ARTICLE

Developing a Research Agenda Aimed at Understanding the Teaching and Learning of Science at a Natural History Museum

KAREN HAMMERNESS, ANNA MACPHERSON, AND PREETI GUPTA

Abstract   Over the past two decades, cultural institutions such as museums are beginning to develop their capacity for engaging in long-term research on teaching and learning (Rennie et al. 2003; see also Crowley 2014). In this article, we describe one museum's efforts to develop an educational research agenda in relationship to these broader efforts. We explain how we got started; share steps taken; describe the agenda itself; and give examples of some of our current research studies. We end with insights into some of the challenges we've faced in developing this work and how we've addressed them and our next steps.

DEVELOPING A RESEARCH AGENDA

Over the past two decades, leaders across museums have begun to recognize the potential for engaging in long-term research on teaching and learning. Museums have always had a strong practice of examining their work and their programming, However, efforts have tended to be more evaluative in nature. A recent study of informal science institutions in the United Kingdom revealed that they do not always draw upon the research base for learning: among the recommendations made by the authors was a call for the field to become more reflective and "evidence-based" (Falk et al. 2012). New efforts, such as the recent 21st Century Natural History Settings Conference reveal a growing conversation across the field about using research in practice. Scholars are also at work to identify a research agenda, for example, in natural history learning (Crowley 2014; Irwin, Pegram and Gay 2013; see also Watson and Werb 2013).[1] Foundations are also supporting the effort: for example, the Science

Learning+ initiative co-led by the Wellcome Trust and the National Science Foundation is supporting opportunities for researchers and practitioners to collaborate in the design of research in informal settings (National Science Foundation 2016; Wellcome Trust 2016).

In this article, we describe our efforts at the American Museum of Natural History to develop a research agenda in education, to build our research capacity,[2] to bring more coherence to our work, and to initiate some research studies. We share how we began; explain the process of development; describe the agenda itself and some of the research studies in which we are currently engaged. We end with insights into some of the challenges we have faced in developing this work, and our next steps. While this work is being undertaken in a natural history museum, the process and strategies may be relevant and useful to those working across a range of cultural institutions. Museum educators or education departments in arts, education and other cultural institutions such as libraries are

Karen Hammerness, Ph.D., is Director of Educational Research and Evaluation, Anna MacPherson, Ph.D., is Manager of Educational Research and Evaluation, Preeti Gupta, Ph.D., is Director of Youth Learning and Research, All three authors work at the American Museum of Natural History, New York, New York, USA.

in a strong position to conduct or contribute to well-designed, original research projects that can help strengthen pedagogical practices and learning. Educators in these positions have the unique opportunity to provide strong evidence around the nature of teaching and learning beyond formal evaluation, and help bolster our understanding of the impact of our cultural institutions.

HOW DID WE GET STARTED?

How could we begin to focus and articulate a research agenda in a setting that serves multiple audiences; provides educational programs for early childhood through adults; works with teachers providing long-term professional support; serves visitors of all ages and nationalities; and even has a teacher preparation program? First, we felt it was important to identify questions that could "cut across" many of our programs. Second, we aimed to identify questions that would both enable us as an organization to learn about our practice, but also would contribute to national conversations about in- and out-of-school learning (Crowley 2014; Rennie et al. 2003).

Given those aims, we agreed that we were aiming to develop an agenda that:

- identifies a set of focused, specific areas for sustained, long-term inquiry;
- has potential for investigation from the standpoint of multiple research studies and disciplinary perspectives;
- draws fully upon the resources and assets of the institution;
- builds upon current research and knowledge in the field;
- is deeply connected to and has implications for practice.

Next, we spent time reviewing many different resources. These included research literature on science learning and teaching in both formal and informal settings; policy papers, and relevant literature reviews and meta-reviews; internal program evaluations, reports, and conference papers. We also created a new institutional structure—the Educational Research and Evaluation group—that drew members across different programs at the museum. This group consisted of program directors and other colleagues within the education department, many of whom have advanced degrees in education and an interest in engaging in research. The Research and Evaluation group would meet monthly to serve as a "community of practice" for research work and members would be responsible for providing leadership in research within their own programs and departments around research.

We asked this group to identify persistent questions about science teaching and learning emerging from their work at AMNH. Many of the questions that our colleagues found compelling revolved around the impact of our programs upon children's lives and on educators' practices. They also raised concerns about access and equity for children and youth; and expressed interest in knowing more about the ways in which the teachers with whom we work applied what they learned in our programs, in their own classrooms and school sites. Finally, they identified questions about the ways in which visitors to the museum interpret what they encounter and what they learn from exhibits.

