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Living Laboratory®:

A Mutual Professional Development Model for Museum-based Research Partnerships

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Living Laboratory® at the Museum of Science, Boston (MOS) educates the public about child development by immersing museum visitors in the process of developmental science research. We invite scientists to conduct their studies on the floor of the museum, amidst the everyday museum activities. This partnership allows visiting families to participate in on-going research studies, and learn more about developmental science through one-on-few conversations with researchers. One unique feature of Living Laboratory is the partnership between the MOS and multiple laboratories from universities across the Boston area. Indeed, since its launch in 2005, the MOS Living Laboratory has hosted scientists from Harvard University, Boston University, Boston College, Tufts University, MIT, and other local research institutions. These collaborators have studied a wide range of topics, including mathematical reasoning, language cognition, causal learning, emotion recognition, and social reasoning. Based on the success of the MOS program, a broad implementation project funded by the National Science Foundation[1] began in 2011 to disseminate the Living Laboratory model to other institutions across the United States, and to bring together a community of learners that shares resources associated with successful museum-university collaborations.

We have organized our chapter as follows. We first describe the history of the Living Laboratory model, its benefits for researchers, museum educators and the general public, and its essential elements. Second, we highlight some of the research findings that have resulted

[1] "Broad Implementation: Creating Communities of Learners for Informal Cognitive Science Education" (Kipling; NSF Award #1113648)

from the museum-researcher partnership. We focus on research from two laboratories: the Early Childhood Laboratory at Harvard University, and the Social Learning Laboratory at Boston University. Third, we describe how we are evaluating the efficacy of the Living Laboratory model. Fourth, we highlight some lessons learned from effective researcher-museum partnerships. We close with our current and future directions: the creation of a national network of museum educators and researchers in developmental psychology.

History: Why Living Laboratory?

Living Laboratory was originally developed to engage adult visitors in MOS's *Discovery Center*, an early childhood exhibition that serves nearly 300,000 visitors annually. *Discovery Center* exhibits allow young children and their accompanying adults to explore a variety of real objects and age-appropriate tools, often set in immersive fantasy environments that encourage learning through play. Staff and volunteer interpreters play a crucial role within the exhibition, facilitating activities, experiments, and conversations that aim to help children develop their emerging science and engineering skills.

Despite a long history of success engaging children in science learning in the Discovery Center, in 2004, the staff at the Discovery Center realized that, while in the exhibition, many adult visitors within family groups were not experiencing meaningful learning themselves. Given that one of the missions of the MOS is to promote appreciation of science across the lifespan, the Discovery Center aimed to devise novel approaches to engage with this "lost audience." At the same time, the museum noticed that the science of child development was infrequently represented in science center offerings, even though this topic is highly relevant and interesting to caregivers of young children.

To address both of these concerns, the first collaborations between the MOS and child development researchers (from Harvard University and MIT) were initiated. Our initial meetings aimed to create a shared understanding of our goals for the collaboration, and to discuss the day to day logistics of introducing research to the museum setting, including details of the proposed studies, temporal and physical setup within the Discovery Center, and interactions among researchers, museum staff and visitors to ensure a positive visitor experience. It was also agreed that the graduate students and museum educators working to build the collaboration would have frequent meetings to openly communicate challenges and work together to bridge cultural differences (e.g., incongruence of museum and academic annual calendar cycles, and differences in the complexity of organizational hierarchies for internal approvals among the institutions involved, among others).

By designing a researcher-scientist partnership, we hoped to create a dynamic and interactive program that would 1) provide the museum staff and visitors with direct access to the latest theories, methods, and findings in the field of child development, 2) engage parents and other caregivers by introducing them to the scientific study of children's learning and development, and 3) allow researchers an opportunity to work with parent and child participants in a unique setting. Our goal was to make participating in research studies and speaking with researchers about their ongoing work a seamless part of the free-choice family learning environment found in the Discovery Center.

This initial collaborative work with MIT and Harvard University laid the foundation for what is now called Living Laboratory. In 2007-2011, with support from the National Science

Foundation[2], the Living Laboratory model expanded to include researchers from additional Boston institutions, including Boston College, Boston University, Boston Children's Hospital, and Tufts University. The program has been extremely popular with museum visitors: as of December 2014, more than 61,000 families visiting the Discovery Center have interacted with research activities, with approximately half serving as formal participants in scientists' ongoing studies, and others learning about scientists' research through informal demonstrations.

Figure 1. The Living Laboratory physical space, one of eight distinct areas within the Discovery Center. Note that all research happens clearly in view of the public and is seamlessly integrated with other interactive activities available.

