Developing Mind Lab: A University-Museum partnership to explore the process of learning

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The Team
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The Museum Setting
The mission of Providence Children’s Museum is to inspire and celebrate learning through active play and exploration. The Museum creates and presents interactive exhibits and programs designed to serve the needs of children, ages 1 to 11, and the adults who care for them, and is committed to being accessible and responsive to all families – culturally, physically and economically. Nationally recognized, the Museum is a leading advocate for the importance of self-directed play in children’s healthy development. The Museum welcomes parents as active participants in their children’s healthy development, and works to increase awareness of the ways in which children and families learn.

In this chapter, we describe the collaboration between the Causality and Mind Lab (CML) at Brown University and Providence Children’s Museum (PCM). As institutions with distinct missions – one to advance understanding of the understanding of cognitive development, and the other to inspire and celebrate learning through active play and exploration – the dynamics of the partnership have evolved over the past 10 years towards meeting the unique interests and needs of both partners.
As Callanan (2012) outlined, collaborations between cognitive development researchers and museums can take a variety of forms, and the partnership between CML and PCM has looked different both over time and based on the goals of a given project. CML and PCM started exploring a collaboration in 2003 when the museum approached Sobel about the possibility of evaluating an after-school program that brought children from community centers servicing low SES families in Providence to the Museum to foster engagement in the learning process. Practitioners at PCM were interested in knowing more about the efficacy of the program. Upon observing the program, Sobel realized that he did not have the expertise to design procedures that would definitively assess children’s conceptions of learning and whether those conceptions changed through participation in the program. Nevertheless, this question lingered for Sobel, and inspired a line of research on children’s conceptions of learning as a mental state in CML.

Fast-forward to late 2007 when researchers from CML approached the Museum to start collecting data for lab-based studies at PCM by recruiting visitors from the exhibits. This initial arrangement was informal. A researcher (and eventually a small research team) would be stationed at a table in a corner of an exhibit or in an open activity room, recruiting families to participate in controlled experiments. There was no signage indicating the researchers’ presence, nor was there any regular interaction between the researchers and Museum staff.

Wishing to formalize the interaction and learning from colleagues at the Museum of Science, Boston (see Corriveau et al., this volume), PCM branded the partnership as Mind Lab in 2010 in order to provide more structure to the research happening at the Museum and increase its educational impact. Researchers from CML were given regular shifts to recruit families to participate in or simply observe ongoing research driven by the researchers’ interests, and answer questions about the purpose and implications of the work. Researchers also discussed their
research and engaged in professional development with Museum staff and volunteers at annual meetings and informal brown bag sessions. With space at a premium, Mind Lab researchers floated among different locations in the Museum, some more conducive to research than others, and none able to support permanent communication with visitors about the work. The partners found certain mutual benefits to this level of collaboration: Hosting research from cognitive development laboratories helped PCM to share some information with staff and visitors about children’s learning and development and how scientists study these processes; and being at the Museum helped CML find willing research participants and disseminate its work to the general public.

Inspired by the depth of collaboration between University of California at Santa Cruz and Children’s Discovery Museum of San Jose (see Callanan et al., this volume), partners at CML and PCM began thinking about where their individual interests and needs might overlap beyond a basic level of interaction. When considering why they should further the partnership, CML was interested in expanding the broader impacts of their work – not only to disseminate current research findings and the importance of developmental science to the general public, but also to apply ideas that emerged from cognitive development investigations to informal learning settings. The Museum’s interest centered on an existing effort to make the learning that happens through children’s play and exploration more noticed and appreciated by caregivers, staff, volunteers and children, themselves. Besides sharing information about CML research with staff and families, PCM also wanted to move towards working with research partners to study the types of learning experiences that happen naturally in the Museum, rather than in controlled experimental situations.
Through conversation and the process of applying for funding, a certain synergy emerged around understanding and supporting children’s developing metacognition. A project proposal to NSF included the specific aim of strengthening the partnership between CML and PCM by incorporating two parallel lines of work: CML-led studies were designed to investigate children’s developing metacognitive and scientific reasoning abilities, with the goal of understanding how young children begin to conceptualize the process of learning. And Museum-led studies explored children’s learning and behavior at the exhibit face, and caregivers’ understandings of how children think and learn through play at the Museum – with the ultimate goal of developing tools and techniques to support children and caregivers in reflecting on the learning that occurs at the Museum.