LINES OF INQUIRY

Our review pointed to three core arenas in which the museum influences the work of teaching and learning in science—within and extending beyond the walls of AMNH: *visitors*;

children and youth; and *school and museum educators*. We decided that we should identify a "line of inquiry" for each of those three arenas. Ultimately we hope to consider working on a fourth line of inquiry that looks at our impact on the community (New York City) (see Figure 1).

Representing each of the four arenas, we are pursuing the following lines of inquiry:

1. How the museum helps visitors challenge, or extend and deepen, their understanding of science and scientific ideas;

2. How the museum helps children and youth develop and deepen scientific practices, content knowledge and an identity as a scientist—and how that learning might vary across gender, race/ethnicity, age and socio-economic status;

3. How the museum helps educators learn to take up ambitious teaching practices; and

4. In what ways the museum as an institution has an impact on the larger community.
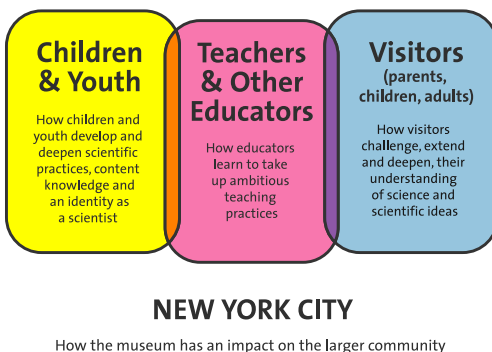

NEW YORK CITY

How the museum has an impact on the larger community

Figure 1. Our lines of inquiry. [Color figure can be viewed at wileyonlinelibrary.com]

Each of these "lines" is broad enough that we can make headway gradually but is not so general that we cannot build some practice and knowledge. For instance, in terms of the first line about visitor learning, we can imagine focusing on what visitors are learning about content areas studied and communicated by the museum through exhibits and programs, and how such experiences are sparking conversations and further engagement with those topics. This focus is aligned with questions other scholars studying natural history institutions have raised (Crowley 2014). The focus on visitor learning also enables us to build upon the body of research on visitor learning, for instance, learning in a family group (e.g. Archer et al. 2016; Ash 2003; Diamond 1986; Dierking and Falk 1994; Gutwill and Allen 2010) or learning with objects, specimens, representations and visualizations (Hannan et al. 2013; Leinhardt and Crowley 2002).

In terms of the second line about children and youth, given the diversity of both our programs and the children with whom we work, we have the potential to look at questions about variations in learning over time. We aim to better understand the variations in pathways children and youth take to learn science and to become scientists—which may be influenced by race, gender, ethnicity, socio-economic status, and academic strengths (Basu and Barton 2007; Lyon et al. 2012; National Research Council 2011). We feel we can learn about the specific features of educational experiences and programs that support successful pathways to careers in science between and across formal and informal settings (Barron and Bell 2015; Emdin 2011; Penuel et al. 2014).

In terms of the third line about teaching, a growing set of studies have begun to

demonstrate how new teachers can learn to use ambitious teaching practices (e.g. Kloser 2014; Windschitl et al. 2012; see also Ball and Forzani 2009; McDonald, Kazemi and Kavanaugh 2013). Helping contribute to an understanding of how teachers at every stage of their careers can take up such ambitious teaching strategies would be a critical contribution. In scholarship in teaching right now, there is a vibrant conversation about identifying "high leverage" teaching practices. We felt we could provide strong leadership in unpacking these teaching strategies—for instance, in relationship to the use of models, visualizations, specimens, and representations. This direction would also enable us to build upon research on representations and objects as important resources for our field and for our colleagues in natural science institutions (Crowley 2014; see also Paris 2002). Furthermore, knowing more about how teachers learn such ambitious teaching practices in the context of a complex urban school system is especially important in a richly diverse society.

Finally, in terms of the fourth line about the impact of the museum, with a few exceptions museums still are working to document the ways in which a cultural institution can impact an entire community (Falk and Needham 2011). But given the wide reach the museum has in the city to multiple audiences, we see this kind of research as deeply exciting. It could be possible, for instance, to begin to examine how our museum has impacted scientific knowledge or thinking in the larger NYC community (as Falk and Needham did in Los Angeles) and how our impacts on different audiences are mediated by program or exhibit design. Through a partnership with the NYC Housing Authorities, for instance, we have an opportunity to understand how we can better serve all communities in New York City.

Working with the Housing Authority may help us understand how different constituencies regard the role of the museum in their neighborhoods and their own lives. Or, given the relationship the museum has with the New York City Department of Education, we may ultimately be able to examine how a large institution like AMNH helped contribute to district policy or the practices of teaching science.