[2] "A Participatory Model for Integrating Cognitive Research into Exhibits for Children" (Kirshner; NSF Award #0714706)

Figure 1 depicts Living Laboratory in the Discovery Center as it currently stands in 2015. A few key features warrant attention. First, the researchers and their research studies are placed "on the floor" of the museum (and in fact, directly next to a station where young visitors engage in daily hands-on chemistry, physics and engineering experiments). This is in keeping with the above goal of devising a program in which developmental scientists conduct their research studies in plain view of the public, *within* the dynamic educational environment of the early childhood exhibition. Second, a permanently-rotating video screen provides adults with an opportunity to learn more about research studies even if they choose to have their child not participate in the current study. Third, each ongoing study is associated with a brief (1/3 page) handout. Researchers use this handout to recruit participating families, as well as to provide families with "try this at home" activities. Each of these features will be described in more detail in subsequent sections.

Benefits of Living Laboratory to Research Scientists, Museum Educators and Museum Visitors

The museum-researcher partnership has highlighted several *essential elements* (see Table 1), both from our continued discussion between museum educators and researchers, and from evaluation of the Living Laboratory model, which we describe in more detail in subsequent sections. Table 1 highlights what we see as the most important and unique aspects of our model. Inspection of Table 1 indicates that at its core, Living Laboratory brings together three audiences who benefit from participating in the program: child development research scientists, museum educators, and museum visitors. Below, we highlight some of the benefits between research scientists, museum visitors, and museum educators.

Essential Elements of the Living Laboratory® Model	
Breaking Down Barriers Between Research Scientists and the Public	1. Visitors contribute to the process of scientific discovery through participation in active studies 2. Visitors engage in one-on-few educational interactions with scientists conducting the research 3. Visitor education focuses on the process of science, increasing interest in and understanding of research questions and methods, as well as results 4. Studies occur in plain-view of the public, on the exhibit floor 5. Non-participant visitors talk with researchers and learn about ongoing studies in ways similar to study participants 6. On site research is an expected and predictable part of the visitor experience
Mutual Professional Development for Scientists and Educators	1. Researchers receive training from museum staff in effective museum-style education techniques, improving researchers' communication skills with public audiences 2. Museum educators gain direct access to current science that is relevant to their work with the public, improving educators' understanding of science and its potential application to practice 3. Museum educators and researchers communicate regularly, collaboratively monitoring the program to ensure scientific and educational goals are met, and that programmatic needs (e.g. logistical, financial) are fulfilled.

Table 1. The Essential Elements of the Living Laboratory Model. Note that this partnership yields benefits for three communities: research scientists, museum educators, and museum visitors.

New Insights: Benefits from Researcher-Visitor Interactions

Working in a museum setting offers plenty of opportunities for dialogue and observation. Researchers can (and do) discuss their proposals with interested parents. Parents can watch as children go through the research procedure and can ask questions when they are being recruited to participate in the study or once the interview with the child is completed. In fact, if children are old enough, they may ask their own questions about the research they have just been a part of. In one particularly memorable exchange, a curious eight-year-old girl asked whether all children "played the same game" with the experimenter. Her question began a

discussion about the difference between an experimental and a control group and the need for such groups to help answer research questions.

Second, discussion with parents quite often leads researchers to think about unexpected areas of research. For example, over a 4-year period, the Social Learning Laboratory at Boston University conducted a series of studies on how children understand that a story can have a real or a make-believe protagonist (Corriveau, Kim, Schwalen & Harris, 2009; Corriveau & Harris, 2015). The results indicated that by the age of 5, young children are able to correctly categorize these protagonists based on situational cues in the story, notably whether or not the story contained events that were impossible or improbable. For example, if the story portrayed a soldier involved in ordinary, realistic events, children were likely to say that he was a real person but if the story described his special sword that saved him in every battle, they were likely to say that he was a fictional character. Over the months, many parents asked how children categorize other types of stories – for example, fictional stories in which no causal violations occur, or religious stories in which a miracle occurs. This led the researchers to consider the effect of church attendance and schooling on children's judgments of reality and fantasy. Subsequent studies, conducted outside of the museum, found that children who had a religious education (whether at school or in church) were more likely to think of the protagonist in stories involving miracles as a real person (Corriveau, Chen & Harris, 2015). Were it not for parental questions, the researchers might not have explored this very fruitful area of research.

The dialogue between parent and researcher can also provide parents with a glimpse of the way that psychological research is conducted with children – and not just a sense of how their own child fares in a given study. That dialogue can highlight how the mind of a child is as

complicated and as worthy of scientific study as the more traditional targets of research that are typically on display in a museum of science. In particular, the dialogue can illustrate and underline how developmental psychologists are not primarily interested in children as well adjusted or troubled individuals – that is the purview of the clinician. Rather, they have a broader canvas – they want to understand the development of children's curiosity, their observational skills, their imagination, and their ways of thinking. Such dialogues also highlight the evolving and cumulative nature of the scientific enterprise. Occasionally parents will ask researchers questions about the anticipated scientific and educational implications of particular studies. Such questions lead to conversations about the limitations of individual studies, the need for follow-up experiments, and the importance of replication. These questions also lead to conversations about the limits of researchers' own expertise. For example, researchers cannot (and should not) give advice about what reading interventions would be most effective for a particular child. These conversations help broaden parents' understanding of psychological research and of the knowledge that individual researchers hold.

