last year.

International participation increased in some cases for some public programming, and other resources and online materials as well. We saw our public programs and online resources and online sites (such as OLogy) with an increase in international views and participation. For instance, Ology experienced an increase in international visits. While the United States has, by far, the most pageviews in both 2019 and 2020, and U.S. pageviews increased by 150% between 2019 and 2020, almost certainly due to the

COVID-19 shutdown (2.7 pageviews compared to 3.9 pageviews). However, other countries had much more dramatic increases in pageviews. Table E.3. (in Appendix E.) shows the percentage increase between 2019 and 2020, with the total number of 2020 pageviews shown as well. Given that typically programs are attended by people who have already attended an AMNH event (i.e. according to survey data, for public programs the majority of attendees are either members or have attended prior AMNH events), this growth is especially important to understand and examine.

Not much evidence of differential or disproportionate participation and registration.
Analysis of data from Urban Advantage, for instance, did not reveal any patterns in terms of boroughs being over- or under-represented in terms of absences or withdrawals from courses. GIS analyses of zip code data of survey participants in Gottesman professional learning opportunities for Chancellor's Day and throughout August offerings also did not reveal major shifts, showing strong concentrations of clusters in New York City. Interestingly, we learned that larger numbers of survey participants from August offerings worked in schools in the Bronx, with higher representation in Districts 9 and 11. Similarly, analysis of our children and families and youth programs did not reveal any shifts in participation that align with race/ethnicity, gender or location. However, this is data we need to continue to examine as the long-term impact of COVID-19 may show up over time, in impacting attendance and participation. As with our analysis of our programs for teachers, we do anticipate and are concerned about potential shifts in participation over time, especially as the data on offerings during the school year data comes in.

In a number of our programs, including public programs and some of our programs for teachers in Gottesman, for instance, we do not regularly collect data from public programs that allows us to look at patterns related to race/ethnicity or gender, so we are not able to examine this question in relationship to some of our programs or the public. For Gottesman, we do find that almost 70% of teacher participants teach in a Title I school, so while we do not have data on teachers' demographics, this data does shed some light upon the demographics of the schools in which they teach.

More experienced teachers and visitors with prior connections to the museum.
Alternatively, for Gottesman, many teachers attending had attended a prior PD at the museum, so we know they have experience with the museum and a connection to it. For Gottesman PD, we also find that a majority of the attendees are more veteran teachers with more than 10 years of teaching experience (61%). While few teachers (only about 5%) had been teaching less than 2 years. This trend is also consistent with

survey data from Public programs, showing that many participants who responded had a connection to the museum and had attended events in person in the past.

For youth, challenges to participation related to lack of up-to-date hardware and connectivity. However, in terms of access to technology and internet bandwidth, we did have considerable anecdotal evidence from youth educators that students in our youth programs were sometimes dropping off and online during courses which was likely disruptive to their learning--this was not something we noticed with other audiences but because it does intersect with our concerns about equity and access, and our youth participants in particular represent a more racially and economically diverse group, this is an important concern. We do not have rigorous data collected on this challenge but many youth educators reported this concern.

Fortunately, educators in the youth programs found that most students had laptops or iPads due to the efforts of the DOE to provide them to anyone who needed one. As one educator noted: "Hardware wise the NYC schools did give out laptops or iPads to students that needed them so that helped even the playing field for everyone so we didn't have to figure out if we would have to give out laptops to our students." However, many youth educators noted a variety of challenges from students' having old computers without new programs or that could not run new software; connectivity that was interrupted; or harder, youth logging in on iPhones which made it harder for the depth of work required for the course or session. As one educator noted, "Students dealt with a number of challenges related to technology: broken headphones/mics, spotty wifi, access only to tablets or phones instead of laptops."

Considerable personal and emotional impact on youth; but good attendance. We were unable to do a rigorous analysis of youth attendance, by zip code or other demographics. Overall, we did not find evidence of considerable shifts in attendance during the closure--in fact, youth educators reported good attendance at this time. As one noted, "We had excellent attendance (equivalent or exceeding in person instruction) and retention." Some youth did leave for short periods of time; however, most students were able to continue with the program. One student, a youth educator noted, stopped going to all virtual school classes and events but was very active in SRMP. Two others took long breaks from the program as they dealt with personal/mental health challenges that were exacerbated by the pandemic.

These examples do not really capture, however, that while youth did not necessarily stop coming to the program, and their attendance was not affected, still, the challenges they faced and the experiences had lived during this period were stressful, and

emotional, and often intersected with grief, loss, tension and anxiety. Not only did students deal with regular, minor stresses related to technology (see above) but they also had to deal with chaotic family life in the background while on Zoom, but students faced personal tragedy and highly stressful personal situations: loss of loved ones, illness of family members, moves, natural disasters such as storms which damaged homes or cut out internet. Students were often tired when joining sessions, either after a day of school on Zoom or early in the morning during the Summer.

QUESTION TWO: FEEDBACK FROM PARTICIPANTS

Visitors

Overall, participants found the quality of programming as well as engagement online to be the same as in person events. Regardless of the program or series, when comparing online to in person events, responses indicate that the vast majority considered their engagement as well as quality of the event online to be the same. Interestingly, this was particularly the case with the quality of Trivia Nights, which were designed for social interactions where players played in teams.

Gratefulness for public resources and programs.

Participants were very appreciative of online programming for public programs. Survey respondents expressed gratitude to AMNH for providing offerings remotely, especially during this challenging time. Viewers commented on how programming was designed with various audiences in mind like adults and families, as well as the fact that the museum was trying something new.

> *General appreciation...well done. Geared for kids but just as interesting for adults. Learned several new things. Thank you!* (Field Trip: *Moon*)

> *I really appreciate the online programming that has been presented during this time. The programs are well-paced, conversational and informative. Thank you for answering viewer questions.* (Scientists at Home: *MarsFest*)

> *This is incredible and important work y'all are doing. Thank you for making science fun, engaging, and accessible. Heaps of gratitude.* (Scientists at Home: *Killer Snails*)

While we do not have data from users of OLogy or the educator guides, due to the lack of opportunity to survey or reach out to participants, we do have some unsolicited data from teachers and parents who initiated contact with the museum and reached out to share experiences and responses and underscored the usefulness of the materials

during the pandemic and quarantine. This teacher remarked: "*I am an elementary science teacher in the Bronx, teaching remotely during the Covid-19 closure. I wanted to send a big thank you for creating the Ology website! I direct my students to your content all the time now. They've enjoyed your articles, videos and games immensely! I truly appreciate your museum keeping kids engaged in learning during these difficult times.*" And from an international visitor to OLogy, this Spanish teacher noted the helpfulness of materials that kept students who were isolated at home, busy with artistic activities: "*Hello, I'm a third-year primary school teacher in Spain and I contact you for the Ology challenge. First of all, I want to thank you for the challenges, you know that children in Spain have been confined at home since March 11, due to the state of alarm and it's very hard for them not to be able to go out, this kind of artistic activities help them to stay excited. I've attached ten drawings because some parents have not been able to contact you directly. I hope things will improve soon in New York.*"

Participants report that online programs are providing more opportunities for learning remotely. Viewers commented that they are finding sessions educational, informative, and that they learned a lot. Several parents also shared how programs offer exposure to various science careers and ways to potentially spark interest in science for their children. Teachers also shared how they had students participate, made connections to content in their classes, and incorporated programs into their assignments.

> *Keep 'em coming! This was great. Especially for remote learning. I made this an assignment for my students. It's nice to hear from experts in the field who can speak to the content we teach in the classroom. I loved it. (Field Trip: Moon)*

> *We really enjoy the child-friendly topics and presentations. It really opens up amazing learning opportunities and creates an interest in a field that may otherwise be off limits to some families. We enjoy the ability to encourage our child's interest in science and space and your presentations are really exciting and inspiring to her! (Field Trip: Asteroid Day)*

Participants want more. Across public programs series, but especially evident with the COVID-19 series, there is immense interest in more offerings on the same topic. Many participants also expressed interest in continuing online programming even after the Museum reopens.