Potential for Studying Learning Along a Continuum

We are especially excited about the potential for longitudinal studies in our work. Our setting and span of programs mean that we can examine questions along the entire continuum of development for children, educators, and visitors. For instance, we can examine questions about how children engage in scientific thinking and develop an identity as a scientist starting in early childhood, and we can continue to ask some of the same questions with the children at the museum who work with us in middle school and high school in enrichment and mentoring programs. Similarly, because we have programs for pre-service, novice and experienced teachers, we can also examine questions about how teachers take up ambitious teaching practices across what Feiman-Nemser has called the "continuum of teacher learning" (Feiman-Nemser 2001; see also Windschitl et al. 2012). And finally, because we have a range of visitors who engage with the museum during one-time visits, but also those who are repeat visitors and who have long-term relationships with the institution we can also investigate questions about visitor learning in ways that reflect brief interactions as well as more sustained relationships.

Throughout all lines of research: the theme of equity and access

Within each of these four lines, we are asking questions that recognize the value in diversity and the complexity and richness of our New York City setting. We are asking specific questions about how learning happens and teaching works for children and teachers who bring resources, experiences and cultural and ethnic backgrounds that are rich and varied. In each of the studies below we have worked to ensure that we are paying close attention to issues of equity and access.

Where Should We Get Started? Criteria for Identifying Sites for Studies

To help us narrow down sites for study, we developed criteria to help us identify programs or settings within the museum that would be ready for research. We knew we would have to be selective, given limited time and personnel devoted to research. We proposed the following criteria to help us identify programs or settings within the museum that might be most productive for study in our early efforts:

- Size and scope (or potential reach) of program
- Duration, or degree to which program is established over time
- Degree to which program reflects resources and investment by museum and/or centrality to museum mission
- Demonstrated impact from summative evaluations that are well grounded and systematic
- Degree to which program has potential for shedding light on questions about children, teacher, or visitor learning articulated in our research agenda
- Degree to which program has potential for investigating "big" questions that reflect central, relevant policy and practice questions in the field and in scholarship, for instance, issues around equity and access
- Degree to which programs have grant funding/evaluation work/possible funders interested in supporting work

OUR INITIAL STUDIES

Acknowledging that we have the greatest capacity to study the lines of research in two arenas–educator and youth learning–we began to craft studies. Below we share three examples sets of studies that illustrate longitudinal work and attend to questions of equity.

Research studies in "Urban Advantage." Research in our Urban Advantage (UA) program demonstrates how we are beginning to develop studies along two of our research lines: how students develop content knowledge, scientific practices and identities as scientists; as well as how teachers take up ambitious teaching practices. Urban Advantage[3] is a twelve-year partnership that unites eight informal science institutions (American Museum of Natural History[4] ; Brooklyn Botanic Garden, New York Botanical Garden; New York Hall of Science; Queens Botanical Garden; Staten Island Zoo; and the Bronx Zoo, and the New York Aquarium) in New York City and the New York City Department of Education. Urban Advantage has operated on a large scale for more than a decade, with more than 100 schools participating in each year since 2007. The partnership has been in existence since 2004–2005, and the numbers of schools participating in UA have grown over time (from 31 schools 2004 to 129 in 2007) and as of 2016, 151 middle

Figure 2. Urban advantage annual science expo. Students presenting their investigations. Credit: American Museum of Natural History. [Color figure can be viewed at wileyonlinelibrary.com]

schools participate—nearly half, roughly 45%, of New York City middle schools.

A longstanding aim of the partnership has been to improve inquiry-based science education, especially for high-need students, so that children have rigorous project-based learning experiences (see Figure 2). The program also aims to improve middle school children's science achievement—in turn aiming to support greater participation and success in high school science. A third aim is to improve teachers' science teaching practices, by supporting teachers to learn to use inquiry-based instructional strategies and performance-based formative assessments. In partnership with colleagues at the Institute for Education and Social Policy at New York University, Urban Advantage has established a research program that examines longitudinal data from NYC middle schools

and students, 2005–2015. These studies show that attending a UA school increases a students' likelihood of being proficient in science by approximately 2.0 percentage points in the school's first year in UA, with larger impacts of approximately 5–7 percentage points in subsequent years of participation (Weinstein and Whitesell 2015; see also Weinstein et al. 2014). Closely tied to the aims of the program, the research also examines variations of impact by student characteristics, and found that being in an Urban Advantage school is also correlated with larger effects upon the science outcomes of Hispanic students and male students (Weinstein and Whitesell 2015). In addition, a recent analysis showed positive effects of field trips (measured through the number of program vouchers redeemed) on science achievement (Whitesell 2016).