CML was awarded funding for this project (The emergence of diagnostic reasoning and scientific thinking) in 2012. This funding allowed CML and PCM to deepen their partnership in concrete ways: It created a shared researcher position between the two institutions, allowing research studies in Mind Lab and cycles of research (led by Museum-based researchers), evaluation and development in Museum exhibits to take place around a common topic. The funding also allowed for the creation of a permanent and dedicated space for the Mind Lab program, which has increased the research presence at the Museum in several ways. First, it provides a more visible site for ongoing research at the Museum, allowing families to learn about and participate in active research studies. Second, it contains exhibit labels (aimed primarily at caregivers) that describe research topics in child development, allowing caregivers to learn about research on children’s learning and its importance in their lives. Finally, it houses a hands-on activity that relates to CML’s research on causal learning (designed in collaboration between
CML and PCM), which provides opportunities for children to learn by exploring and experimenting and encourages caregivers to reflect on their children’s learning.

Research at the Museum now exists more visibly, including CML and other university-led studies in Mind Lab, PCM-led research taking place in Museum exhibits about children’s learning and families’ experiences, and iterative cycles of development and evaluation of activities and labels based on shared research findings. CML and PCM are still developing the partnership – to this end, we (the authors of this chapter, representing the research team currently involved in the collaboration) think of much of the work we do as cooperative, or “parallel play” – simultaneous ongoing investigations led by both groups with some overlap in structure and personnel, finding common ground in our interests and goals, and exploring research questions within this space.

In this chapter, we articulate some of the research done by CML on children’s understanding of learning, conducted primarily in Mind Lab. This work examined the factors children use to make judgments about whether learning has taken place in others, what children know about the process of learning, and when they begin to reflect on their own learning. We next describe Museum-led observations of children’s play at the exhibit face, which examined how children demonstrate and reflect on their own thinking as they play. We then present interviews with caregivers, which examined how they notice, describe, and interpret children’s play and learning within the Museum. In the final section, we explore some of the ways in which the lines of work have been influenced by the partnership, what we have learned from working with each other, and our goals for sustaining and building the collaboration.

CML Research on Children’s Understanding of Learning
What do children know about whether learning has occurred in others? Early research in theory of mind focused on a number of topics related to learning, but not learning directly. For instance, by age 3, young children incorporate the word *know* in their spontaneous conversations (Bartsch & Wellman, 1995; Shatz, Wellman & Silber, 1983), and at this age, children recognize when someone knows something (as opposed to not, e.g., Pillow, 1989; Pratt & Bryant, 1990). Between the ages of 3-5, children show significant changes in their understanding of beliefs. They begin to understand the distinction between ignorance and knowledge (Hogrefe, Wimmer & Perner, 1986), they recognize that beliefs represent one’s ideas about the world and can be false (e.g., Perner, 1991; Perner, Leekam & Wimmer, 1987; Wimmer & Perner, 1983), and recognize when their own knowledge has changed (Gopnik & Astington, 1988).

None of these lines of work, however, explicitly address children’s understanding of learning itself as a mental state. Children’s developing knowledge of belief does have some importance for their understanding of learning. Sobel (in press) found that children’s developing understanding of false belief predicted their ability to recognize that a person could claim to have learned something when they actually have not learned it. These data are consistent with a more general hypothesis: Children construct a concept of learning based on their understanding of other mental states, like knowledge and ignorance. Because learning involves changes to knowledge states (e.g., replacing ignorance with knowledge), children’s understanding of knowledge, ignorance, and how beliefs change all influence their concepts of learning.