> *I attended the previous Covid 19 panel which was also excellent. I would think having a Covid 19 panel once/month would be terrific and very informative. How do you ensure that this valuable information is spread widely? Government and public health, as well*

as general public should watch something like this. (COVID-19: Vaccines, Testing, and the Science behind the Cure)

Perhaps you could have a continuation of this series, not only by delving into further COVID-19 related topics, but also by revisiting the topics of these two parts with the same speakers in a few weeks. (COVID-19: Vaccines, Testing, and the Science behind the Cure)

Keep up scientists at home. We watch most of them live but love that we can go back and watch any we may have missed. Your speakers and topics are sooo interesting! Please continue the series even after we are all allowed out of our homes! (Scientists at Home: Amazing Mammals)

Participants found programs accessible in multiple and varied ways that allowed for flexible engagement. Comments across sessions indicate that participants found online programs were accessible, which ranged in meaning and interpretation. For instance, participants shared that they: a) could watch programs from any location, b) could view programs at any time since they were online, live and recorded; c) could participate in flexible ways with the ability to pause, rewind, replay; d) could engage with different kinds of behaviors and actions at the same time, such as eating, lying down, walking around; e) found the content clear and understandable (or can replay when needed); f) could see things that are not necessarily visible to others (e.g., scientists, space); and g) could watch programs because they were free. Additionally, several participants shared that they had various medical conditions and found online programming more accessible to them than in person events.

Participants also discussed the importance of hearing from multiple perspectives and voices, and appreciated the diversity of speakers and panelists represented at particular events. As one viewer commented, it was "*Wonderful to have an all-female panel and panelist of diverse ages and ethnicities."* and another posted: *"I appreciate that all panelists were Women of Color. Go women scientists!"* Another visitor noted the importance of diversity as especially critical for youth and children: *"Keep up having the wonderful diversity of scientists participate in this program. Sex, race, ethnicity - connecting this way with the kids that are viewing is necessary."*

The challenges that participants' experienced were largely technical in nature, such as issues with connectivity, glitches, delays, and audio quality. In addition, multiple participants shared the need for more monitoring in the chat box, if questions were unanswered or if internet trolls posted inappropriate comments. There were also several viewers who expressed dissatisfaction with particular platforms such as

FaceBook. Outside of technical issues, a common thread that surfaced was that participants missed being at the museum.

Families and Children

Initially, in March, CFL educators heard a range of types of feedback from parents and families. First, parents expressed strong interest in synchronous learning experiences. Many parents expressed interest in continuing programming online. There was considerable uptake of the activities in the newsletters; families responded with positive emails about the experiences, some sending photos of themselves and their children engaging in the activities in the newsletters.

Strong interest in summer camps that were remote, especially during breaks from school. The majority of parents who participated in the AIS survey indicated that they would enroll their children in future remote camps, if they were offered. Specifically, 55% of families were interested in more remote camps during school year; and 76% of families were interested in more remote camps during breaks.

Caregivers varied considerably in terms of their expectations for online learning for children.
It was difficult to identify patterns in parents' responses regarding successes, challenges and suggestions for the future. Caregivers had vastly different ideas about what they desired in terms of a remote camps experience. Relatively equal numbers commented that they desired more "live" instruction as compared to parents that thought the amount of time on Zoom was too much. For some families, project time was the highlight. For others, project time was not seen as important. In sum, a percentage of parents in CFL did press for continued time on screen, but underlying that push seemed to be a conception that 'seat time' or 'time on task' in a program necessarily meant learning.

Lack of understanding of the role of exploratory time in learning science.
Conversely, some parents expressed an underlying worry that if children had free or exploratory time it was not 'useful' or part of learning, suggesting that some may not be aware of the role of such discovery and inquiry time in learning and in particular, learning science. However, a number of parents also communicated a different response, relaying that they felt that the amount of screen time was appropriate and expressed appreciation that their children were able to participate in discussion and not just sit and listen passively; this reflects some of the challenges we write about in implications regarding the variations in educational visions held by parents.

Youth

Gratefulness for move online. As with our other audiences, parents and youth emphasized their appreciation for online/remote offerings. They recognized what it took to make these huge shifts, and expressed considerable appreciation and understanding for that effort.

Personal and close impact of the virus. Several students or their families contracted coronavirus, and some had very serious cases. In one team, two of the three students had parents with serious cases at different points in the spring. The team was very supportive with one another, and sent pictures and notes throughout. Students reported learning a lot about teamwork and expressed gratefulness for the support of their peers and mentor as their parents recovered.

Challenges with focus and attention. Youth educators noted that a number of students had more trouble keeping track of their schedules, and sometimes missed meetings (most common reason was that they slept through it). Most had more trouble focusing on the meetings than before. Students reported anxieties about the pandemic affecting numerous aspects of their lives, ranging from college applications, graduations, and proms, as well as how to manage being with family in the same space constantly.

Youth appreciated mentoring by a trusted adult. Students expressed gratefulness for the consistency of the programs and, with SRMP, for instance, for the support of their mentor. Having a trusted adult in their lives seemed even more important than before, and they noted that they could see how much their mentors cared about them and put energy into making the work engaging - and flexible to fit the new situation. They also told our youth educators that it was nice to have a consistent project to work on and think about outside of the chaos of school and family challenges.

Youth were grateful for the program; and saw benefits in remote even as they missed the in person. Students reported frustration with some of the technical issues listed above, but they emphasized also the positives aspects of remote learning: fewer distractions from other students, ease of access and no travel. They also appreciated the opportunity to connect with their peers, especially given the isolation they were experiencing. They loved hands-on materials delivered with the kits we sent them, and told our youth educators that it helped them feel connected to the rest of the class. They were very eager for in-person experiences and were very appreciative of the few in-person instruction days offered. A few students said they loved school-from-home, that it reduced their stress and gave them time for hobbies like baking, reading, and sleeping.

Despite the challenges, youth adapted, and creatively made use of online learning's contexts and affordances. As one youth educator noted, "Given all of this, (with rare exceptions) the youth in our programs were incredibly resilient and engaged. They participated however they could, tried to troubleshoot technical issues, and had a lot of fun with digital and hands on (sent via kit) activities, and in conversations in breakout rooms and Zoom chat." Students got creative in ways to keep their SRMP community strong, as one educator reported, "one team planned color coordinated outfits for their zoom meetings. others did show and tell with objects they had at home."

Parents wished for in-person as soon as possible. One other theme that emerged from surveys with parents is that while they greatly appreciated the enormous effort it took to put programs online, they were eager for in-person instruction to begin again. They worried students were exhausted and raised concerns about time on screen. They missed the opportunities for their youth in person.

Teachers
Participants were grateful and appreciative of the quick move to online. UA teachers, for instance, underscored how much they valued the efforts of the program to make their courses accessible online. They highlighted how quickly and efficiently instructors moved the course online and also offered the usual positive feedback and course content and structure. As one teacher noted, "The care, even in the emails, makes us feel respected as NYC teachers felt really good and empowering. The supplies, everything. We don't feel like that every day." (Elementary teacher). Gottesman teachers also reflected surprise and eagerness about the online offerings: "*I was so surprised at the quality of this workshop especially being interactive which I was clearly not expecting. I loved the breakout session; it reminded me of the past inhouse PDs that was awesome.*"

Surprisingly, when asked about the transition to online and the comparison to in-person learning, the majority of Gottesman respondents remarked that their experience in remote learning was the same as in-person in terms of level of engagement in content, quality of discussion, and immediate usefulness of strategies to teaching. In fact, many participants noted some of the benefits to the online format that they felt would have been different in an in-person PD such as accessibility, convenience, fewer distractions, more opportunities to talk with people they might not have otherwise in randomized breakout groups.