Our research agenda enables us to develop and identify opportunities to look even more closely at these results and to develop our own research that complements these studies by New York University. We are eager to understand *why* the program is having this effect on student achievement (especially as the program is not designed to raise test scores; it aims at helping students work on long term investigations). While we have data on outcomes, the program has not previously examined Urban Advantage teachers' practices in a systematic way. We also have not had opportunities to examine student learning in qualitative ways. To that end, this year, we are conducting qualitative research at AMNH. We are nesting a targeted qualitative study within NYU's larger quantitative study with the goal of understanding *why* we see the "UA effect." We are looking specifically at the classroom practices of Urban Advantage teachers to see if we can unearth those aspects of the professional development experience most strongly related to their work in schools.

In collaboration with our New York University colleagues, we have selected a sample of Urban Advantage teachers to observe and interview. We are studying teachers with a range of experience in the program (from first year teachers through veteran teachers, who have been in the program more than 5 years), and asking the following questions:

- What is the relationship between participating in UA and middle school science teachers' practice?
- Do we observe differences in UA teachers' practice across a range of experience in the program?
- Which tools and knowledge from the UA PD is most strongly related to teachers'

enactment of high-leverage science teaching practices?

To do this we are observing teachers using an established observation protocol (UTOP) and a newer instrument designed to look specifically at discourse in the science classroom (Thompson et al. 2016). In addition, we are conducting interviews during which teachers discuss their experiences with Urban Advantage and how they incorporate knowledge and tools from the program into their classroom.

Alongside the study of teachers' practice, we are also studying how students conduct long-term scientific investigations in Urban Advantage. We have begun a systematic analysis of several years of long-term investigations, which have been photographed at the culminating "Expo" event each year. We are characterizing the types of questions students choose to investigate and the quality of the projects, using a program-wide rubric. In addition, we conducted a small interview study at the 2016 Expo event, in which we asked students, their parents (who attended the event with their students) and classroom teachers about the process by which students' identified topics and questions to investigate, and the ways in which parents and teachers offered feedback during the process of completing the project. Through systematic, qualitative analysis of UA teachers' practice and students' work we hope to learn more about how this long-standing partnership between formal and informal educational institutions shapes students' experiences in middle school science.

The "Staying in Science" Study

As one means of beginning to work on our research line about how children and youth develop and deepen scientific practices, content
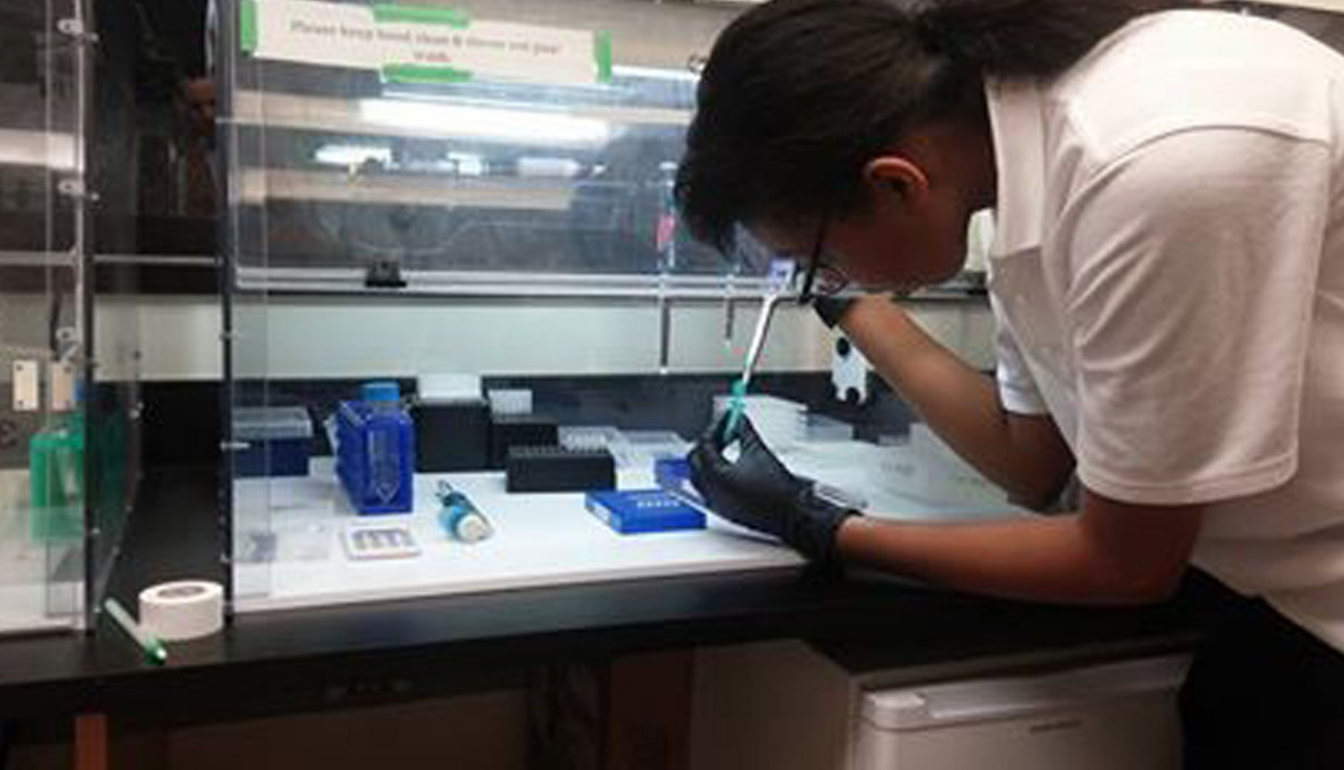
Figure 3. Science research mentoring program. A student working with DNA. Credit: American Museum of Natural History. [Color figure can be viewed at wileyonlinelibrary.com]

