23 Informal Learning in Museums

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During the 19th century, educators began to see museums as environments where people might learn. Curators made collections available for public viewing to enlighten the public and to instill the values of the state (Bennett, 1995; Hooper-Greenhill, 1992). During the 20th and 21st centuries, there has been a dramatic increase in the number and types of museums, and a steady movement to identify museums as educational as well as cultural institutions. During the 19th century, museums primarily focused on collections – preserving and curating were their primary functions (think of zoos and art or history museums). Today, many museums, such as interactive science centers and children's museums, have no collections at all. The exhibits in these institutions focus on providing experiences that are often designed explicitly to meet educational goals. The success of this newer interactive form of museum has encouraged many more traditional forms of museum to reposition themselves as educational institutions, especially with respect to school-aged children who visit either with families or in school groups. This new focus on learning is also motivated by increasing pressure on museums to demonstrate that they serve a broader public, and not only an educated and cultured elite.

As museums have become comfortable embracing a learning mission, they have also become more common locations for learning research. In this chapter, we explore new research findings and note what they suggest about how to design museum experiences to support more powerful learning. We also hope this chapter might inspire a new generation of learning scientists to use museums as laboratories for their work. Museums are filled with complex, rich, and fascinating learning problems. They are sometimes referred to as *free choice learning settings* because people are guided by their own interests, goals, or knowledge. As they learn, visitors engage with objects, signs, tools, discourse, and new technologies. And the topics that people learn about are diverse, including all aspects of art, science, history, geography, culture, and more. Museums are public and social places of learning, where it is easy to find learning happening with families or peer groups who need to collectively negotiate how to move through the museum, decide what to do at each exhibit, and figure out how to make sense of what they encounter. Museums also provide a wide range of diverse examples of designs to support learning for audiences ranging from the youngest children to the

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oldest adults. Because of these features, museums are learning environments that expand our existing definitions of learning; they require learning scientists to account for phenomena that are very different from formal, in-school learning.

The history of learning research might be described as evolution through behavioral, constructivist, and sociocultural paradigms (Greeno, 2006; Nathan & Sawyer, Chapter 2, this volume). The history of learning research in museums in some ways echoes this trajectory. A first wave of research focused on tracking behavior in museums, producing findings about the kinds of exhibits that tend to attract and hold visitors as they move through a museum (Allwood & Montgomery, 1989; Beer, 1987; Bitgood, 1988; Cone & Kendall, 1978). A second wave of constructivist-inspired work explored how individuals make meaning of museum experiences, focusing on the ways that prior knowledge, visitor goals, and different levels of engagement impact understanding and construction of the message of the museum (Falk & Dierking, 1992; Falk, Koran, Dierking, & Dreblow, 1985; Screven, 1986).

The third wave of work, and the focus of this chapter, uses sociocultural theory and notions of participation to understand learning in museums. This work often focuses on the ways that groups of visitors talk and interact with one another, and how these conversations contribute to learning. This approach is perhaps typified by Leinhardt and Knutson (2004), who examined conversations of 207 groups visiting seven exhibitions at a variety of museums. Group visitor conversations were audiotaped and tracked, and after the visit, groups self-conducted a joint interview about the visit. Learning was measured by analyzing the amount of *conversational elaboration* during the interview – the extent to which groups went beyond listing details of exhibitions to synthesizing and explaining exhibitions in ways that connected to disciplinary content. A path analysis found that greater learning was associated with visitor identity, the design of the learning environment, and the extent to which learners engaged in explanatory sense making during the museum visit. This landmark study formed an important bridge between sociocultural perspectives and methods in the learning sciences and studies of informal learning in museums.