The transition of courses from in-person to remote appeared fairly seamless. This was a particular theme in UA, and MAT. In MAT, some residents attributed this to much of the course curriculum already being available online (and, since MAT was already somewhat accustomed to using online platforms like Moodle, certainly that kind of expertise was an important contributor and support). Several residents shared that a positive surprise for them in the shift to online learning was that they were still able to "retain a lot of the information" and "get all of our work done." However, many missed the unique and special setting of the museum, and acknowledged that 'impossible-to-replicate' experience as a loss. As several noted, "*Transition to online has been fine--breakout rooms for discussions have been ultra helpful.*" Another reported, "*I think the online portion was handled well by the instructors but it would be impossible to replace what we had at the museum.*"

Gottesman teachers echoed similar sentiments; as one teacher noted, "*I felt like the transition to online was done very well. It was not difficult for me to remain engaged.*" And another summarized: "*I am excited about the new and relevant resources that I can use in the classroom! As for the Zoom meetings - I feel like it worked extremely well. There was high level of engagement in all the groups that I was in. It helps to have everything digitalized. I would be interested in other PD opportunities like this.*"

Seeing distance learning modeled by AMNH instructors helped participants think about how to improve their own pedagogy online. UA's SIMPL model of professional learning, in which teachers experience the science as learners and then reflect as teachers, allowed teachers to experience remote learning as students of science. Participants, in turn, reflected that their experiences in remote UA PL helped them think about how they could improve their own pedagogy online. In Gottesman and MAT, we heard similar reports from participating teachers. Gottesman survey respondents, for example, were extremely enthusiastic about learning strategies they could use online themselves:

> *I can use the modeling process – both technology (break into groups, collaboration on jamboard, back to the whole group) and content … in my classroom to engage students and encourage collaboration and discussions. (Chancellor's Day participant)*

> *Really like the variety of resources in the lesson, and the variety of lesson formats. I will love to try to reproduce this with my students – everything was great, both in terms of data set, buy-in (suspense!), and pedagogy. (Chancellor's Day participant)*

I will be online in the Fall so having this as an online workshop helped to model aspects I can recreate in my lessons. (August PL participant)

I felt like since we were actually using the tools, it helped me to better visualize how I would use it with my students in a remote setting. (August PL participant)

Strong interest in having AMNH provide more support for online instruction and pedagogy. Across the surveys of MAT, for instance, participants indicated that learning about more online strategies, technology platforms and programs, and resources would be helpful. Participants were also interested in having opportunities in the program to learn from others about online teaching strategies and resources, as one mentor noted, wanting help with "more strategies that can be used with remote learning since this may be the new wave of teaching and learning." In Gottesman, there was unanimous enthusiasm for online offerings: 100% of survey respondents from August sessions expressed interest in participating in remote PL throughout the school year either after school, weekends, or school vacations. As one Gottesman survey respondent noted, "*I want this PD to be brought to schools for whole staff to reflect on to better support our students!*"

Need for flexibility and adaptation for successful learning. Related to concerns about workload, online teacher learners (like everyone) reported many external pressures that affected their coursework - particularly during the Spring session. In SOS and Coursera, for instance, many of the learners had sick relatives, or lost loved ones, or were sick themselves. Many were juggling the immediate transition to online teaching themselves while also caring for children at home. So the courses had a few more learners who needed more flexibility in terms of course deadlines. But since many of the SOS learners were repeat learners, program faculty suspected that they were already familiar with our online format and that format, in and of itself, was not easier or harder because of COVID.

There was no consensus about the optimal balance between synchronous and asynchronous instruction. Some participants felt strongly that courses should run completely or almost completely synchronously; that is, they wanted to be on a video-conference platform interacting with course participants and instructors for the duration of the learning experience. Other participants felt strongly that they were only able to be successful because there was flexibility built into asynchronous learning. Some felt as though they would not have been able to complete the course if it had been entirely synchronous (due to other work or family obligations). Others felt like they did not enjoy being on Zoom and preferred to work at their own pace.

Challenges related to amount of screen time, ability to stay focused, and lack of social interaction. In MAT, residents shared some challenges related to being online for considerable periods of time. Residents reported these concerns, "Staying focused and not getting headaches from the constant screen time"; "Staying motivated during the class session" and "Staring at a screen triggers migraines and then I can't focus." As one summarized, it was very challenging "*Sitting for wayyyyyyy too many hours staring at a laptop screen. So exhausting.*" and another reported, "*Lack of social interaction makes learning hard.*" For future online courses, residents suggested providing options to lessen the screen time, such as shortening the length of classes and increasing the frequency or providing more breaks, and providing slides in advance.

If any dissatisfaction was expressed in programs like UA, it was most often tied to beliefs about the workload of the course. Even if the workload was similar to face-to-face, it is possible that participants felt the weight of the work more heavily since it was occurring entirely at home, whereas Urban Advantage work is usually completed entirely during the face to face session. For instance, 35% of survey participants *somewhat* or *strongly disagreed* that they could complete their work in one sitting. As one teacher reported, "It was a lot of work when it shifted to remote: This course had wonderful content. However, considering the circumstances this was way too much work for a UA course over 2-day workshop."

Gottesman survey respondents also brought up missing personal connection and challenges related to working online while at home. These excerpts capture these concerns:

> *Nothing can take the place of human-human physical interactions. A small percentage of participants didn't show their faces. (August PL participant)*
>
> *Because my Zoom connectivity was impaired, I found it difficult to participate unfortunately. (Chancellor's Day participant)*
>
> *I did enjoy having my own device in front of me, and the ability to work within a setting I am familiar with, but I did not believe the virtual piece adversely affected my ability to converse and discuss any topics with the facilitators or other teachers. I would rather be in person at the museum doing these PDs, however it is good to know they are just as effective online in case I am unable to physically get to the museum. (Chancellor's Day participant)*

> *Being with my child made it challenging to focus – but that is expected! If this took place in the museum I would be more present.*

In only a few cases, participants did feel that pacing was slower or faster from their past experiences. This Gottesman participant noted: "*The pacing was much slower online than it probably would have been in person, particularly due to technology issues. Although I learned a good deal about the content, the pace at the beginning of the online session was very slow and I struggled to remain engaged*" while another participant commented that "*I would have like to have this been longer, maybe over 2 days, 3 hours each.*"

QUESTION THREE: WHAT SHIFTS DID WE MAKE AND WHY? WHAT DID WE LEARN?

All programs
Finding a way to leverage museum resources online. While educators and publishers in many of our in-person programs we offer note that the programs and materials situate their identity, resources and strength in being physically in the museum itself, one key theme was that programs across education discovered creative and thoughtful ways to take full and innovative advantage of the museum materials, resources and other assets. From providing opportunities to roam the museum halls virtually using Google Culture, to involving scientists who were hosting animals at their own homes who could then share them and talk to children about them, to developing panels of speakers who had expertise for visitors, to offering 'field trips' to other planets using OpenSpace, museum educators creatively shifted and devised new ways to use these materials and resources to try to reach their audiences. As one of the youth educators we interviewed explained:

> If I were to step back and think about all the challenges, I think the first one would be creating the content. As a team we had to rethink our curriculum. We are so used to doing hands on projects in the museum and now we are working in a virtual space. So we had to first outline what are the resources we have now in this virtual space? So we first listed out and brainstormed all the possible resources we have virtually and then we began to craft lessons around the resources we had.

In Gottesman, for instance, staff designed sessions for NYC Chancellor's Day teacher professional learning focused on using Museum resources to connect with the science curriculum. In a session on using museum resources to support social emotional learning, teachers made observations and sketched the dioramas in the

halls as a way to focus on perspective taking and critical thinking in teaching and learning as an activity to support understanding of state benchmarks.

Leveraging museum expertise in online learning. A second key theme was the strength in the museum's expertise in remote programming. Due to long-standing online programs already in existence, such as Seminars on Science and Coursera (programs in existence for 20 years), the museum's education department was in a particularly good position as compared to other museums (Sweeney & Frederick, 2020). The education department thus had internal colleagues and programs, with considerable expertise in teaching online that could serve as resources and provide guidance and support. Online teacher education colleagues, for instance, led a set of professional workshops about using Zoom and Zoom pedagogy for remote teaching with the MAT faculty throughout the summer in preparation for the new cohort. Gottesman, as another example, already had courses online that they could then offer in the Fall, having already offered them and were able to use and draw on the tools and resources already created.

Tremendous time and resources needed for the transition to online learning. Despite the expertise and pedagogical strength of the department, educators all emphasized the tremendous time commitment and personnel resources needed to carry out the fast transition to online programming and courses. Even with support, guidance, and colleagues willing to help, the transition to online learning was an enormous shift for most programs, and required re-thinking, and new learning about online instruction (often requiring creativity and self-education by educators). Furthermore, while the department had expertise and strength in online teaching inherent in programs like Seminars on Science and Coursera, there were no existing structures in place for explicitly working with those online educators, or for turning to them with questions or challenges.