knowledge and an identity as a scientist and how that learning might vary across gender, race/ethnicity, age and socio-economic status, we have undertaken a 4-year longitudinal study of the pathways of STEM-interested high school students from underrepresented groups who plan to pursue or complete science studies in their post-high school endeavors. The research investigates the ways in which authentic science research experiences may support youth's persistence in STEM. The "Staying in Science" study focuses on approximately 900 urban youth who are high interest, high potential STEM students who participate in or are alumni of a program that offers intensive mentored science research experiences to high school students (Gupta et al. 2016). The Science Research Mentoring Program, in existence since 2009, is designed to serve youth typically underrepresented in STEM careers (see Figure 3). Seventeen sites around New York City offer these mentoring programs, including and originally started by American Museum of Natural History.

Responding to calls for more longitudinal research with an ecological perspective, this particular research combines longitudinal social network and survey data with analysis of matched student data from New York City Public Schools records. We ask three research questions in this study: (a) how do youths' social networks develop through their participation in scientists' communities of practice? (b) what is the relationship between features of the communities of practice and youths' social networks, measures of academic achievement, and youths' pursuit of a STEM major? and (c) what are the variations in youth pathways in relationship to learner characteristics, composition of social networks, and features of the community of practice?

To address these questions we are employing a mixed methods design with multiple sources of data including *surveys*, *interviews* and *case studies*. This design allows for a rich, layered perspective of student pathways and variations applying survey analyses, social network analysis, and ethnographic accounts. In particular, by employing social network analysis, we aim for

Article: **Developing a Research Agenda at a Natural History Museum**

our study to reveal the *relational* features of persistence that may be particularly critical for underrepresented youth, for whom STEM role models and "cultural brokers" may be particularly important. We also have access to a New York City Public Schools data set comprised of student-level records containing biographical and demographic variables, secondary and post-secondary course enrollment and grades, exam scores, persistence indicators, and post-education employment records and wages.

This data provides for the examination of inter-relationships between in-school achievement and out-of-school STEM experiences, as well as the comparison of program participants to similar non-participant peers. By taking a "pathways" perspective, we address concerns that research examining pursuit of STEM majors often fails to fully account for: such as the multiple contexts, factors and settings at play in youth development, and accurately documenting the complexity and variability of STEM pursuits themselves. Identifying key supports and obstacles in the pathways of high-interest, under-represented youth towards STEM careers can help practitioners design more inclusive and equitable STEM learning experiences and supports that can capitalize on student interest and build youth experiences so that students with potential continue to persist.

The Master of Arts in Teaching Research Agenda

Finally, research in our Master of Arts in Teaching program illustrates some of the ways that we are growing our research agenda in a program that is relatively new. Our teacher education program launched in 2011 with a pilot program; the fifth cohort just started coursework this summer 2016. The program aims to prepare Earth Science Teachers for New York

City schools and requires the teacher candidates to take pedagogy (16 credits) and science courses (15 credits) as well as a year-long residency in our partner schools. The program seeks to address the acute need for effective science teachers and the shortage of certified secondary Earth science teachers in New York City in particular, as well as a specific concern about access for children to science in complex, urban schools (Kena et al. 2014).

The teacher education faculty is focused upon evaluation and development, as the program works to establish itself and move through accreditation. However, they are also taking up some targeted research that will both inform the program and the field of teacher education. Nested within our line of inquiry about how teachers take up ambitious teaching practices, we have developed studies examining this question in the setting of pre-service and novice teachers' learning. For instance, faculty are focusing upon how the teacher education program helps new teachers to use "high leverage" science teaching practices. Faculty are also examining how program graduates draw upon the affordances of the museum (current resources, technical/scientific knowledge, rich science materials, scientists in residence) and how they draw upon their own experiences conducting research with AMNH scientists (see Figure 4).