This last point is closely linked to a mission that researchers and museum educators can share. A science museum can and should offer its visitors the opportunity to learn about a given domain of science. However, it can also invite visitors to think about and even participate in the way that science is conducted. A museum can go beyond the documentation and display of the known. It can underline the incomplete but evolving nature of the scientific enterprise. Watching data being gathered, and especially watching a familiar child make his or her contribution is likely to be a memorable illustration of that process.

Mutual Professional Development: Benefits from Researcher-Museum Interactions

Collaborating researchers not only gain access to the diverse and accessible participant pool of museum visitors, but also work closely with museum educators as they learn to interpret their research questions and methods effectively for the public. Similarly, by conversing with active research scientists, museum staff become engaged in the research process and use that experience to inform their practice. We ensure such *mutual professional development* through a variety of regular interactions.

For example, researchers receive ongoing training in informal education practices, through an initial orientation and daily 'greetings' by a museum staff member or a museum volunteer. The daily greeting works as follows. At the beginning of every 3-hour research shift, a museum staff member approaches the researcher and asks her to run the study with the staff member acting as a child participant, and then to describe the study with the staff member acting as an adult visitor. The researcher is then asked a series of targeted questions designed to ensure they are being given the support they need in the recruitment process. This daily greeting has two intended purposes. First, although the collaborating laboratories provide extensive training to their research assistants well before they arrive at the museum, the initial greeting helps to place the researcher in the appropriate mindset: for the next three hours, s/he will be tailoring the discussion of the research to the museum's many audiences: museum staff, parents, and other visitors, who come from a variety of cultural and educational backgrounds. Second, through the same exchanges, museum educators are given an opportunity to learn about developmental science, including the methods the researchers use to study children's development.

A second example is related to the daily greeting, and comes from how the Discovery Center has approached times of the year when partnering university researchers are less likely to be able to be on-site (for example, during winter break, and summer holidays). Because of the daily greeting, museum educators have become familiar with the researcher studies taking place in Living Laboratory. Instead of closing Living Laboratory, the Discovery Center invited their high school and undergraduate interns to choose some of their favorite studies and create hands-on activities inspired by the research. For example, consider the line of research described above exploring children's understanding of fictional and historical narratives (Corriveau et al., 2009; Corriveau & Harris, 2015). In the research study, children were shown a picture of a novel figure and told a short story about her. Based on the story, children were invited to place the picture into a 'real' box or a 'pretend' box. Museum educators created a very popular storybook that included some the novel figures used in the research. An adult (a museum educator, a parent) would then read a story to the child and ask her to choose whether the figure was real or pretend. The end of the storybook included a description of the original research study, and the study's findings. Thus, even when researchers are not present, children and adults might have an opportunity to learn about research from the Living Laboratory model.

Finally, the Discovery Center has incorporated, into several exhibits, adult-focused activities that encourage caregivers to observe their children interacting with components in ways similar to how scientists might observe and interact with children during studies. The most robust examples are in the *Infant Area* (with components and related labels that draw attention to research from MIT's Early Childhood Cognition Lab) and the *Ball Maze* (which is

complimented by a set of activity cards which reference studies conducted in the exhibition by Bascandziev & Harris). For both components, the original research methods are presented to adult visitors as strategies for interacting with children that will allow caregivers to observe the same kinds of behaviors in their own children that have been documented in published research studies. Museum educators routinely incorporate similar strategies into casual interactions with caregivers throughout the Discovery Center – daily volunteer briefings frequently train volunteers to engage adult visitors in such conversations. A collective fluency - in study questions, methods and results - that has resulted from educators' daily interactions with researchers has transformed the way early childhood educators interact with visiting families, putting a spotlight on psychology as a STEM discipline, on-par with those traditionally represented in science museums, and helping caregivers observe and consider their own children within the context of a larger body of research.

Between 2005 and 2014, the MOS Living Laboratory partnership has included 31 unique research labs from across 9 institutions. Because each of these research laboratories includes postdoctoral fellows, graduate students, undergraduate students, lab managers, and high school interns, in total, more than 600 developmental science researchers have been trained in informal science education practices through the MOS Living Laboratory. In turn, hundreds of museum educators and other staff from departments across the institution have interacted with the collaborating researchers, and through these interactions learned about developmental science methods and research.

Examples of Specific Research from the Living Laboratory

In the following section, we review in more detail some of the research studies that have taken place in the Living Laboratory. We do this by highlighting research from two research lab partnerships. Both the Early Childhood Laboratory at Harvard University (PI: Paul Harris) and Social Learning Laboratory at Boston University (PI: Kathleen Corriveau) have conducted research studies in collaboration with the Living Laboratory since 2007 and 2011, respectively.