The generativity of cross-departmental collaboration. Relatedly, however, another important finding many educators, designers, and colleagues across education pointed to was the value of cross-departmental collaboration. Again and again, AMNH staff noted that they had reached out to researchers or colleagues in other departments in order to do something new or innovative and to draw upon their colleagues' work. For instance, Public Programs collaborated closely with teams in Communications, SciViz, and Science to offer online programming on multiple social media platforms like YouTube, FaceBook, Instagram. Similarly, OLogy staff reported that this was one of the first times they had worked closely with Public Programs and Communications to offer

and promote OLogy Challenges on the website, which appeared to result in a broadening mix of audiences across OLogy which has traditionally been more nationally-based and programs' audience which is more local.

Opportunities to connect key scientific ideas to home and family. A second insight was the value of a strategy many programs--particularly public programs, and programs for youth and children and families-- leveraged to focus upon 'science at home' and to help visitors, children and families to understand, use and connect to materials at home in ways that would help deepen and strengthen their scientific practices, understanding and knowledge. We saw this in the way that public programs supported participants to learn to create "at home" gardens/kitchen gardens, or that the Science and Nature program encouraged children to share something "science-y" they did at home--all were examples of how educators helped visitors, children and families see science in the everyday.

Taking advantage of 'local' assets. Related to this strategy of connecting ideas to home and family, was the realization and insight regarding the important role that museum programs could play in helping leverage the most local of assets. Whereas some of the UA programs, for instance, would have carried out experiences at gardens or the zoo, those experiences had to be translated into online. Instead of taking walks through NYBG, instructors asked participants to take a walk in their own neighborhoods; which also had its own value as participants were able to make connections to their learning in their very own communities or local neighborhoods and blocks. Public programs made similar use of local connections: EarthFest at Home leveraged local partnerships as assets with a botanist at NYBG to learn about plants and gardening, scientist at Lamont-Doherty Earth observatory to present experiments on glacier physics, and NYC Trivia League for virtual Earth Trivia.

Increasing emphasis upon facilitating connection and well-being. Consistent with the findings from evaluations that visitors seek connection and community and with the literature on education in emergencies, museum educators' efforts to shift their programming reflected an understanding that offering teachers, students, families and children --and the public--opportunities to connect and build and sustain community was a special and particularly important programmatic priority at this time. While all programs carried this out in different ways, the emphasis and the particular commitment to make this a goal for remote experiences was clear--and many educators emphasized how especially important this was for them, as part of their commitments as educators and as part of the kind of program they aimed to provide. Across all programs, educators made clear that providing opportunities to see one another, to

check in on one another, was critical and important as a goal. While this looked somewhat different in different programs (office hours in YI programs; office hours for BridgeUp; opportunities for parents and children to connect online in SNP and 'show your pets' to one another; the "chat and chew" for parent coordinators in UA; opportunities to create a design online and share with others in OLogy; continuation of Community Meetings with residents in MAT), all program educators made clear this was of special importance and need during the pandemic when students, families and teachers were so isolated, and with so many in quarantine, this felt critically important.

Communicating a sense of care and emphasizing flexibility. Across all programs, we found that educators were making informed choices about flexibly grading policies, providing more time to complete assignments and experiences. Online teacher education (SOS and Coursera) educators noted that even within their already online offerings, this was an important shift they made to account for working from home, for having additional childcare or school supervision, or for students dealing with illness in the family. Educators emphasized that this was an overwhelming and difficult time for so many people, who have lost loved ones, homes, jobs. In MAT, educators worked hard to develop a responsive and compassionate approach. For instance, they revised the Academic Standing policy for residents to adjust to the environment and take into account the social, emotional, and psychological impacts of the pandemic during this time.

Creating a sense of community online. Relatedly, across all programs, educators were also focused upon what it would mean to create a sense of community online, and implemented many strategies to try to develop that environment. For example, with an interest in supporting the sense of community in MAT, two graduates collaboratively developed and led a series of online workshops for other graduates called "Healing Centered Start to School." The workshops focused on healing-centered engagement and trauma-informed care in efforts to help prepare teachers to return to school in the fall and support students during this time, as well as strategies for building community and fostering connections in an online environment. Gottesman professional learning sessions incorporated tools and strategies for building community online amongst teachers participating in workshops, modeling ways that teachers could then use in their own virtual classes with students in the fall. Emphasizing the importance of cultivating online social engagements to stay connected and creating a sense of being together with others who share similar interests, Public Programs partnered with local TriviaNYC -- a local pub quiz company that develops game nights -- to develop TriviaNights where participants played in teams.

The usefulness of multiple platforms, and potential to take advantage of different advantages of each one. This was especially apparent in programs like YI, UA, SNP, MAT, Gottesman, and Public Programs. Urban Advantage educators, for instance, used multiple platforms including both Moodle and Google Drive for organizing and conducting their online courses. Zoom was the primary video-conferencing software used to conduct synchronous learning. Padlet and Google Jamboard were used for participants to engage in "chalk talk," to record ideas during discussion and to engage in "card sort" style activities, such as the "What Counts as Evidence" activity in the UA Elementary course.

The case was the same for the youth programs. As one youth educator explained:

> We've been using Google Docs, Google Classroom, some really cool functions on Zoom like the annotate function. We've been using Kahoot, we've been using Patlit, and Flipgrid. It's interesting that different tools provide different avenues for learning for different types of students. I've noticed that the quieter students who wouldn't usually be comfortable turning on their mics, are more likely to be more active on a different tool like FlipGrid, where it's easier for them to share their thoughts. So having a nice blend of the different tools can help you reach out to different groups of students.

In MAT, faculty transitioned courses online using Zoom combined with other platforms, such as Google jamboard and padlet. In weekly meetings, faculty discussed techniques and strategies that they tried in their courses, sharing ideas that they had experienced with some success. The program also offered New Visions Google Suite Foundations online training to provide additional tools and approaches to faculty and residents, and extended to mentors and graduates in the fall.

More explicit teaching collaboration. Almost all programs noted the need for multiple educators to support learning--whether for teachers, children or even visitors to public programs. One instructor or presenter is not sufficient for an online class or program; almost all educators noted the importance of having someone leading the class and someone supporting in chat or working with the technology. Gottesman, for instance, created a technical facilitator position for all fall sessions where staff rotate in each other's PLs to provide support. They also established norms and considerations for remote delivery, a document that details plans to incorporate and coordinate technology support in advance of each session to help with any difficulties that arise. Youth educators noted with interest, in particular, the degree to which their

teaching became much more 'visible' to one another, and reflected that the collaboration necessary for online teaching was 'different' from in-person and in some ways more collaborative:

> I feel like we now collaborate in a different way now. The partnership between me and the co-teacher is so tight, it's almost like we are performing a show. So we have to really communicate explicitly, like "OK I'm going to be talking about this part of the topic and then at this point I'm going to pass it over to you." Just because in a physical space it's so easy to give eye contact to communicate or you read the visual cues but in a virtual space you need to be really clear about who's going to be covering what, who's going to be screen sharing when, who's going to be leading this activity, so it's a lot more collaborative that way.

Remote Visitor Learning

Finding a way to leverage museum resources online. While educators and publishers in many of our in-person visitor programs we offer note that the programs and materials situate their identity, resources and strength in being physically in the museum itself, visitor programs discovered creative and thoughtful ways to take full and innovative advantage of the museum materials, resources and other assets. From providing opportunities to roam the museum halls virtually using Google Culture, to developing panels of speakers who had expertise for visitors, to offering 'field trips' to other planets using OpenSpace, museum educators creatively shifted and devised new ways to use these materials and resources to try to reach visitors online.

Opportunities to connect key scientific ideas to home and family and providing authentic opportunities to 'do' science. Public programs focused upon 'science at home' to help visitors, children and families to understand, use and connect to materials at home in ways that would help deepen and strengthen their scientific practices, understanding and knowledge drawing upon materials and phenomenon that might be easily and readily accessible right in the home. We saw this in the way that public programs supported participants to learn to create "at home" gardens/kitchen gardens.

An opportunity to further develop commitment to diverse voices and talents. With a recognition of the criticality of providing multiple perspectives and voices, participants of online Public Programs expressed appreciation for the diversity of scientists and researchers represented following a COVID-19 panel, SpaceFest, and various Scientists at Home programs. Viewers noted the importance of and diverse representation across ethnicity, race, gender, and age. For instance, a program on COVID-19 featured an all-female panel with scientists of color representing various science specializations to

discuss vaccines and testing, implications of the pandemic for health and healthcare, moderated by a science reporter.