Our research group is also conducting a small set of qualitative case studies of program graduates, observing their classroom teaching as well as interviewing them about their work. We are also focusing our work with pre-service mentors on several "high leverage" teaching practices (eliciting student thinking and teaching with objects), practices that seem especially fitting to study in the context of a natural history museum. We are documenting the professional learning

Figure 4. An MAT resident teaching in the museum. Credit: American Museum of Natural History. [Color figure can be viewed at wileyonlinelibrary.com]

experiences we provide for these mentors, and working on aligning assignments we give our pre-service teachers with these specific teaching practices.

In addition, we are also focused upon questions about our purposes in terms of helping more youth learn science in meaningful ways, *and* the degree to which we provide more equitable access to rigorous science teaching. This research, quantitative in nature, draws upon large-scale data sets from the New York City Department of Education. These

Article: **Developing a Research Agenda at a Natural History Museum**

questions are being pursued in partnership with our colleagues at the Institute for Education and Social Policy at New York University who are gathering and analyzing data on our Master of Arts in Teaching program teacher's school placements (if they are teaching in high needs schools); on teacher retention and mobility (are they staying in high needs schools, or moving); on relationship to number of students' taking the Earth Science Regents; and on impact on students' test score in their schools. New York University researchers are also gathering data to examine the impact of participating in the teacher education program upon our residency schools.

CHALLENGES AND NEXT STEPS

Evaluation has historically been a strong facet of the culture of the Education department at AMNH. Practitioners at the museum (as well as our numerous external evaluation partners) are adept at developing measures of participation and satisfaction, systematically collecting these data as part of programs, and reflecting upon the results. There have been several long-standing partnerships that have produced robust evaluations of programs at the institution. However, the practice of research and the practice of evaluation differ significantly in terms of goals, process, timeline, and ultimate product. While evaluations aim to inform the program itself and should lead to immediate action on behalf of the program, research is aimed at generating findings that are generalizable and useful to an entire field. Evaluation often occurs over the course of months. Developing a solid research program could take a year or more, between developing theory, attracting funding, designing measures, collecting data, analyzing data, and finally writing for publication. The final product of an evaluation is often

an evaluation report or white paper, used mainly by practitioners and stakeholders. Research is meant to travel beyond the institution through published articles, written for a wider audience consisting of policy-makers, researchers, and practitioners. These differences require that we provide strong justification for research and moving from a strong culture of evaluation and toward developing research connections has not been seamless.

One challenge to advancing the research agenda is that research requires a shift in perspective around findings. We have often found that evaluators in the past have tended to focus upon the strengths of the museum and our work, but are more hesitant to share challenges or concerns. We are now working with evaluators to be clear that we seek evidence for what we need to learn and improve upon, not only about what we are doing well. This perspective also prepares us more fully for research work.

Another challenge lies in the importance of generalizability. The process of designing educational research is predicated on the idea that the study will illuminate findings that are relevant to other places. AMNH values its uniqueness; and in fact, it is a truly special and unusual setting. However, we need to be able to underscore features of AMNH that are *shared* with other settings. While it is a unique place, AMNH also has many features that make it similar to other museums or other informal science institutions, and even schools and research institutions. We assert that findings from studies at our museum will be useful to others in many different contexts.

A final challenge lies in the richness of the setting and the programs at AMNH. There are so many possibilities for productive and fresh inquiry. But the requirements of research are deep and time-consuming. We have to remain focused and selective. We have to balance our

attention to evaluation and research and be protective of the time it takes to do this work well. We have to be reasonable and practical in our reach, even as we hope to dive deeper over time.

Next steps include making choices about the careful development of research. We are in the process of determining the most valuable directions to build this work beyond these three programs of research. We are continuing to build capacity around research. This year our Educational Research and Evaluation group will be exploring how we use research findings from the different studies we are conducting, to inform our practices around teaching children and educators. We collaboratively authored a set of guidelines for evaluation and are working with our current evaluators to gather data that will prepare us better for systematic research across other programs beyond those currently being studied. We are also putting in place some shared approaches to gathering certain kinds of data across the museum (i.e. pre and post program surveys of visitors, parents, teachers, students). We also hope to "build out" our visitor research in ways that are consistent with our current research agenda.

Aside from shaping our practice and contributing to larger national conversations, we believe that a strong research agenda will also provide us with a "broader view" for our work. We hope to use our agenda to help us make decisions about whether and how new (and even existing) work helps advance questions the organization is trying to answer. For instance, we are aiming to study our programs for middle school youth more systematically. Our research agenda has lead us to prioritize seeking funding for longitudinal research around youth agency in science careers, rather than invest in writing grants for additional program development. We are also beginning to articulate a research agenda for early childhood. There are many

areas for productive research in early childhood science education, but in light of our commitment to equity, we want to ensure that our research includes questions about diverse learners.