As mentioned above, because the research studies take place on the main floor, the research projects are competing with many other options. Thus, whether or not the research projects are appealing is an important practical consideration. The best projects are ones that actively engage children, and are relatively brief. The issue of engagement might seem obvious: after all, the participants are volunteers, and if the tasks appear to be fun, parents are more likely to volunteer their child (the promise of a sticker is also very helpful). But there is also a benefit for the researchers. Once the family has agreed to participate, having the child actively engaged helps to focus the child towards the task and away from the myriad distractions going on all around the Museum.

For example, in a series of studies exploring children's conceptions of fairness, children were asked to divide up some stickers between themselves and another child (Smith, Blake & Harris, 2013). In another set of studies exploring gravity, children were asked to predict where a ball would land when it was dropped down some tubes (Bascandziev & Harris, 2010; 2011). Finally, to explore children's preference for learning from written information over spoken information, we asked them to listen to the advice from two puppets and then drop a marble

down a Y-shaped tube based on which puppet they thought was correct (Corriveau, Einav, Robinson & Harris, 2014). In all of these cases, we had no difficulty having children complete all of the trials – indeed, many children asked to play the game again after we had finished! As a result of such positive experiences with research in Living Laboratory, many parents and children often seek out researchers to participate in additional studies on their next visits.

Designing a brief and engaging experiment can be challenging but this challenge can prompt the development of new means to test complex relationships. Consider the example we discussed above where we were interested in how children learn from written over spoken information. We thought it was likely that children's own reading ability might be related to their preference for learning from text. Yet a seven-minute time window (the approximate length of time we've found children can remain engaged in a study within the Discovery Center) does not allow us to administer many standard reading assessments in addition to our experimental task. We solved this problem by creating a very short test of emerging reading ability in which children were asked to point to a color circle that matched a color word. Thus, even in seven minutes we can begin to explore some – but not all – complex relationships.

Indeed, we have found that any experiment requiring that the child attend carefully to a spoken message can be challenging. For example, over many years at the museum, we have explored how children come to decide that a particular person is a trustworthy source of information when learning about the world (Corriveau, Fusaro & Harris, 2009; Corriveau & Kurkul, 2014; Chen, Corriveau & Harris, 2013; Fusaro, Corriveau & Harris, 2011; Harris, 2012). In this research, we often use videos to present children with sets of people who differ in one variable of interest. For example, children might see one person label an object accurately

(labeling a shoe as 'a shoe') and the other person might label the same object inaccurately (labeling a shoe as 'a ball'). We can then ask which person children prefer to turn to when learning novel information – the previously accurate person, or the inaccurate person. By presenting these people on video, we can control for all aspects of the people beyond what they have said. However, in a museum setting, this requires that the child has actually heard what the two people have said above the background noise of the museum. We have solved this problem in several ways. First, we provide headphones for the child (and disinfecting wipes so that parents are not concerned!). Second, we build into our procedure multiple checks to ensure that the child has actually heard the information. Finally, in some cases, we show movies to the children that do not require sound. For example, instead of labeling an object orally, children watch as people point or gesture (Corriveau et al., 2009; Chen et al., 2013; Morgan, Laland & Harris, in press). In sum, we have found that procedures that work just fine in educational or university settings may need to be modified to accommodate the unique constraints and challenges of the museum setting.

Before leaving these practical considerations – considerations that weigh heavily in the day-to-day conduct of research even if they are not especially exalted – it is worth underlining a related, cognitive issue of considerable, theoretical interest. As described above, much of our own recent work has examined the degree to which children trust an informant to supply reliable information, especially about matters that children cannot investigate or determine for themselves. We have found that even preschool children are sensitive to a surprisingly large number of informant characteristics. They prefer to learn from familiar, hitherto accurate informants and from those who appear to 'belong' – either to the same cultural group as

themselves or to a larger consensus. Stated differently, children are not so receptive to dissident voices. In very recent research, we have begun to examine children's sensitivity to expertise. One way that young children might determine that an informant is an expert is by evaluating his or her explanations. We have found that even 3-year-olds are able to evaluate the quality of an informant's explanations – and more impressive, they are able to use that information to make inferences about whom to turn to when learning new information (Corriveau & Kurkul, 2014; see also Mercier, Bernard & Clément, 2014).

What do young children do when faced with an informant who presents him or herself as an expert – for example, by wearing a white coat? Do children accept what such a person claims and does their acceptance of those claims depend on the nature of the particular claim (Lane & Harris, in press)? For example, do they trust an animal expert who makes surprising claims about animal behavior but not when he or she makes surprising claims about physical artifacts? Indeed, we have found that children as young as 3 and 4 years are more trusting of claims made by people who have relevant expertise; and this is true whether they are learning about ordinary or extraordinary phenomena (Lane & Harris, in press). Lurking behind these questions is a deeper one that we have yet to tackle. At what point do children come to think of particular institutions – schools, churches, hospitals, zoos and, of course, museums – as places where the adults belonging to the institution speak with special authority, an authority that is closely connected to the larger function of that institution in the transmission of a particular body of knowledge. By the age of five or six, children have begun to realize that their teachers in school have a distinctive type of expertise – different from that of their mothers, for example (Ronfard, Lane & Harris, submitted). However, what leads to this realization: their own