On this view, children come to recognize that certain mental states are more directly related to learning than others, through appreciating that some mental states lead to others. For example, in most learning environments, perceiving or paying attention to information should be more directly related to learning than the desire to learn. If an opaque container is opened, one
learns its contents by looking inside, regardless of whether one has the desire to learn this information or whether the container was opened intentionally or accidentally. In contrast, if one does not see what is inside, wanting to know will not result in any learning.

Based on the hypothesis that children believe learning is related to other mental states, Sobel, Li, and Corriveau (2007) investigated how children made judgments about characters whose desire, attention, and intention to learn varied. Four and 6-year-olds were introduced to characters who were all in a similar learning situation (e.g., a teacher was teaching them to sing a song at school). Children were told about two of the character’s mental states, which were potentially in conflict with the learning goals. For example, children were asked about characters who wanted to learn, but failed to attend to (and hear) the teacher, or characters who heard, but did not want to learn. When asked whether each character learned, 4-year-olds mostly responded based on the character’s desires (saying that characters who wanted to learn, would); they did not recognize that some mental states were more important for learning than others. Six-year-olds, in contrast, were much more likely to recognize the role of perceptual access and intentionality when making these judgments (stating that characters would learn only if they paid attention to and heard the teacher).

What is learning to the developing child? CML’s initial research goal was to understand how children made judgments about whether others learned when faced with specific situations — for example, when particular mental states were pitted against one another, as in the study described above. However, these scripted scenarios may not relate to children’s personal experiences, or reveal children’s own conceptions of learning or their beliefs about themselves as learners. To address this issue, the CML team wanted to use a more exploratory method to investigate children’s understanding of and reflection on their own learning. This line of inquiry
is one example of the ways that the NSF funding, which allowed a project researcher (the second author) to work at both CML and PCM, influenced the ways that CML approached its research questions, making connections to children’s own experiences and using methods that were adapted to less controlled museum settings.

Sobel and Letourneau (in press) used a short interview to allow children to articulate their understanding of learning in their own words. In this study, researchers conducted a structured interview with 4-10-year-olds, asking them to describe what and how they learned in any way they chose, using examples that were meaningful to them. Interviews began with an open-ended question: “What do you think ‘learning’ means?” Children’s answers were coded as identity responses (in which children simply defined learning as learning), or as being about content or process. Content responses involved the child defining learning as a subject or topic (e.g., “like reading and math”). Process responses involved the child defining learning as either a source (e.g., “when your teacher tells you something”) or a strategy (e.g., “when you practice again and again until you know it”) that would result in knowledge change. Figure 1 shows the distribution of responses to this question. There were clear relations with age: 4- and 5-year-olds mostly did not respond to the question or defined learning in terms of content. Process-based responses increased with age: Eight- to 10-year-olds generated process-based responses ~95% of the time, significantly more often than 6- and 7-year-olds (66%), who were significant more likely to do so this than the 4- and 5-year-olds (42%).

Children’s definitions of learning also influenced the ways that they recalled and described their own learning. After this first question, children were asked to give examples of content (“Can you think of something that you have learned?”) and process (“How did you learn that?”). Children who generated a process-based definition of learning were more likely to
mention learning a skill (e.g., “how to tie my shoes”) or a fact (e.g., “ants have six legs”) than children who did not. Moreover, children who generated a process-based definition of learning were more likely to respond to the question about how they learned something by describing a source or a strategy through which they acquired their knowledge (e.g., “my teacher told me,” “I watched my friend and then I did it,” etc.). Finally, children were asked to talk about other ways they could learn (e.g., “How else could you learn?”). Again, children who had given process-based definitions were more likely to be able to describe different strategies for learning (e.g., “someone could show you,” “you can just try it yourself”, “you can read a book”). These questions were then repeated several times over a 5-minute interview, so that children could generate several different examples. Importantly, all of these differences held controlling for children’s age and a gross measure of their language capacities.