By analyzing how group interactions contribute to learning, sociocultural perspectives go beyond constructivist approaches, which often attempt to "factor out" individual learning from the group in a way that ends up neglecting the role of the group (see Greeno & Engeström, Chapter 7, this volume). In the sociocultural approach, the group is the unit of analysis and the focus is on how conversation and interaction contribute to learning (Vygotsky, 1986; Wertsch, 1991). Because conversation and interaction are the focus of the sociocultural approach, video or tracked audio recordings of visitors' interactions are commonly used. Transcripts of talk and interaction may be coded to analyze interactional patterns, participation structures,

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or group practices, or talk may be analyzed sequentially, adapting methods and conventions from conversation analysis, among other traditions (Derry et al., 2010; see Enyedy & Stevens, Chapter 10, this volume).

We study museums because they foreground aspects of learning that are sometimes overlooked or underemphasized when we study learning in other settings. Through a comparative logic, we thus gain different perspectives on learning that can offer unique and valuable windows into basic questions of how people learn. However, as we study museums, we also uncover knowledge of how to design museum experiences to broaden, deepen, and extend learning impacts. Our review focuses on two areas where strong progress has been made during the past decade in terms of advancing both our understanding of learning and our understanding of how to support it in museums: family learning in museums, and learning during school trips to museums.

Family Learning in Museums: The Role of Parents

Children spend the majority of their waking hours in out-of-school settings and much of what they learn about science, art, technology, and other domains comes not from school, but from informal settings such as museums (e.g., Falk & Dierking, 2010). Yet we still know relatively little about exactly how this informal learning actually occurs. From the perspective of the learning sciences, families are interesting examples of distributed systems for learning. From the perspective of museums, families are an important audience to be served – an audience (and a future audience) who comes to the museum to spend some pleasant time together and perhaps to learn something while they visit. One of the major contributions of museum learning research during the past decade has been to explore systems of family learning and the role of parents as facilitators of children's learning in out-of-school settings.

When visiting museums with their children, parents adopt different roles in the interaction – even enacting multiple roles within the course of a single visit (e.g., Ash, 2004; Melber, 2007). Sometimes parents treat museums more like playgrounds – places for children to explore independently while parents stand back at the edge of the action. But more commonly, parents expect to be involved. After all, most families come to museums to spend time together, and often what parents expect to do together is to learn about science, art, history, or culture (Falk, Mousouri, & Coulson, 1998; Knutson & Crowley, 2010). Thus, adults are often observed enacting the role of coach, guide, or explainer – following the lead of the child, reading signs, suggesting ways to engage, responding to impasses and difficulties, and helping the child to explore the space of possibilities at an exhibit more broadly and more deeply (Gleason & Schauble, 1999).

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Parents frequently offer explanations within the child's zone of proximal development (Vygotsky, 1986), thereby scaffolding children's learning. Knutson and Crowley (2010) observed parents in an art museum engaging in the major categories of disciplinary art talk (e.g., criticism, creation, context) as well as making personal connections between art and the family's shared experience outside of the museum context. Parents will sometimes point out causal connections, analogies, and conclusions as they use interactive science exhibits with children (Crowley et al., 2001). In natural history museums, parents often take the lead in asking questions and identifying biological themes and disciplinary big ideas as they view dioramas, fossilized dinosaurs, or live plants and animals (Ash, 2004; Kisiel, Rowe, Vartabedian, & Kopczak, 2012; Palmquist & Crowley, 2007). When children hear these spontaneous adult explanations while using science exhibits, they are more likely to understand exhibits at a deeper, conceptual level, as opposed to a surface and more procedural level (Fender & Crowley, 2007).

What supports parent engagement in productive scaffolding during museum visits? There is undoubtedly some influence of general parent education or specific parent expertise in the content of the museum (e.g., Siegle, Easterly, Callanan, Wright, & Navarro, 2007). But regardless of how knowledgeable they are, it can be a complex task for parents to navigate the museum, interpret exhibits, read, understand, and translate signage for a child, and make connections between the museum and other contexts that the family knows about (Allen, 2004).