experience with teachers, the endorsement of teachers by their family and culture, or a combination of both? This same question can be asked about children's perception of researchers and museum educators in museum settings: do children perceive them as experts, and, if they do, why exactly? It seems plausible that older children will increasingly assume that the museum staff and the researchers that they meet during their visit have a particular type of authority or expertise. This developing understanding of the role played by cultural institutions and the people who work for them may lead children to develop expectations about their interaction with these individuals. As psychologists, we need to think more about whether these expectations impact the way that children perceive experimental tasks. As educators, we need to think more about how these expectations impact how children learn from their interactions with professional staff (e.g., museum educators or teachers) and with museum exhibits. In short, understanding the development of children's thinking about the role of institutions and their members and the inferences that these developments license has important implications for research and practice.

Lessons Learned from Evaluation

This museum-researcher partnership has been highly productive. As of August 2014, the authors are aware of at least 40 scientific articles using data collected in the Discovery Center that have been published in peer-reviewed academic journals. Many more are in preparation or under review. In addition to the numerous publications that highlight the effectiveness of the partnership, the MOS has conducted internal formative evaluation, and commissioned external summative evaluation of the Living Laboratory model. These evaluations are described in more detail in the following sections.

From 2007-2011, Living Laboratory received generous support from the National Science Foundation[3] to develop and evaluate various mechanisms for communicating the research to museum visitors. The summative evaluation had two main goals: to explore whether Living Laboratory had any effect on adult visitors' understanding of research in developmental science, and to explore the impact of Living Laboratory on participating MOS educators and research scientists. Below, we outline the evaluation process, and highlight some findings of interest.

In 2008 and 2009 an independent evaluator conducted observations of child and adult visitor interactions with Living Laboratory researchers, and MOS educators presenting hands-on research activities. The evaluator also observed adult visitors interacting with their children at two exhibits highlighting completed Living Laboratory studies (now permanent components installed in the Discovery Center), and surveyed visitors who interacted with any aspect of Living Laboratory (e.g., as research participants, users of staff-led activities and/or users of exhibit components) as they exited the Discovery Center. Finally, the evaluator conducted a series of individual interviews and focus groups with researchers, MOS educators, parents whose children participated in Living Laboratory, and the cohort of non-MOS museum professionals.

The evaluation documented measurable positive outcomes associated with both of the goals. Interaction with Living Laboratory helped to enhance adult visitors' understanding of developmental science research. For example, of the 127 adult visitors surveyed, about half (49%) felt more informed of the methods used in developmental science research after visiting

[2] "A Participatory Model for Integrating Cognitive Research into Exhibits for Children" (Kirshner; NSF Award #0714706).

the Discovery Center. Moreover, just over one-third of the adults (37%) felt that their visit changed how they thought about how children learn. The survey findings were remarkably similar to the findings from individual interviews with adult visitors after their child participated in a Living Laboratory research study. About two-thirds (62%) of adults felt that they understood the 'process' of the research, and 42% of adults outlined research-related observations they would make while interacting with their child at home (Soren, 2009). Taken together, Living Laboratory is an effective mechanism for stimulating adults' understanding of the value and process of developmental science research.

In addition to enhancing adult visitors' understanding of research, Living Laboratory had positive impacts on both research partners and museum educators. To evaluate the impact of Living Laboratory on researchers' ability to explain their questions and methods to a lay audience, both 'novice' (new to the museum) and 'expert' (collaborating with Living Laboratory for many years) researchers were observed. These researchers also participated in focus groups. After a semester of regular interactions with museum educators and visitors, qualitative differences emerged in how researchers spoke with adult visitors. Living Laboratory researchers improve in their ability to use lay language to describe their research questions, to explain the method they use to conduct the research, and to highlight the practical implications of their work. In turn, museum volunteers and staff have expressed increased comfort in talking with visitors about child development, have changed their own approaches to teaching in the exhibit, and have noticed changes in the way parents interact with their children since the introduction of Living Laboratory (Soren, 2009). By drawing on the strengths of both research scientists and museum educators, and encouraging ongoing interactions between our teams,

an emphasis on both 'the process of science' and 'the process of communicating science to the public,' has resulted in a more effective educational program for museum visitors.