We are also using our growing understanding of youth pathways and variations in trajectories to help inform and even guide the identification of research questions for studies of early childhood. Asking some similar questions about development in different settings across age groups would enable us to start to build some specific expertise around child development in a deep way. We are already finding that some of the surveys we developed for our "Staying in Science" study are helpful for other programs that serve high school students interested in science. And in turn, the research we are doing on the teacher education program is helping inform some of our professional development work with experienced teachers. This doesn't mean that individuals within our institution cannot or should not do research that takes other directions. However, colleagues across different programs can connect their work to a broad agenda potentially enabling collaboration between programs investigating similar lines of inquiry. We are excited about the possibility this work has to help bring even more coherence to our teaching and learning practices with children, adults and visitors: at the same time as we continue to try to have an impact on science teaching and learning in our institution and more broadly.

TOWARDS RESEARCH ACROSS INSTITUTIONS

We are hopeful that our process will help inform the efforts of other cultural institutions initiating or pursuing this kind of systematic research. Furthermore, there is rich

potential for collaboration around well-conceived educational research across different cultural institutions. At AMNH we have carved out a set of initial studies that focus—in the near term—upon youth learning and educators' learning. We would benefit from sharing findings with and learning from other institutions that focus more upon visitor learning, looking at (for example) the learning of first time visitors or impact upon cities and communities. Many scholars have argued that cultural institutions need to take a more "ecological" view of youth learning (Barron and Bell 2015; Bronfenbrenner and Morris 2006). Perhaps we also can be even more powerful sites for learning if we take an ecological perspective on research as cultural institutions. By pursuing complementary lines of research, different lines of work can come together and build greater understanding about teaching and learning across all our organizations. In this way, we may be able to garner our collective resources to understand, leverage and even strengthen the long-term impact of our institutions on teaching and learning.   END

ACKNOWLEDGMENTS

NOTES

1. Efforts reflected in the 1994 NSF conference on "Public institutions for personal learning: Understanding the long-term impact of museums" illustrate that this focus is not necessarily new, but has been growing.
2. As a research institution, AMNH has a long history of scientific research dating back to over 125 years (Rexer and Klein 1995). However, in this article we focus upon our efforts to develop a research agenda in education.

REFERENCES

Archer, L., E. Dawson, A. Seakins, and B. Wong. 2016. "Disorientating, Fun or Meaningful? Disadvantaged Families' Experiences of a Science Museum Visit," *Cultural Studies of Science Education* 1–23. Accessed June 1, 2016, doi: 10.1007/s11422-015-9667-7.

Ash, D. 2003. "Dialogic Inquiry in Life Science Conversations of Family Groups in a Museum," *Journal of Research in Science Teaching* 40(2): 138–62. Accessed June 1, 2016 from doi: 10.1002/tea.10069.

Ball, D. and F. Forzani. 2009. "The Work of Teaching and the Challenge for Teacher Education," *Journal of Teacher Education* 60(5): 497–511.

Barron, B. and P. Bell. 2015. "Learning in Informal and Formal Environments." In *Handbook of Educational Psychology*, 3rd edn, edited by L. Corno and E. Anderman. Mahwah, NJ: Lawrence Erlbaum.

Basu, S. J. and A. C. Barton. 2007. "Developing a Sustained Interest in Science Among Urban Minority Youth," *Journal for Research in Science Teaching* 44(3): 466–89.

Bronfenbrenner, U. and P. A. Morris. 2006. The Bioecological Model of Human Development. In *Handbook of Child Psychology*, Volume 1: Theoretical Models of Human Development, 6th edn, edited by W. Damon and R. M. Lerner, 793–828. New York: Wiley.

Crowley, K. 2014. "A Research Agenda for Learning in Natural History Settings." Informal Science, Accessed May 31, 2016 from: http://www.informalscience.org/news-views/research-agenda-learning-natural-history-settings.

Diamond, J. (1986). "The Behavior of Family Groups in Science Museums," *Curator: The Museum Journal* 29(2): 139–154.

Dierking, L. D., and J. H. Falk. 1994. "Family Behavior and Learning in Informal Science

Settings: A Review of the Research." *Science Education* 78(1): 57–72.

Emdin, C. 2011. "Citizenship and Social Justice in Urban Science Education." *International Journal of Qualitative Studies in Education* 24(3): 285–301.

Falk, J. H., and M. D. Needham. 2011. "Measuring the Impact of a Science Center on Its Community." *Journal of Research in Science Teaching* 48(1): 1–12.

Falk, J., J. Osborne, L. Dierking, E. Dawson, M. Wenger, and B. Wong. 2012. Analysing the UK Science Education Community: The Contribution of Informal Providers.

Feiman-Nemser, S. 2001. "From Preparation to Practice: Designing a Continuum to Strengthen and Sustain Teaching." *Teachers College Record* 103(6): 1013–55.