These data suggest two conclusions. First, children’s ability to define learning as a process develops between the ages of 4-10 years old, and is related to the kinds of examples they offer of their own learning and to their descriptions of how they have learned in the past. This suggests that children’s appreciation of their own learning is developing into the elementary school-years.

Second, even though children’s definitions of learning changed between ages 4-10, an understanding of learning as a process (rather than age) was the critical predictor of children’s ability to recall and describe examples of their own learning. That is, some 4-year-olds already conceptualized learning as a process, and across all ages, children’s ideas about learning affected how they reflected on their own learning. Some important questions remain: Do children who think of learning as a process approach informal learning environments differently than those who think of learning as focused on content or facts? Are these children more engaged by the
process of learning, rather than focusing on the outcomes or the “right answers”? Do they explore and play in different ways in museums or similar free-choice environments, or reflect differently on what they learned through these experiences? If young children are beginning to recognize learning as a process, how can parents and educators better support children in developing this understanding, and scaffold their thinking about their own learning? Future work CML and PCM want to do together will try to explore such questions in more depth.

*PCM Research on Learning through Play at the Museum*

*Observing children’s play in Museum exhibits.* Research on the development of metacognitive awareness in childhood is closely related to PCM’s goal of making learning visible within its walls — a goal it shares with many other museums and educators in general. As part of the NSF project described above, the Museum’s project team (which includes Meisner and Letourneau) used research and evaluation in PCM exhibits to explore existing and new ways of making children’s learning more noticed and appreciated by caregivers and by children themselves.

The research findings described in the previous section suggest that museum practices can make learning more visible to children by helping them see learning as a process, rather than as being focused on content or outcomes, or by helping them actively reflect on their own learning. However, research studies on children’s metacognitive abilities have often required children to be able to articulate descriptions of their own learning or participate in structured laboratory tasks, making it challenging to apply the results to museum settings. A question that PCM had in this project was how children begin to demonstrate and reflect on their own thought processes during everyday play at the Museum. Further, PCM questioned whether there were
observable behaviors in children’s play that educators (and caregivers) might use as cues to notice and support children’s developing awareness of their own thinking. Given that the PCM serves children ages 1-11 (with an average age of 4) and their caregivers, the Museum also wanted to relate research to educational practices that are appropriate for young children, not just those who already possess an explicit understanding of learning.

Early in the project, the research team agreed that museum experiences might contribute to young children’s general awareness of their own thinking as well as their view of themselves as learners, perhaps scaffolding earlier forms of cognitive self-regulation that feed into metacognitive development. Relevant self-regulatory processes include planning, monitoring, strategizing, and reflecting on the outcomes of one’s actions (see Kuhn & Dean, 2004; Schneider, 2008 for reviews and links to educational practice). The foundations of these cognitive skills begin to emerge in early childhood, and with cumulative experience and support from peers and adults, children gradually develop a more explicit understanding of their own learning (Bronson, 2000; Schunk & Zimmerman, 1994, 1998; Whitebread, 2010).

Observational studies suggest that children do monitor, regulate, or describe their own thinking in a variety of ways: by working from a plan or with a purpose in mind, self-commentating and describing their ideas, concentrating and resisting distraction, correcting errors, systematically trying different strategies, and reflecting on their accomplishments. Some of these findings are based on observations conducted in school settings (Dermitzaki 2005; Dermitzaki, Leondari, & Goudas, 2009; Whitebread et al. 2009). However, researchers in informal learning have observed similar behaviors in museums — for example, explaining ideas or noticing and correcting errors while engaging with exhibits (Borun, Chambers, & Cleghorn, 1996; Pucner, Rapoport, & Gaskins, 2001).
To understand what these cognitive processes might look like specifically in children’s play at PCM, the research team asked for the input of staff and volunteers at the Museum. In group discussions, PCM educators (and later, educators at the Museum of Science, Boston) were asked: “Have you ever seen children planning, monitoring their thinking in the moment, strategizing, or reflecting on what they’re doing? How do you know? What shows you that this is happening?” These discussions generated many examples of instances when children noticed or controlled their own thinking — for example, by pausing to look at their work from different angles, by trying different strategies to complete a challenge they had set for themselves, and describing what they figured out to others.