Lessons Learned Through Researcher-Museum Collaboration

We now turn to consider the intellectual gains from conducting research in a museum setting. Some of these are less obvious than others. At the Museum of Science in Boston, considerable effort has been invested in training researchers – training them to approach and talk to potential volunteer families and to convey the nub of a given experiment in a simple and accessible fashion. With some exceptions, researchers, especially at earlier stages in their career, tend to have a particular audience in mind when they think about their research: their mentor, their immediate colleagues, and readers of the journals in their field where they hope to publish their findings. When these young researchers make an oral presentation it is typically in the context of a scientific conference or job talk. In those contexts, certain assumptions can be made about what notions will be shared between speaker and audience, what might be novel for the audience, and what will provoke discussion or probing questions. In that sense, then, conducting research in a museum setting has an educational impact on researchers. Describing a research project to museum staff or parents calls for different skills from those needed in narrower, professional settings. Some of those skills are obvious – an ability to avoid jargon, and to provide a clear, concrete description of the procedure. Some, however, are less obvious. For example, museum educators would often like to get a sense of the larger agenda that guides a particular experiment but researchers may take that larger agenda so much for granted that they do not think to articulate it. In addition, having watched their child answer an experimenter's questions, parents may want to know how their child compares to others. An

explanation that the questions are not pass-fail but meant to illuminate children's thinking – especially the way of thinking that characterizes a given age group – can be reassuring for parents. In other words, researchers working in museum have to present and explain what they are doing. They are prompted to set their study in a less narrowly scientific context – to think about how a non-specialist audience will gauge its value, and to give consideration to the personalities and families of the individual children who pass through a given study.

One of the most valuable parts of researchers' training at the Museum consists of writing with museum staff members short and accessible descriptions of the studies that are conducted in the museum. These short abstracts are meant to provide background information about the study, to introduce the research questions, to describe the experimental procedure, and to outline possible results and their implications. They are used to recruit and debrief parents and help to facilitate conversations between researchers and museum visitors. Writing these educational pamphlets requires several rounds of revisions to ensure that they are appropriate for museum visitors. In addition, annually, researchers present their findings to a diverse group of museum volunteers and staff, ranging from high-school students to scientists with advanced degrees. Following these presentations, attendees can ask questions of the researchers, allowing audience members the opportunity to learn from the presentation and from one another's questions, and providing an opportunity for researchers to hone their skills in addressing a diverse audience.

In summary, we believe there have been many benefits to such collaborations between academic researchers and museum educators. The most important aspect of Living Laboratory is the ongoing communication and collaboration between the many stakeholders. It is only

through sharing the strengths and challenges with the model that we have developed a viable and sustainable program.

Future Directions: The National Living Laboratory Project

Taken together, the Living Laboratory model has been highly productive for researchers, museum educations and museum visitors. Because of the model's success, we were interested in extending our reach beyond the Boston area. The *National Living Laboratory*[14] project was designed to connect a growing community of museum and research professionals who are interested in bringing current research in child development to science centers, children's museums and other informal education institutions.

Three additional sites were first approached: Maryland Science Center (Johns Hopkins University), Madison Children's Museum (University of Wisconsin-Madison) and Oregon Museum of Science & Industry (Lewis & Clark College). Each of these sites has adapted and implemented the Living Laboratory model in their own early childhood exhibitions. These three sites and the MOS work together as the National Living Laboratory (NLL) project team and now serve as *hub sites* for disseminating resources about the model to other museums and academic institutions (see Table 2 for a list of current museum-researcher partnerships). As the NLL project team has scaled-up the Living Laboratory model at these and additional sites, a focus has been on how each site achieves their intended goals. In particular, we are learning about the ways that different institutions adapt the model based on their varying mission, organizational structure, community dynamics and scale.

[14] "Broad Implementation: Creating Communities of Learners for Informal Cognitive Science Education" (Kipling; NSF Award #1113648)

Current Living Laboratory Sites		
Informal Education Institution	**Research Institution(s)**	**Location**
Museum of Science, Boston - HUB	Harvard University Boston University Boston College Tufts University Boston Children's Hospital	Boston, MA
Stepping Stones Museum for Children	Yale University	Norwalk, CT
Connecticut Science Center	Wesleyan University	Hartford, CT
Sciencenter	Cornell University	Ithaca, NY
Explore and More Children's Museum	SUNY Buffalo	Buffalo, NY
Please Touch Museum	Monell Chemical Senses Center	Philadelphia, PA
Phipps Conservatory and Botanical Gardens	Carnegie Mellon University	Pittsburgh, PA
Da Vinci Science Center	Lehigh University	Lehigh, PA
Maryland Science Center - HUB	Johns Hopkins University	Baltimore, MD
Delaware Children's Museum	Penn State – Brandywine	Wilmington, DE
Children's Museum of Richmond	Virginia Commonwealth University	Richmond, VA
Madison Children's Museum - HUB	University of Wisconsin - Madison	Madison, WI
Ann Arbor Hands-On Museum	University of Michigan	Ann Arbor, MI
Museum of Natural History at University of Michigan	University of Michigan	Ann Arbor, MI
Fort Worth Museum of Science and History	University of Texas	Fort Worth, TX
Children's Museum of Southern Minnesota	Gustavus Adolphus College	Mankato, MN
Children's Museum of Fond du Lac	Marian University, Wisconsin	Fond du Lac, WI
Oregon Museum of Science and Industry – HUB	Lewis and Clark College	Portland, OR
Science World	University of British Columbia	Vancouver, BC (Canada)
Children's Museum of Denver	University of Colorado – Boulder	Denver, CO
KidsQuest Children's Museum	University of Washington	Bellevue, WA
Reuben H Fleet Science Center	University of California - San Diego	San Diego, CA
Science Factory Children's Museum and Exploration Dome	University of Oregon	Eugene, OR
Bay Area Discovery Museum	University of California - Berkley	San Francisco, CA

Table 2. Active Living Laboratory sites, December 2014. More than 230 informal learning and research institutions are represented by members of the NLL community (see www.livinglab.org/directory).