The generativity of cross-departmental collaboration. Public Programs collaborated closely with teams in Communications, SciViz, OLogy, and Science to offer online programming on multiple social media platforms like YouTube, FaceBook, Instagram. Similarly, OLogy staff reported that this was one of the first times they had worked closely with Public Programs and Communications to offer and promote OLogy Challenges on the website, which appeared to result in a broadening mix of audiences across OLogy which has traditionally been more nationally-based and programs' audience which is more local.

Cultivating social interactions based on scientific content and materials specific to AMNH. With a concerted effort to not replicate programs online but have offerings that meet people's present needs with experiences that felt uniquely "AMNH" in terms of subject matter, research area and specialization, Public Programs has been thinking about ways to make experiences online feel communal. For instance, Public Programs designed events for group participation, like TriviaNights, to intentionally create activities where participants could socially interact online that built upon scientific content, materials and connections related to the museum. Virtual field trips using OpenSpace is another example in efforts to foster a sense of an online museum community with virtual programs. Similarly, OLogy designed Challenges around scientific content (butterflies, viruses) and practices (spatial visualization) that are a specific focus of AMNH researchers.

Communicating with the public about the science of COVID-19. While several of the offerings during this period were originally designed as an in person event and would have taken place at the Museum under different circumstances (e.g., EarthFest), many new offerings have been developed and featured during the closure. For instance, two panels were developed as part of a series on the science of COVID-19 highlighting new science research as well as the natural history that caused the virus. The two panels explore the origins and spread of the coronavirus as well as the vaccines and testing to advance finding a cure.

Broadening and expanding reach; identifying new audiences. For a number of our online programs, (both public programs and resources like OLogy) we saw an increase in global audiences. Even as programs reached a local audience, we saw considerable growth in a national (and international) audience. For instance, visits to OLogy (as

measured by pageviews) by international visitors were dramatically increased (for instance, most particularly in Russia, Greece, Brazil, and Mexico) even as US visits also dramatically increased. This additional outreach raises important questions about continuing to make these programs accessible and connected to this larger audience, and potentially deliberately cultivating an international one. Looking carefully at attendance for these programs, and use of these online resources, raises new and promising questions about who our audiences are during this time.

New forms of participation possible online.
 In addition, across a number programs, the type of participation shifted. For public programs and OLogy, for instance, educators and program designers noted that they were finding that participants began to play new roles--almost co-creating content and programmatic focus in the moment. During synchronous online events, presenters could respond to Q&A's in the chat and shift the conversation or focus of the experience. Gottesman educators noted a kind of shift as well, in the professional development courses in which participants were productively pushing one another to participate, reminding one another of norms and routines, and eagerly encouraging discussion.

Remote Children and Family Learning
Leveraging museum resources online. CFL educators noted that the identity of the early learners programs, in contrast to some of the programs we offer to teachers and for educators, is deeply tied to the unique space of the museum. How could educators take advantage of the special setting and resources of the museum, and create learning opportunities that translated--or picked up--those aspects into an online, remote experience? Sessions creatively built upon the connections to scientists and the museum: for instance, while an in-person session for SNP might have included a 'behind the scenes' visit to Herpetology with a scientist, these online sessions had scientists talking from home. Dr. Lauren Vonnahme, shared the lizards she had in her apartment at home with the children and families, as part of the "Feature Creature" sessions they might have otherwise done in person.

Opportunities to reveal science in the home setting. For a session for five year olds, educators focused a session on 'signs of spring' --and children were asked to come to the session with something which was a sign of spring. As another example, children would be asked to share with their classmates "who has been doing something science-y." Other activities included read-alouds of science books to children online.

Maintaining a balance between socio-emotional learning and science. A particular emphasis CFL educators noted was making sure that they maintained a thoughtful and age-appropriate balance between a focus upon science content, and socio-emotional learning. This meant that educators were often working to ensure that children felt comfortable, had time to make connections, and also had opportunities to learn key ideas that were developmentally appropriate.

Re-framing parental participation. Typically, participation of parents and guardians has been a hallmark of the program and a key principle for learning. However, with online learning, it was harder to request and carry out parental participation. In some cases, children were participating without their parents (parents would situate the child and then the child would continue on their own) and it was difficult for educators to require this, especially knowing that many parents might be working, or have other children who needed support during online instruction in school or with homework. These observations have led educators to shift expectations about parental participation and to try to accommodate to a less central role for parents in online education.

Distinguishing out of school online learning from 'school' learning. One particular challenge raised by the responses from parents was the wide range--but often narrow-- conceptions of 'what education should look like' online. The variation in aims and purposes expressed by parents was considerable and did not always reflect an understanding of out of school learning. Some parents wanted more time online, others wanted far less. Educators in CFL, for instance, worked thoughtfully to focus upon the materials and setting of the museum and found that especially critical in this effort; as well as a deep focus upon connecting children with one another and families with one another (critical for early childhood learning). However, helping parents understand that balance--and appreciate the role of socio-emotional learning and the importance of communication and connection--was not always easy.

Parents bring many preconceptions about learning for young children, but not a clear vision. Parents not only had strong ideas about what children should be doing, but their ideas varied widely, and were not often based in a vision or understanding of the principles of teaching and learning. This may be consistent with any novice understanding about teaching and learning, as parents, like new teachers may tend to rely on their own 'apprenticeship of observation' (Lortie, 1970) in school and often have a more fixed view of what science learning can and should look like.

Making pedagogical rationale clear to parents helped support a clearer vision. Educators found that making the pedagogical rationale explicit to parents helped tremendously. Indeed, this kind of 'making instructional choices visible to parents' may be a way for AMNH educators to further and continue to help deepen parents' understanding of what science teaching and learning can look like. Going forward, this may be an especially important role that CFL can take in helping develop and strengthen parental visions of good science teaching and learning--a means of teaching parents more about good teaching and learning in science.

Remote Youth Education

Maintaining program principles in online learning. As the CFL educators pointed out, YI educators also noted their main challenge was to maintain key programmatic principles of teaching and learning, in this new online learning environment. As one educator put it, "The challenge was "*How can we stick with the spirit of hands-on, community based, AMNH asset-based rigorous science?* We kept those principles in mind and we found ways to adapt it."

YI educators drew on in-house resources and their larger network to adapt their courses to a remote learning environment. Educators used a number of resources, colleagues, museum scientists and partnerships to help support learning online. As one YI educators reflected: "One saving grace was that we had a consultant on the project (for Decode NYC) , Irene Lee from MIT, who had done similar camps in the past, partially remote. She connected us with teachers who had done remote learning. We met with them, picked their brain. Read about best practices. We also learned from SAP and Lang educators what was working for them remotely, plus what was working in our adult zoom meetings."

Educators noted the steep learning curve teaching online required of them, and dove in with some eagerness and a sense of creativity, even with the urgency. One educator noted he already had prior experience: "It definitely changed how we as a department planned. Luckily for me, I had some prior experience with teaching online learning courses." Another noted, "It came as a surprise to suddenly have to switch gears. Initially it was a culture shock, kind of scary, but also exciting at the same time because we got to explore all these different tools and use all this new software programs to try and engage our students. So it was a mix between being really nervous and not really knowing what to expect and also a challenge in terms of pushing our creativities to a different level."

Different social interactions online. Youth educators noted some of the surprising ways that youth managed to connect despite the lack of in-person opportunities. As one

educator noted: "I was worried Zoom would prevent forming a sense of community. But I was surprised that the students were able to form a sense of community, and even friendships." She acknowledged, "The lack of video of some students at times made things harder. The students did become more comfortable expressing themselves and asking for what they needed as things went on. More inside jokes ….more connection to each other. I was surprised to see that."

Nonetheless, educators noted that some of the value of in-person connections were especially hard to recreate. They relayed continued concerns that youth missed out on valuable in-person interactions and relationship building. As one educator reflected: "I think what they really lose out on is the interaction with fellow friends. It was kind of sad to see that in an online setting you can make friends, but still you are just an 'online friend.' You can't actually have lunch together. You can't actually share materials. So that's where they really lose out. And of course to experience the camp together in a physical space is so different because you get to tour the museum together and you get that immediate feedback with one another in the conversation. And even in a physical space when students might be distracting each other from the task, there is still that social dynamic that is missing from Zoom."