Following these discussions, the research team used the behaviors that educators had mentioned as important for children’s learning to structure a set of observations in PCM exhibits. This approach shared some characteristics with action research, in which practitioners guide and contribute to the research process in order to inform their own practices.

The team observed children between the ages of 3-11 in three exhibits, and recorded behaviors as running records. The team identified instances of each of the behaviors defined in the group discussions and supported by the research literature, and examined whether aspects of the environment or children’s interactions with others contributed to their occurrence. Children often showed intense concentration when they could create something of their own design, or when exhibits provided sensory experiences that children could repeat, observe, and make subtle variations on. Children often thought out loud or described their ideas when they collaborated or shared materials with one another, or when they engaged in activities that involved creative construction (e.g., creating patterns with geometric pieces, building with blocks, etc.) or that offered visual examples of finished products (e.g., pictures of various patterns that could be
made or structures that could be built with the materials available). Children who announced
their plans at the beginning of an activity were also more likely to reflect on what happened later.

This study made connections with Museum practices on many levels. The observational
data provided a rich source of information on the ways that children make their thinking visible
in their play, and the ways that Museum experiences can support them in reflecting on their own
learning. Educators’ input was critical in the development of observational methods used in the
research, and the results of the research were directly applicable to exhibit design and
educational practices (e.g., supporting facilitators trained to engage children in exhibits). More
broadly, having observational research taking place at the Museum has contributed to a culture
of observation and reflective practice among Museum staff and volunteers.

*Making learning through play visible to caregivers.* In addition to examining children’s
thinking and learning through observable behaviors, the Museum research team also considered
the ways that caregivers might support children’s learning by noticing and reflecting on their
play. Making learning through play visible to caregivers in this way is a longstanding
educational goal of PCM, because child development experts generally agree that valuable
learning occurs through play (see Ginsburg et al., 2007; Fischer et al. 2008) and the Museum is
committed to advocating for child-directed play as an essential element of children’s learning
and development. PCM’s research team was interested in evaluating its existing exhibit
materials and developing new ones that would help caregivers observe children’s play, notice
thinking and learning in children’s behavior, and recognize moments when they might support
children in reflecting on their own learning.

Previous research has examined parents’ perceptions of children’s play in general, and
the learning they associate with different kinds of play activities (e.g., Brooker 2003; Fisher et al.
2008; Goncü & Gaskins, 2006; Rothlein & Brett, 1987; Tamis-LaMonda, Damast, & Bronstein, 1994; Singer et al., 2009). This work has found that caregivers hold generally positive views about the overall importance of play for their children, but vary in their beliefs about what “play” entails and the relative value of different types of play activities for children’s learning. A small number of research studies and evaluation reports have examined parents’ perceptions of play in children’s museums (Downey, Krantz, & Skidmore, 2010; Haas, 1997; Korn & Associates, 2010; Swartz & Crowley, 2004), often focusing on the roles caregivers play in facilitating their children’s learning within particular exhibit spaces. To better understand caregivers’ perceptions of their children’s play and learning specifically at PCM, which places a particularly strong emphasis on child-directed play, the research team conducted several sets of open-ended interviews. One set of interviews focused on what caregivers observed about their children’s play at the Museum, and the thought processes that they associated with their children’s behavior. The second author asked parents: What do you notice your children doing while they play at the Museum? What are you thinking about as you watch them play here? What do you think they’re thinking about? What behaviors show you that your children are thinking or learning?