Evaluation has been a key tool to determine how the model can be implemented in different informal settings, with collaborating laboratories focused on a wide range of child development topics. At each site, it is important to maintain a high-quality visitor experience, as well as an effective mutual professional development program for museum educators and researchers. While the nature of each museum-academic collaboration differs, formative evaluation during year one of Living Laboratory's nation-wide implementation indicated that each of the three new sites adopted the model with a high degree of fidelity (Lussenhop, Cahill & Lindgren-Streicher, 2013). Partnership logistics and mutual professional development programs at each site were iteratively improved throughout implementation, with a focus on ensuring effective interpretation of the research for visitors by both scientists and museum educators.

Summative evaluation of the national implementation (conducted by Evergreene Research and Evaluation, LLC) has three phases. Phase One (2012-2014) examined the short-term impacts of Living Laboratory's mutual professional development program on the two professional audiences at each of the NLL hub sites (Beaumont, in prep). Phase Two (2014-2015) examines the spread of the model from hub sites to new adopter sites - documenting the transition from "Potential Adopter" to "Partial Adopter," and from "Partial Adopter" to "Full Adopter," of the Living Laboratory model at informal learning institutions across the US. Phase Three (2015-2016) will examine broad national implementation of Living Laboratory by drawing on Coburn's (2003) theory of "Scaling Up" to consider depth of change, shift in ownership, spread and sustainability of the model across a variety of Living Laboratory partnerships (e.g., those at science centers, children's museums, other informal learning settings; those

collaborating with large research universities, small liberals arts colleges, independent research institutions). The summative evaluation uses a mixed-methods approach, which includes direct observation of interactions among the three audiences, as well as surveys, interviews and focus groups with researchers, museum educators and adult visitors across sites.

The NLL project[5] also works to connect with museum and research professionals who have worked successfully in other collaborative models (for examples, see: Callanan, 2011). Such a community has the potential to serve as the initial infrastructure for a national network of professionals interested in studying and promoting early learning across museum, lab and home contexts. This community bridges academic research and educational practice, and aims to develop and document best practices in scientist-museum collaborations across a variety of settings. By working together through common challenges and identifying opportunities, we hope to support the sustainability of Living Laboratory sites as well as other academic-museum collaborative projects that benefit scientists, museum professionals, and the general public.

[5] For more information about the national initiative and to connect with the community, see www.livinglab.org

References

Bascandziev, I. & Harris, P.L. (2010). The role of testimony in young children's solution of a gravity-driven invisible displacement task. *Cognitive Development, 25*, 233-246.

Bascandziev, I. & Harris, P.L. (2011). Gravity is not the only ruler for falling events: Young children do not commit the gravity error if given rich perceptual information about the tubes mechanism. *Journal of Experimental Child Psychology, 109*, 468-477.

Beaumont, L. (in prep). National Living Laboratory Broad Implementation – Year 2 and Year 3 Summative evaluation of "*Creating Communities of Learners for Informal Cognitive Science Education*" (NSF grant #1113648).

Callanan, M.A. (2012). Conducting Cognitive Development Research in Museums: Theoretical Issues and Practical Applications. *Journal of Cognition and Development*: 13:2, 137-151.

Chen, E. E., Corriveau, K.H. & Harris, P.L. (2013). Children trust a consensus composed of outgroup members – but do not retain that trust. *Child Development, 84*, 269-282.

Coburn, C. E. (2003). Rethinking Scale: Moving Beyond Numbers to Deep and Lasting Change. *Educational Researcher*, 32 (6): 3-12.

Corriveau, K.H., Chen, E.E., & Harris, P.L. (2014). Judgments about fact and fiction by children from religious and non-religious backgrounds. *Cognitive Science.*

Corriveau, K.H., Einav, S., Robinson, E.J., & Harris, P.L. (2014). To the letter: Early readers trust print-based over oral instructions to guide their actions. *British Journal of Developmental Psychology, 32*, 345-358

Corriveau, K. H., Fusaro, M., & Harris, P.L. (2009). Going with the flow: Preschoolers prefer non-dissenters as informants. *Psychological Science, 20*, 372-377.