Sensitivity to and understanding of student home environments. Educators acknowledged the more intimate view of students' lives that remote learning revealed, noted an increasing awareness of youth's personal lives and home settings. They underscored the importance of respecting and being sensitive to youth's own home lives and experiences and pointed to the importance of building trust, with youth, in an online context. As one educator noted: "In teaching the online classes, I've become a lot more aware that students have a lot going on in their homes and so I'm a lot more sensitive to the different needs and different challenges that students face. This is something that I never spent a lot of time reflecting on when we were teaching in the museum. Because when students come into the classroom, it's classroom time and they don't bring their families and all their challenges with them, at least not as much as what we see now, because we are literally in their homes. And so there is a lot of trust that needs to be built around that space, to make sure students feel comfortable and feel safe. And that is a priority."

As another educator noted this kind of view of student's lives also helped emphasize the importance of respect, patience and understanding required to work with youth in the program:, "….we try so hard to ask them to keep their screen on, to unmute, and use the chat for questions, etc. But part of it may be that the students are afraid to show what's going on in the background – it could be really noisy, or really messy …. And as

much as I want to inquire about what's going on, I have to respect their privacy and give them the space they might need right now. This has never been navigated before, so having a little patience for your students needs is a very important lesson to take away from this."

Concerns about identifying struggling students.
One additional challenge youth educators noted was the increase in difficulty of identifying students who may be falling behind; noting that online coursework and interactions can make it harder for quieter or struggling students to be visible. As one educator noted: "It's not as easy to catch when a student is falling behind in a virtual space, because you have less input. So by the time you realize they are falling behind, it may be a bit too late. The quieter students, if they are falling behind, if you don't catch them, they can actually fall back a lot faster."

In support of that concern, educators noted that they worked to develop some different approaches to assessment that focused more upon the socio-emotional. "Given all the stress and tumult of the early summer – the pandemic and then the social justice movement, etc- I wanted to gauge where students were emotionally. So I created a simple chart of emojis and asked students to anonymously circle how they were feeling today. So this way we could see how the class was feeling as a whole and I could use that to jumpstart conversations if I saw obvious patterns. That helped me as a teacher connect with the students even though we were still doing it through the screen."

Remote education for teachers
Science-specific challenges: to make phenomenon visible to teachers--re-imagining what phenomenon look like online.
Another challenge raised by the move to online teaching was how to make scientific phenomena explicit and visible to teachers online. Educators in UA, for instance, selected a variety of strategies: from shipping materials to teachers to do hands-on work in their kitchens (like an owl pellet dissection), to spending hours preparing videos of phenomena (e.g. the Sundew experiment in the Darwin's Garden course), to planning self-guided walks in teachers' own communities. Gottesman professional learning created a set of offerings including one titled "Analyze and Interpret Data to Investigate How Blue Whales, the Largest Animal to Ever Live, Survive." This new session was offered both in June and August: teachers used essays, videos, and a graphing tool to analyze and interpret data to look for patterns to help understand the phenomena of how an organism so large can survive by eating something so small. Using secondary data sets seems especially 'translatable' to online learning.

The online learning platforms allowed for a unique 'view' of science and science practices. In some cases, educators found that online provided a closer, more deep view of phenomenon and practices than in person might. For instance, UA instructors were able to take advantage of the online platform to create videos: i.e. one that showed a time-lapse experiment--that in some ways was more effective because participants could see reactions more quickly and come to conclusions more rapidly than in real-time; and another in which an instructor modeled an owl pellet dissection, narrating her process and thinking as she conducted the experiment, which teachers then themselves did at home (with materials that had been mailed in advance). To reimagine fieldwork excursions, MAT faculty in the science practicum used a variety of technologies when creating virtual field trips for residents in the science research practicum, combining photos and mosaics of outcrops, as well as video, animation, and Google Earth gain a sense of locality and context. Through the virtual field trips, instructors were able to model observations and lead discussions at outcrops with residents so that they could then make their own observations and take fieldnotes.

Specific activities and learnings seem to benefit from synchronous experience. Some of the best opportunities to learn together in real-time seemed to be using secondary data sets, and reflecting on teaching and learning together. In UA, instructors spent a lot of time thinking about how to help teachers construct final explanations and reflect on their learning using their teacher lens. Instructors chose to do this in both synchronous and asynchronous modes; based on limited data, it seems like some of these larger wrap up activities may benefit from a synchronous format.

Communities and 'local place' as important resources; pandemic amplified this for educators. Given restriction on travel and gathering, it was fruitful and generative to focus on science in the local community. One UA educator, for instance, highlighted the neighborhood investigation he facilitated in his course, and commented, "This is a great time to get students hooked on local phenomena." That is, it's a great time to help students realize that there are tons of amazing scientific phenomena to observe in all communities.

New ways to think about engagement. As with the findings from the children and families educators, educators for teachers reflected a similar learning: we need to re-think what it means to be deeply involved in and participating in scientific work. Some teachers engage more fully in the remote environment, where they can reach out to an instructor via the chat function rather than jockey for the instructor's attention in a face-to-face session. It may be possible that schools that do not attend administrator breakfasts and PC breakfasts are just as, or more, engaged than schools that do show

up to face-to-face meetings. Educators in UA, noted that they as a program were thinking about "engagement" in ways that go beyond "how many people came to the meeting." Being explicit with teachers about a vision of good teaching and learning both online and in person, may help support that effort and help educators clarify their own expectations for online learning.

Engaging with families directly during remote learning. With school shifting to remote learning in the spring, parents became more directly involved in their children's daily learning. Parents are eager for resources and materials. UA and other programs for teachers, for instance, recognize they may have an expanded role to play in helping families directly with facilitating their children's learning in science. Gottesman also offered a session for teachers on emphasizing family engagement for student success, featuring tools and strategies to build relationships and help bring families into their child's learning. Just as CFL may have potential to help families and parents develop a clearer vision of strong science teaching and learning, our programs for teachers also have an opportunity to help families and parents develop a deeper understanding of what it looks like to learn science--and what that could look like in partnerships between parents and children.

Centering Diversity, Equity, Inclusion and culturally responsive and sustaining education in remote and blended teaching and learning. While critical before the pandemic, with the increased awareness and understanding of social and racial inequities and movements for social justice, teachers and teacher educators are placing even greater importance on and expanding efforts on teaching in equitable, inclusive, and culturally responsive ways. In MAT, for instance, programming was developed for new residents at the start of the program featuring workshops on racial literacy and diversity, equity and inclusion, when the summer I museum teaching residency was cancelled, and provided opportunities for faculty to build connections with CR-SE in courses. In Gottesman, online teacher professional learning included sessions on culturally responsive teaching using nature journaling as a tool and a plan for a session in the later fall on resources and strategies for teaching virtually about Haudenosaunee culture while addressing issues of cultural representation. (Similarly, across education and throughout the museum, staff engaged in a series of virtual discussions and presentations to further learning together across the institution towards supporting an inclusive and equitable work culture, examining key concepts such as privilege and biased-based beliefs).

IMPLICATIONS FOR FUTURE WORK

In this section, we share some ideas for specific actionable, possible implications for our work. We share suggestions emerging from our analysis, by audience--visitors, teachers, youth and children and families--in the hopes that they will generate helpful discussion and future planning.

<center>Visitors</center>

Consider continuing to offer remote programming even after re-opening, to reach a broader audience. Because audiences were unanimously interested in participating in online programming and felt it gave them access they might only have if they were local, consider continuing some form of remote programming in the future. In addition, given our focus upon equity and access for all visitors, consider making programs (at least some) freely available to visitors. In this way, a program lasts longer; and in a way, takes on a longer life online.

Even more purposeful outreach to national and international audiences. Because the pandemic-closure remote programming surfaced an especially interested international audience, consider even more programming or designs that might continue to cultivate that audience. In light of the findings from the large-scale Culture Track survey that online offerings can be a virtual 'gateway' to attract broader audiences, we might consider ways that our virtual offerings could play that kind of role for us.

Focusing upon community-building locally. Because our findings, consistent with research and national surveys emphasize the importance of developing and maintaining connections at this time, we might consider ways that our programming can continue to support community-building and social networks--and how we can continue to serve local needs.