Principles of discovery and inquiry-based approaches increasingly inform the design of resources, games, and other technologies that aim to support "learning through play" on family visits to museums (Beale, 2011; Katz, LaBar, & Lynch, 2011). Gutwill and Allen (2010) explored the use of inquiry games to enhance learning through inquiry while families interacted with science museum exhibits. One game was designed to increase collaborative activity and involved groups deciding ahead of time on a shared guiding question. The other game, designed to give individual control to people within the group at the moment when they were learning something valuable, involved normal engagement with the exhibit with the rule that anyone in the group was able to call "hands off" at any time. When this happened, everyone in the group stopped what they were doing to listen to and discuss what the individual had to say. These two strategies were explored in a study in which families were randomly assigned to four conditions: the shared goal game; the individual control game; a condition where the family was guided through the exhibit by an experienced museum educator; or a control condition where the family used the exhibit without any scaffolding or guidance. The study found that groups in the two supported inquiry conditions improved their inquiry more than groups in the educator-led or control conditions.

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Signage can also influence interactions in museums. In one study, families were randomly assigned to use an exhibit where they tested the flying properties of paper helicopters in one of two conditions: signage that encouraged them to adopt the scientific goal of discovering how different features changed flying times or signage that encouraged them to adopt the engineering goal of finding the combination of features that had the longest flying time (Kim & Crowley, 2010). Families in the science goal condition talked more, were more collaborative, and were more likely to design informative tests. Families who were encouraged to adopt engineering goals were more likely to have parents who pulled back and allowed children to do more of the design and interpretation without adult scaffolding. As a result, children in the science goal condition learned more about the task than children whose families adopted engineering goals.

Learning technologies have now been designed for museums using inquiry principles so that individualized paths, facilitator roles, and skill levels are adapted to different family members. Family activities modeled on treasure hunts, mysteries, and puzzles are common in museums, as is the use of mobile devices to guide and facilitate the collecting of exhibition information to collaboratively solve tasks. A familiar approach is seen in the design of *Mystery at the Museum* at the Boston Museum of Science (Klopfer, Perry, Squire, Jan, & Steinkuehler, 2005). Family members used handheld PCs to collect information using infrared tags in a collaborative problem-solving activity. In a study of 20 parents and children playing the game, researchers found that the interdependence of roles structured group collaboration and that many participants felt their role had made a unique and essential contribution.

Hatala and colleagues (2009) explored the potential of an adaptive system in *Kurio*, a game that was responsive to both personal and group needs and levels when guiding families through different learning "challenges" at a local history museum. Eighteen family groups comprising 58 individuals participated in studies to identify factors that affected learning when using the system, which was loosely modeled on treasure hunts and involved the use of different kinds of tangibles to collect and share information. Based on analysis of questionnaires, semi-structured interviews, and data logs, the study found that when the pace, level, and number of family challenges were balanced, there was increased learning and the visit as a whole was valued more highly. The study also identified tensions between what individual members experienced as positive and effective for their own learning when solving the shared challenge, and the need for them to help other family members, which was boring and less valued. Further, although family members enjoyed interacting more closely, there was the potential for overload when learning activities dominated the visit. The latter finding is supported in the museum research reviewed earlier, which stresses that families visit museums for a variety of reasons, and motivations related to learning vary

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among family members. Accordingly, family activities are primarily designed as games, and research on effective learning is secondary to studies that focus on how to support collaboration and interaction among family members.

Across the Formal/Informal Boundary: School Trips to Museums

Formal learning environments, such as schools, are compulsory, include standard curricula, have a limited range of classroom structures, and emphasize accountability through individual testing. Informal learning environments, such as museums, are often defined by being the opposite of schools – they are free choice, include a diverse and nonstandardized range of topics, and have flexible structures, socially rich interaction, and no externally imposed assessments (Callanan, Cervantes, & Loomis, 2011). What happens when these two very different institutional types are brought together – for example on school trips to museums?