When asked what they noticed children doing, caregivers reported observing where children spent a long time playing and what interested them. Beyond this, many made specific observations about their children’s play: noticing how they had changed over their development, wondering what they were working on, or thinking about their children’s particular strengths, personalities, or interests. Parents also associated many different kinds of thought processes with their children’s behavior. When asked what they thought their children might be thinking about as they played, some caregivers focused on children’s activity levels or enjoyment: 25% of caregivers replied that children were thinking about having fun, and 23% said that children were
mostly being hyper or physically active. However, many caregivers mentioned some kind of cognitive process: 33% described children trying to “figure something out” or “accomplish something” (often refusing help), and 30% described children thinking about exploring and “seeing what happens.” When asked if anything showed them that their children were thinking or learning as they played, caregivers often described intense concentration, persistence, independence, or children learning from their mistakes or telling others about what they did. These interviews showed that, with prompting, caregivers did intuitively recognize many aspects of children’s thinking in their play, but that this was not necessarily at the top of their minds as they watched their children.

In a second set of interviews, the second author asked another set of caregivers, which included parents, grandparents and other childcare providers, to describe the kinds of learning that they thought might happen through play at the Museum. The goal of this study was to understand whether some types of learning might be more visible or salient to caregivers than others so that the team could begin to develop exhibit materials and activities to communicate more effectively with caregivers about children’s learning.

Figure 2 shows the results of these interviews. All caregivers stated that their children learn though play in general, but they varied in how they described the learning that might happen through play at the Museum. Seventy-two percent of those interviewed described children learning how a particular exhibit component worked (e.g., “how to build a ramp,” “how to make the gears turn”), and 41% described content or facts that children might learn in particular exhibit spaces (e.g., “about history,” “about water”). Fewer (27%) described transferable cognitive skills that children might be using when they played at the Museum (e.g., “experimenting,” “problem-solving”). On the other hand, 36% of caregivers said that children
might learn social skills, like sharing and cooperating. Less frequent responses included sensory
experiences (e.g., “what things feel like”; 18%), and academic topics (e.g., “reading”,
“counting”; 14%). In light of the interviews we conducted with children about their own
learning, these findings suggest that there may be opportunities for the Museum to support more
process-based ideas about learning in both children and their caregivers, expanding their ideas
about what “counts” as learning during their Museum visits.

It is important to note that caregivers’ views of learning were influenced in part by
different expectations and values that they had when visiting the Museum. Caregivers who said
that they visited the Museum mainly so that their children could play independently or with other
children were also likely to say that their children learned social skills at the Museum. Caregivers
who specifically stated that they valued the Museum as a learning experience for their children
often mentioned topics or facts that children might learn from particular exhibit areas.

In other cases, however, caregivers’ ideas about learning conflicted with their goals for
their visits. For example, caregivers who primarily valued the quality time that they could spend
with their children at the Museum did not mention these social experiences as a part of their
children’s learning. Instead, they sometimes described “learning” as disrupting their quality time
together. Likewise, those who valued the novel, hands-on experiences that children could have
at the Museum often focused on the facts or content within particular exhibits (and questioned
whether children retained this information), rather than the overarching skills or general
knowledge that children might gain through their direct experiences with the world. In addition,
27% of caregivers openly acknowledged that they were not sure what or how children were
learning as they played at the Museum, or felt that they lacked the vocabulary to describe it.
They felt confident that their children were thinking and learning, but this belief seemed to be based on the common messages that “play is important” and “children learn through play.”

To summarize these findings, the majority of caregivers noticed specific details about their children’s play and had something to say about the kinds of learning that might happen at the Museum. But without additional prompting, many of the open-ended experiences that children encounter at PCM may not be recognized by caregivers as ‘learning’ in the moment. Although caregivers generally believe that hands-on, open-ended experiences are important for children’s learning, many caregivers find it challenging to describe how learning happens through these experiences. They may fall back on descriptions of topics or facts presented in particular exhibits because they feel they lack the vocabulary to describe how play relates to broader cognitive skills (including the metacognitive skills that were the focus of this project). That said, it is not the case that caregivers fail to notice what children are thinking about or doing as they play. Instead, caregivers come to the Museum with different agendas and goals for their visits that shape the way they participate in and interpret their children’s play in the moment (see e.g., Beaumont, 2010; Downey, Krantz, & Skidmore, 2010; Gaskins, 2008; Swartz & Crowley, 2004; Wood & Wolf, 2010).