Deepening efforts to reflect and underscore the diversity of science and scientists. In light of the growing understanding of inequities in science, and scientific work--as well as the impact of the pandemic, continuing to deepen efforts to reflect and illuminate the work of scholars of color and indigenous scholars.

Investigate potential to focus upon the process of science. Because one public perception about the virus and the pandemic (which also plagues science in general) has been the uncertainty and lack of understanding about why evidence changes, and why recommendations change, the museum has a possible role to play in helping the public understand how the process of science changes over time. Given that our review

revealed that this aspect of science was rarely addressed by other institutions, this is a role our institution can play--and a programming gap we can fill.

Consider a role in helping parents, children and teachers in understanding a research-based vision of equitable science teaching and learning, and out of school learning. As we make decisions about how we teach and engage the public in conversations, programs and other learning experiences, there may be ways to help signal 'how people learn' even in these sessions, through deepened participation as well as other pedagogical strategies online. Since more and more of the public programs sessions are attended by educators and parents interested in their children's science education, this may be an especially important strategy we can take to help improve conversations about teaching and learning science, and what it takes to make science learning equitable. As this is a challenge that faces all our programs (see below), we might consider ways to address this in our public programs through 'call outs' about our designs or formats, and ways we can explicitly share how our decisions about programming are informed by an understanding of how people learn and of good teaching.

Children and Families

Consider some options for remote learning, but focus upon in-person instruction. Because children and families were eager to come back to the museum, felt more connected to and supported by the museum, and parents and children consistently report heavy screen time during the closure, a focus upon in-person instruction may be best for children and families.

Focus even more explicitly upon a vision of what good science teaching --and learning--looks like for young children. Because parents tend to bring a variety of ideas about schooling with them that inform their responses to their own children's schooling, which are not always informed by research or a vision of good teaching and learning in science, we have an opportunity to help caregivers/parents learn about and understand what good science teaching and learning look like for young children. Even in a remote environment, when parents understand elements of good teaching and learning, they will be more likely not only to support and complement the work of the programs for children at AMNH, but will know more about what to look for in their child's education in the future.

Make pedagogical decisions explicit to parents, along with the research and theoretical base for the choices. Given that parents tended to come without a strong connection to

or understanding of good science teaching and learning, which sometimes can make it harder to build support for the kind of learning experiences we aim to provide for children, helping parents understand some of our specific pedagogical choices--and the research behind them--can be an effective way to help parents begin to understand the features of good teaching and learning. For example, this could include helping parents understand that learning is interactive, and that in order to engage in sensemaking, children learn by talking to one another, which is why AMNH educators are not just lecturing or talking to students all the time.

Suggesting practices parents can use to assess good science learning. Relatedly, we can help parents and children also understand how to better *assess* learning--and how to participate in and support their children's learning--by asking for explanations, evidence and reasoning, or even asking for models and representations that help illustrate ideas or processes or phenomenon. Helping understand a vision of good teaching and learning is critical, and parents also need ways they can evaluate and understand that learning--and just as a letter grade is one 'type' of assessment, we can help parents understand some authentic, formative assessments they can use as well.

Help parents understand--and argue for-- the value and importance of science education. Throughout the pandemic, a major focus in educational discussions has been on a 'lost year' and the impact on children's reading and mathematics. This pandemic has revealed the importance of understanding and interpreting scientific data in our daily lives; it represents a particular opportunity to help parents better appreciate, argue for and ask for science as a critical topic for learning in school--and out of school.

Helping caregivers/parents understand what 'out of school' learning looks like and the value of it. Because parents can play a critical role in shaping discourse in the public about education, and because the current conversation during the pandemic has focused almost solely on in-school learning, we have an opportunity to support and increase parental understanding of the value and role of learning out of school. In turn, a more knowledgeable parent base can complement, and amplify our work and efforts.

Teachers

Consider some versions of remote offerings, alongside in-person experiences. While teachers clearly value and express strong sense of identity at the museum, and value and appreciate the in-person experience and the in-person community and collegiality (for which there is no real substitute), there are some benefits that teachers

emphasized for online offerings. Flexibility for teachers' busy schedules, no travel, and broad reach to audiences beyond NYC might be important features of considering continuing some remote programming.

Be transparent and explicit about our vision of good and equitable online teaching and learning. One of the challenges that many of our programs have run into (and education in general right now) is that parents and the public bring strong conceptions of what teaching and learning should look like but they are rarely informed by a research-based vision of good teaching. Those ideas--that learning only happens in school; that students learn only when a teacher talks to them individually-- have shaped the conversation about learning in the pandemic and have contributed to expectations about what students can and should be doing when learning online. At AMNH, with our strong history of teaching online, we have an opportunity to help communicate what that vision can look like to teachers. We can help teachers come together around a vision of good teaching--and help be clear about what that looks like in remote and in person settings. This can also include responding to teachers' interest in more learning opportunities that address socio-scientific topics and that are connected to a **vision of equitable science**.

More online pedagogical strategies in the context of a vision of good science teaching and learning. One strategy to help teachers learn about and see the connection of our pedagogical decision-making and choices to our vision of good teaching, is to continue to share and model pedagogical strategies that are consistent with our vision of good teaching--but simultaneously, doing some 'translating' or meta-commenting, on our choices. If we can make clear *why* we are focusing upon some teaching strategies and how they connect to a vision of good science teaching, it helps teachers become more aware of and learn about that vision (i.e. "we are focusing upon the practice of developing an explanation because students learn more when they have an opportunity to put ideas into their own words; or, we are focusing upon the practice of making thinking public because students learn more when they see other's ideas and hypotheses, and can compare their own ideas to that of others…). Importantly, this can also involve modeling culturally responsive and sustaining science teaching practices and anti-racist pedagogical practices.

Consider continuing to offer remote programming beyond the pandemic, to reach a broader audience. Because many teachers felt that they could attend remote sessions and that online learning did increase opportunities for access and attendance, we might consider continued remote offerings for programs that were in person-only, prior to the pandemic.

Target PL outreach efforts to newer teachers. Finally, because the majority of teachers we currently reach are veteran teachers, we may want to consider focusing some outreach strategies to newer teachers so that we continue to build our audiences.

Target partnerships with specific schools. As our GIS mapping of data have revealed concentrations of participation in particular districts and neighborhoods, we can continue to compare maps across programs for teachers and youth, and we might consider targeted relationships with a set of schools where we could deepen and strengthen work across both students and teachers. As we have found inroads in shifts in practice and supports are often made more thoroughly, in programs like UA and in our youth and children and families work, when we partner in long-term ways with schools which allows us to build relationships over time, we can continue to consider places to do more deep work across teachers and children.

Youth

Consider a heavy focus upon in-person, coupled with some remote support. Given youth feedback and parent feedback, which suggests that youth and parents "made the most" of the remote experience--but really felt strongly about in-person learning--finding a way to focus most of our efforts on in-person learning for youth may be important. That being said, providing some remote offerings that complement, extend, or help support youth beyond our long-term relationships could be an opportunity to grow our work in some ways. However, with those audiences with whom we work closely (SRMP, Lang), offering as much in-person learning may be most effective and valuable.

Helping target impact of pandemic upon youth learning in science. Given our experience with youth and their interest and continued sense of connection to the museum, we might consider how we can or could partner with schools explicitly to help support some of the negative impact of the pandemic on student and youth learning in science.

Strong support around science content, working with the districts to address specific science topics and supporting deeper learning. While not losing out-of-school choice benefits of the museum programs, we have a possible role to play in helping support districts and schools with particular science content and time in school on key science topics.

Consider opportunities for some afterschool programing throughout the year. Again because of youth enthusiasm for our programming, and the need for consistent adult mentoring and trusted adults who can play a role in youth lives, consider opportunities for afterschool programs throughout the year, especially during school breaks--this could be a great opportunity to help support with learning loss and enrichment. However, the balance between online and in-person should be carefully attended to; while these could be online, it may be important to include some in-person opportunities.

Potential increase in or additional means to support social interactions and socio-emotional learning. Finally, due to the tremendous emotional and social challenges and personal challenges youth have faced this year, a focus upon social interactions, social supports and socio-emotional learning may be especially important as potential ways to help students.