Gupta, P., K. Hammerness, T. Podkul, P. Shields, and K. Vogt. 2016. Staying in Science: Examining the Pathways of Underrepresented Youth Mentored in Research. Project Narrative for Grant # 1561637 funded by National Science Foundation.

Gutwill, J. P. and S. Allen. 2010. "Facilitating Family Group Inquiry at Science Museum Exhibits," *Science Education* 94(4): 710–42. doi: 10.1002/sce.20387.

Hannan, L., R. Duhs, and H. Chatterjee. 2013. Object-Based Learning: A Powerful Pedagogy for Higher Education. In *Museums and Higher Education Working Together: Challenges and Opportunities*, edited by A. Boddington, J. Boys and C. Speight, 159–68. Abingdon, UK: Routledge.

Irwin, B., E. Pegram, and H. Gay. (2013). New Directions, New Relationships: The Smithsonian's Twenty-first Century Learning in Natural History Settings Conference and the Natural History Museum, London," *Curator: The Museum Journal* 56(2): 273–278.

Kena, G., S. Aud, F. Johhnson, X. Wang, J. Zhang, A. Rathbun, and P. Kristapovich. 2014. *The Condition of Education 2014* (NCES 2014–083). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Kloser, M. 2014. "Identifying a Core Set of Science Teaching Practices: A Delphi Expert Panel Approach." *Journal of Research in Science Teaching* 51(9): 1185–217.

Leinhardt, G., and K. Crowley. 2002. "Objects of Learning, Objects of Talk: Changing Minds in Museums." In *Perspectives on Object-centered Learning in Museums*, edited by S. Paris, 301–24. New Jersey: Lawrence Erlbaum and Associates.

Lyon, G. H., J. Jafri, and K. St. Louis. 2012. "Beyond the Pipeline: STEM Pathways for Youth Development," *Afterschool Matters* 16: 48–57.

McDonald, M., E. Kazemi, and S. S. Kavanagh. 2013. "Core Practices and Pedagogies of Teacher Education A Call for a Common Language and Collective Activity." *Journal of Teacher Education* 64(5): 378–386.

National Research Council. 2011. Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads. Committee on Underrepresented Groups and Expansion of the Science and Engineering Workforce Pipeline. Committee on Science, Engineering, and Public Policy: Washington, DC: The National Academies Press.

National Science Foundation. 2016. "Science Learning + Partnership Grants." Accessed July 1, 2016 from https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505240.

Penuel, W., T. Lee, and B. Bevan. 2014. *Designing and Building Infrastructures to Support Equitable STEM Learning Across Settings*. Research + Practice Collaboratory Research Synthesis. San Francisco: The exploratorium.

Rennie, L. J., E. Feher, L. Dierking, and J. Falk. 2003. "Toward an Agenda for Advancing Research on Science Learning in out of School Settings." *Journal of Research in Science Teaching* 40(2): 112–20.

Rexer, L. and R. Klein. 1995. *American Museum of Natural History: 125 Years of Expedition and Discovery*. New York: Harry N. Abrams, Incorporated.

Thompson, J., S. Hagenah, H. Kang, D. Stroupe, M. Braaten, C. Colley, and M. Windschitl. 2016.

    Article: **Developing a Research Agenda at a Natural History Museum**

"Rigor and Responsiveness in Classroom Activity." *Teachers College Record* 18(5). Accessed July 1, 2016 from https://tcrecord.org/library/abstract.asp?contentid=19366.

Watson, B. and S. R. Werb. 2013. "One Hundred Strong: A Colloquium on Transforming Natural History Museums in the 21st Century," *Curator: The Museum Journal* 56(2). Accessed May 11, 2016 from doi: 10.1111/cura.12023.

Wellcome Trust. 2016. "Science Learning +" call for proposals, Accessed May 5, 2016 from https://wellcome.ac.uk/funding/science-learning.

Weinstein, M. and E. R. Whitesell. 2015. "Rolling Out and Scaling Up: What Happens When a Program Is No Longer New," Paper presented at the XXIV Meeting of the Economics of Education Association, Madrid, Spain.

Weinstein, M., E. R. Whitesell, and A. E. Schwartz. 2014. "Museums, Zoos, and Gardens: How Formal-Informal Partnerships Can Impact Urban Students' Performance in Science," *Evaluation Review* 38(6): 514–45.

Whitesell, E. 2016. "A Day at the Museum: The Impact of Field Trips on Middle School Science Achievement." *Journal of Research in Science Teaching* n/a–n/a. Accessed June 1, 2016 from doi: 10.1002/tea.21322.

Windschitl, M., J. Thompson, M. Braaten, and D. Stroupe. 2012. "Proposing a Core Set of Instructional Practices and Tools for Teachers of Science." *Science Education* 96(5): 878–903.