Based on these findings, PCM is currently developing exhibit labels and resources for caregivers to communicate the variety of ways that children can learn through play, and the ways that they can help children reflect on their thinking as they play. For example, the exhibit text developed for the Mind Lab space provides multiple concrete examples, based on current research and educational theory, and makes connections to research on various relevant topics (e.g., how children learn from sensory experiences, from their peers, and from adults). The aim of these materials is to communicate more effectively that learning is not limited to topics or
content, but also includes open-ended cognitive, social, emotional, and physical experiences. The goal is not to negate the value of content-based learning, but rather to broaden visitors’ perspectives about other kinds of learning that happen naturally through play. Evaluation of the labels and resources has shown that caregivers report learning something novel about children’s learning from the research synopses presented and seeing the relevance of the research findings in their own lives.

Other resources aimed to communicate that caregivers can use their own observations to recognize their children’s learning, and use what they noticed to judge when and how to be involved in their children’s play. Prototypes of observation activities for caregivers included a list of specific behaviors that relate to children’s developing cognitive and metacognitive skills, along with brief explanations of their importance for children’s learning and development. Caregivers who participated in the activity reported watching their children’s play in a more focused way, and seeing more meaning and purpose in what their children were doing. In addition, the observation activities validated behaviors that caregivers occasionally viewed as negative or unproductive (e.g., repeating something over and over) and helped caregivers see their children’s play in a new light.

Benefits and challenges of the collaboration

The collaboration between CML and PCM has grown in many respects since it first began, and has had both planned and unanticipated benefits (and challenges) for researchers, Museum staff and volunteers, and Museum visitors. Because the benefits outweigh the challenges, we present the challenges first.
**Partnership challenges.** Developing and sustaining the collaboration across such different institutions has not been without difficulties, many of which are not unique to the CML-PCM collaboration and are probably represented among several chapters of this volume. Such challenges include negotiating schedules, finding appropriate space within the Museum, ensuring that the length of experiments does not detract from the overall visitor experience at the Museum, and committing to training for new researchers. Communication – another common struggle – is an ongoing issue, as we strive to address challenges as they arise and keep each other more informed about the needs and research activities at the two institutions. Regular monthly meetings and having a shared project researcher working in both settings have been essential to the many successes of the work (see details below).

Perhaps the most salient challenge is appreciating the different goals of the two institutions. The synergistic aspects of the collaboration are equally exciting to both partners, but each also has individual concerns beyond the partnership. A major motivator for PCM is to understand how children learn through play *within the Museum*, and ultimately to use the findings both to better design exhibits and to advocate more effectively for child-directed play, while CML seeks to gain generalizable knowledge about child development. The agendas of the two institutions are therefore complementary but work toward different ends. This requires parallel lines of inquiry with different research or evaluation approaches to take place within the larger project, and making connections between them is both an exciting opportunity and an ongoing challenge. In addition, as a children’s museum with broad interests, PCM presents hands-on experiences that explore the arts, culture, history and STEM, and foster children’s cognitive, emotional, social and physical development. CML is specifically focused on children’s STEM learning, and as such, the two institutions have to negotiate mutually relevant
lines of work. Some research ideas of great interest to CML have little bearing on PCM’s mission, and, likewise, some lines of research of relevance to the Museum are outside the scope of CML’s research goals and expertise. None of the challenges are insurmountable, but they all require increased communication to find common ground.

Partnership benefits. One intended mutual benefit of this project is the presence of the project researcher, whose position is shared between CML and PCM. More so than anything else, the position has increased the capacity for collaboration between the two institutions. By moving between academic and museum cultures, the shared researcher bridges the interests and needs of the two institutions and helps establish a common language to facilitate communications between the partners. She also allows for multiple related projects to take place simultaneously around a common topic, using different approaches that meet the needs of both institutions. Information about ongoing work at each site is shared between partners more quickly and accessibly, and as a result, we have been able to inform and influence one another’s work in new ways. For CML, studies on children’s developing understanding of learning have been expanded not only to include more open-ended research approaches, but also to address children’s perceptions of play and learning through play. These projects were not part of the original NSF proposal’s scope of work, but have emerged from the collaboration. For PCM, research findings about children’s developing understanding of learning as a process have provided new perspectives about ways that the Museum and caregivers can support children in actively reflecting on their own learning.