Target partnerships with specific schools. As with our teacher programs which show some concentrations of participation in particular districts and neighborhoods, we compare maps to youth service. We might consider targeted relationships with a set of schools where we could deepen and strengthen work across both students and teachers. Given the importance of deep relationships for students (and the need to partner with teachers who can help us support youth), this could be powerful as a strategy.

HOW CAN WHAT WE LEARNED INFORM OUR FUTURE PLANNING?

In light of the education in emergencies literature and learnings from other institutions, these five themes have the potential to shape our work going forward:

Consider an array of programming both online and in-person. Given that we did not lose the audiences we care about, and we did not see inequitable participation due to the move to remote, we might consider some array of online programming in the future. There may be ways to leverage online learning to increase participation in the future (particularly audiences beyond NYC). This could even potentially allow us to continue to address issues of equity by reaching audiences that cannot easily come into the museum; so we may be able to reach some families, teachers and visitors who are unable to travel or may have obligations that make it hard to get onsite (or reach rural communities, or boroughs that are especially distant). However, the evaluation did suggest that remote learning was more powerful and effective for some audiences, but

not all. Visitors and teachers were more able to make the transition easily, and did not report as many concerns or impact on their experience (in fact, teachers in our PD reported the quality of online learning as just as high quality, though they missed the in-person experience markedly). Children and families adapted but may prefer more in-person programming, so some version of mostly in-person, coupled with some online may be a model to consider. Youth in our programs struggled perhaps the most--with connectivity, hardware and attention and need for interaction. Considering an emphasis upon in-person learning may be most important for youth, and for children and families. That doesn't mean we should not consider *some* supplemental programs online, which may also be an option, but perhaps not a heavy online emphasis for our programs that rely upon long-term relationships with our educators.

Focus upon how science shifts and changes over time. Our review both of our efforts, and the literature on education in emergencies and the evaluations of other institutions' work during the pandemic, underscores the potential for our role in educating the public. This was a role AMNH took on--through public programs about the virus, as well as panels that explored socio-scientific issues, such as the disproportionate impact of the virus upon communities of color. In addition, based on our related review of science institutions' programming during the pandemic specifically about the virus, we see that the focus upon scientific sense-making, use of and interpretation of evidence, and understanding about how science changes over time--seems to be less of a focus across the work of other institutions and could be an area of focus for us (Hammerness, MacPherson & Wallace, 2020). One long-term important implication for our work may be the potential for helping the public better understand the nature of the scientific process, so that when information gradually shifts and changes as we understand more, the public will be more able to appreciate that and be better equipped to evaluate scientific data and evidence.

Help parents and families develop a stronger vision of science teaching and learning. Intersecting with the potential to help the public understand the value of out of school learning, one of the key challenges a number of programs faced was around helping parents and children (and sometimes teachers) re-orient their ideas about what 'good learning in science' looks like. While through UA, MAT, Gottesman, and our online programs for educators, we have been able to more and more clearly communicate a vision of good teaching and learning--we have not often had an opportunity to help parents and caregivers understand a vision of good science teaching. In our programs, we often find that caregivers start with many preconceptions about learning, but not a clear vision of what learning looks like or familiarity with the research base underlying teaching and learning. In addition, those preconceptions often reflect ideas about

learning that over-emphasize the role of direct instruction—memorization, sitting in seats, "covering" the curriculum, and passively taking in knowledge. Understandably many have not had opportunities to encounter rich, research based conceptions of teaching and learning. Their knowledge of teaching and learning are often exclusively related to their own experiences as students. However, when caregivers are such close partners in learning, it is essential that caregivers and teachers have a shared vision of high quality learning.

We can use our programs as an opportunity to make more explicit our vision of science teaching and learning--which focuses upon students and teachers' sensemaking, and the authentic development of scientific practices, in the context of changing evidence and knowledge. We can help parents and caregivers understand the importance of children and youth needing to do science, having opportunities to analyze data, develop arguments and explanations, and continuing to ask questions in a field where science develops and changes constantly over time. We can help parents and children also understand how to better assess learning--and how to participate in and support their children's learning--by asking for explanations, evidence and reasoning, or even asking for models and representations that help illustrate ideas or processes or phenomenon. And for programs for children, we can also help parents and families understand the role of socio-emotional development in learning in general--as well as the social nature of learning itself. Related to this challenge, is the potential to help the public develop a strong vision of online science teaching and learning. For this reason, we might consider some parent education and some programs for parents to help us accomplish this effort.

Sharing and modeling what a vision of equitable teaching and learning can look like online. Part of helping teachers and administrators, as well as and *parents and families*, learn to create learning opportunities that reflect a powerful and engaging long-term vision of science learning also requires reflecting together about what this vision can look like in remote and online instruction. What does a vision of sensemaking, scientific practices, developing an identity as a scientist (upon the work of doing science and the way science is carried out over time) and that centers equity and anti-racism look like online in our various settings? As teachers either shift to in-person or continue to teach remotely, and as administrators must support them and provide settings for students to learn in person or online, teachers and students will need continued support to translate key practices of learning and teaching science online. Given our extensive experience with deep, meaningful online learning, we are poised to help teachers and administrators continue to deepen practices for online teaching and learning in sophisticated and ambitious ways that enable us to maintain and strengthen this vision.

We are well positioned to share, and model this vision and to reveal how our practices and pedagogical choices reflect this underlying vision.

Support public understanding of out-of-school learning. Among many of the sobering realizations that have emerged during the pandemic has been the limitations of focusing solely on in-school learning. Newspapers and journals have been focusing upon concerns about the disastrous effects of the pandemic and resulting school closures upon the entire generation of learners, and suggestions that children affected by school closure are akin to a 'lost generation' (e.g. New York Times, 2020; USA Today, 2020). The impact of the virus and the long-term closures have clearly revealed tremendous disparities and suggested serious gaps in access and opportunity. [these are disparities that existed before the pandemic as well; they are just more visible now] At the same time, the critical learning that we offer and that happens out of school-- and that shows considerable impact-- has been rarely addressed or attended to in these national conversations (Hammerness, MacPherson and Gupta, under review). We have an opportunity to show the community about the impact of this learning and the power of it, and to reassure parents and community members that children and youth are always learning.

One specific challenge from this view of 'lost learning' in the time of the pandemic is that educational discussions and decision making has reinforced a view of learning as 'coverage.' We hear similar messages from parents in our programs about their expectations for learning in our programs. We have an opportunity, by sharing our vision, to re-orient an understanding of teaching and learning around a more generative and richer vision of deeper science learning. As educational historian and reformer Theodore Sizer pointed out, "Serious use of the mind takes time . . . If you have really high intellectual standards for kids, the curriculum overloaded with stuff has to give way." The museum's education programs can continue to help reinforce and reveal that —more than ever—reaching for higher standards, focusing our attention on what is most meaningful, and helping our students become lifelong learners is what helps students learn in depth, with long-term impact. While we need to continue to acknowledge the tremendous loss and impact of learning time and the intersection with equity and access, we can play an important role in helping reframe and focus how the public understands *when and where learning happens*, and helping continue to help the public understand that learning is happening all the time--not only in schools and classrooms--and importantly, in out of school settings.

Build education back better, by helping shift the focus on education beyond coverage to a meaningful vision of deeper learning and by centering equity in that work. As an

institution, we fully understand and acknowledge the inequities and differential impact upon low income children and families placed at risk. Relatedly, at the AMNH we can play an important role in helping reframe and focus this response to schooling and learning during school closures and after the crisis recedes when learners and teachers will need continued and deep support. This means not only reinforcing an understanding of the critical role of out-of-school learning, but also making plans to help support students post-pandemic or post school closures who need help deepening learning of key ideas they may have struggled to understand during remote learning and school closures. This means helping, as educators have pointed out, reconsider a view of 'lost learning' or a 'lost generation' which reinforces a deficit view of students-- but continuing to focus upon the vast potential of students, children and families in contributing to a public understanding of science and to the scientific endeavor. In particular, this also requires *building education back by centering equity and anti-racism*. By continuing to explicitly problematize key ideas in teaching and learning, by being prepared and ready to dive into socio-scientific challenges using research on culturally sustaining practices, by being willing to make race, gender, and multiple perspectives explicit and to welcome that complexity, by bringing deep knowledge of the research on teaching and learning and a clear, strong vision of scientific work and practice and how science develops, the AMNH will continue to play a critical role in the education of young people, families and visitors even at this most perilous moment.

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