Corriveau, K. H., & Harris, P.L. (2015). Children's developing realization that some stories are true: Links to the understanding of beliefs and signs. *Cognitive Development.*

Corriveau, K. H., Kim, A. L., Schwalen, C., & Harris, P.L. (2009). Abraham Lincoln and Harry Potter: Children's differentiation between historical and fantasy characters. *Cognition, 112*, 213-225.

Corriveau, K.H. & Kurkul, K. (2014). "Why does rain fall?": Children prefer to learn from an informant who uses non-circular explanations. *Child Development, 85*, 1827-1835.

Fusaro, M., Corriveau, K.H. & Harris, P.L. (2011). The good, the strong, and the accurate: Preschoolers' evaluations of informant attributes. *Journal of Experimental Child Psychology, 110*, 561-74.

Harris, P.L. (2012). *Trusting what you're told: How children learn from others.* Cambridge, MA: The Belknap Press/Harvard University Press.

Lane, J. D. & Harris, P.L. (in press). The roles of intuition and informants' expertise in children's epistemic trust. *Child Development.*

Lussenhop, C., Cahill, C., & Lindgren-Streicher, A. (2013). National Living Lab Broad Implementation - Year 1 Formative evaluation of "*Creating Communities of Learners for Informal Cognitive Science Education"* (NSF grant #1113648). Available on-line at: http://informalscience.org/images/evaluation/NLL%20HUb%20Site%20Implementation-Y1%20Formative%20Evaluation.pdf

Mercier, H., Bernard, S., Clément, F. (2014). Early sensitivity to arguments: How preschoolers weight circular arguments. *Journal of Experimental Child Psychology, 125,* 102-109.

Morgan, T.J.H., Laland, K.N., & Harris, P.L. (in press). The development of adaptive conformity in young children: Effects of uncertainty and consensus. *Developmental Science*.

Ronfard, S. Lane, J. D. & Harris, P.L. (submitted). Teachers know best: role-based selection of informants by young children

Smith, C. E., Blake, P. R., & Harris, P.L. (2013). I should but I won't: Why young children endorse norms of fair sharing but do not follow them. PLoS One, 8, (3): e5910.

Soren, B.J. (2009). Summative evaluation of "A Participatory Model for Integrating Cognitive Research into Exhibits for Children," (NSF grant # 0714706). Available on-line at: http://informalscience.org/images/evaluation/MOS_DC_Final_Summative_Evaluation_Report.pdf

The Team

Kathleen Corriveau is the Peter Paul Assistant Professor in Human Development at Boston University, where she directs the Social Learning Laboratory. Her research focuses on social and cognitive development in childhood, with a specific focus on how children decide what people and what information are trustworthy sources.

Becki Kipling oversees early childhood education initiatives at the Museum of Science in Boston, where she is responsible for creating exhibits and programs that support the development of science, math and engineering process skills for the youngest visitors. Her work, including co-innovating Living Laboratory in 2005, firmly established the Museum's Discovery Center as a regional and national leader in informal science education for early childhood audiences.

Samuel Ronfard is doctoral student in Human Development and Education at Harvard University in the Graduate School of Education. His research focuses on knowledge acquisition and transmission in childhood. From June 2012 to June 2014, as a National Living Laboratory Research Liaison, he helped develop a toolkit of resources for scientists and museum professionals interested in beginning new partnerships.

Marta Biarnes is co-founder of Living Laboratory, developed at the Museum of Science in Boston, and has worked at the intersection of informal science education and early childhood education for over a decade. As co-PI for National Living Laboratory initiative, she currently facilitates national and international collaborations between museum professionals and scientists.

Brittany Jeye is a graduate student in the Memory and Perception Laboratory at Boston College, where she studies the functional role of the hippocampus in human memory. She has more than five years of experience as a staff educator in the Discovery Center at the Museum of Science, Boston where she is actively involved with Living Laboratory. She previously served as Educational Coordinator for the National Living Laboratory Initiative.

Paul Harris is a developmental psychologist with interests in the development of cognition, emotion and imagination. For many years, he taught in Europe. In 2001, he moved to Harvard University where he holds the Victor S. Thomas Professorship in the Graduate School of Education. His latest book is: 'Trusting what you're told: How children learn from others' (Harvard University Press, 2012).

The Museum Setting

The Museum of Science mission is to play a leading role in transforming the nation's relationship with science and technology. Our *Discovery Center* is the keystone experience for young children (ages 0-8 years) and their adult caregivers, and home to the flagship *Living Laboratory* program. This 4,200 square-foot exhibition provides a safe and supportive environment for early learning and exploration. Since its inauguration in 1988, more than four million children and accompanying adults have experienced the Center's dynamic activities - including live animal exhibits, discovery boxes, sensory activities, an experiment station, and unique hands-on experiences with the museum's collection. The Museum is a nationally recognized for its work connecting public audiences with STEM, leading not only the National Living Laboratory® Initiative, but also the Nano-scale Informal Science Education Network (NISENet) and the award-winning Engineering is Elementary® project.