A second intended mutual benefit of this project is the new Mind Lab space, which is the permanent home at the Museum for learning about learning. By allocating space, the Museum has elevated the value it places on research partnerships and the potential outcomes they offer for
both research and practice. For CML, the new space and deeper partnership not only serve to include researchers as a greater part of the Museum community, but also help undergraduate and graduate students learn more about communicating research to the public in order to make their studies accessible and relevant to the caregivers and children who participate.

As alluded to earlier, because of the discussion between the CML and PCM staffs, new research ideas are able to bloom and resonate. Most of the CML-led studies described in this chapter would not have been conducted without discussion between the two institutions, and a clear benefit to CML is thinking through the process of translating between applied ideas and basic science. The development of the Mind Lab space offers an interesting case of research informing practice and vice versa: Based on CML research, PCM developed a tabletop activity to encourage scientific thinking and metacognition in children, as a way of illustrating these research topics for Museum visitors. The activity includes a set of circuit blocks (wooden blocks with batteries, motors, buttons, and lights that can be connected in various configurations, similar to those that exist in other museums and maker spaces), along with accompanying information for caregivers about the ways that children learn by exploring and experimenting with the blocks, and suggested prompts that caregivers can use to support their children’s thinking and learning as they play together. The activity itself may now become the subject of further study by CML researchers in Mind Lab. In this way, the collaboration might allow CML researchers to form novel research projects by building upon a Museum experience. Such a project is in its infancy, but will hopefully be of interest not only to other researchers, but to other practitioners as well.

Beyond this, from PCM’s perspective, a clear benefit of the collaboration has been to develop the Museum’s research activities more formally, which sets the stage for the Museum to consider a broader research agenda. Having a stronger research presence at the Museum (both in
Mind Lab and in the exhibits) has also contributed to PCM’s efforts to communicate information about the ways that children learn, and about how scientists gather evidence about children’s learning. Moreover, research happening in the Museum (especially observational research of children’s play) has led to many educational interactions with adult visitors — in particular, the presence of an observer often arouses caregivers’ interest in their own children’s behavior. That is, when caregivers see that researchers from both CML and PCM consider their children’s activity to be important and noteworthy enough to study, they seem to focus their attention on their children’s behavior more closely.

**Future directions**

CML and PCM are motivated by the work that has come out of the recent shared project and the new lines of inquiry that have emerged from the research. A second project funded by NSF, which begins in 2015, is allowing the partners to continue to explore the intersections between cognitive development research and museum practices by extending CML research into Museum exhibits. In this project, CML and PCM are collaborating with research teams from University of California, Santa Cruz/Children’s Discovery Museum in San Jose and University of Texas at Austin/the Thinkery, in order to investigate how open-ended exploration and parents’ explanations affect children’s causal learning in each of the three museums. In addition, the teams will examine how museum exhibit design and facilitation might influence parent-child interactions, as well as children’s exploration and learning. In this way, CML and PCM are deepening their collaboration both with one another and with colleagues from other universities and museums by working together to answer research questions that directly relate to families’ play and learning within Museum environments. The work is exciting to both partners because it
meets many of the individual institutions’ goals and interests, and acknowledges the unique expertise of both researchers and museum practitioners. With each new project, CML and PCM hope to work incrementally to close the gap between the cultures and practices of the two institutions, learning from one another’s perspectives and from the challenges we have worked through as a team.
References


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Figure 1

Figure 2.

Caption: Distribution of responses of caregivers when asked to describe the kinds of learning that they thought might happen through play at the Museum
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