Museums have always been popular sites for school excursions, and driven by increasing accountability demands from schools, museum education departments now provide a broad range of activities and resources for teachers that are specifically designed to link museum visits with school curricula. Field trips are planned in advance by teachers to incorporate exhibitions and thematic tours into their study plans, and some measure of cognitive outcome may be required to justify how the museum visit will help them meet required standards (Mortensen & Smart, 2007). School field trips aim to comply with curricular demands, but are also viewed as an essential part of enculturation, empowering young people to use museums independently and purposely, cultivating certain skills and competencies as a kind of "museum literacy" (Stapp, 1984).

Reviews of research on museum field trips suggest modest but positive and lasting impacts on learning concepts and facts (DeWitt & Storksdieck, 2008; Kisiel, 2006), with memories of both subject matter and the social context surrounding a visit particularly strong (Anderson, Storksdieck, & Spock, 2007; Dierking & Falk, 1994). Research on field trips also finds that organizing sequences of pre-visit preparation work in the classroom, guided instruction during the museum visit, and post-visit follow-up work back in school maximizes the potential for learning (DeWitt & Storksdieck, 2008; Kisiel, 2006). However, teachers do not often make time for recommended pre-post visit activities and, in practice, students, chaperones, and many teachers tend to view field trips as "free day" excursions (Kisiel, 2005; Mortensen & Smart, 2007). Generally, museum educators meet classes with mixed expectations regarding learning aims and outcomes and face the challenge of engaging students in activities that are fun, educational, and that will hopefully inspire young people to become lifelong museum visitors.

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The use of worksheets (sheets of paper with tasks and problems the students are expected to complete while visiting an exhibition) to meet formal curricular goals also has a long history and is still common today. There is evidence that well-designed worksheets may increase curriculum-related conversations during the museum visit (McManus, 1985; Mortensen & Smart, 2007). However, the design and implementation of worksheets can also make the museum visit too "school-like," with students focused more on procedural aspects of completing a task, such as gathering information from labels, than on conceptually oriented talk based on observations of exhibits and objects (Griffin, 1998). Analyses of field trips using museum worksheets have identified key design characteristics that have implications for student learning (DeWitt & Storksdieck, 2008; Kisiel, 2003; Mortensen & Smart, 2007), including the complexity of the task, the types and location of information sources, and balancing guidance and structure with levels of choice and opportunities to explore the unique qualities of the museum setting.

Students on school trips are often led on guided tours by museum educators. With their field termed the "uncertain profession" during the late 1980s (Dobbs & Eisner, 1987), front-line museum educators often do not have specific training in museum education and the training, skills, and experience of volunteers and staff who lead tours varies, sometimes greatly. Museum educators often fall back on epistemologies and pedagogies that spring from their own personal learning experiences in formal settings (Allen & Crowley, 2014; Bevan & Xanthoudaki, 2008; Cox-Petersen, Marsh, Kisiel, & Melber, 2003). Thus, many guided tours have been based on an IRE (initiation-response-evaluation) whole-class lecture model that constrains a group's movements to objects and displays preselected by the expert. Studies have illustrated tensions between instructional approaches that aim to produce learning outcomes that meet formal education requirements valued in schools and those that foster informal learning and social skills valued in museum environments, such as inquiry, discovery, observing, and conversational elaboration on artworks, historical narratives, or topical issues in science (Griffin & Symington, 1997; Kisiel, 2003; Pierroux, 2005).

Recently, dialogic approaches are increasingly informing guided tour research and practice (Pierroux, 2005, 2010), drawing on sociocultural perspectives on learning conversations in museums (Leinhardt, Crowley, & Knutson, 2002), best practice guidelines (Grinder & McCoy, 1985), and classrom discourse research (Reznitskaya & Glina, 2012; Wells, 1999). This dialogical turn has directed analytic attention to guided tour discourse and instructional approaches to formulating questions, fostering rich descriptions, introducing concepts and disciplinary knowledge, and developing a repertoire of dialogical moves. In a study of different instructional approaches on guided tours in art museums, Pierroux (2010) compared a dialogic method designed to support students' skills in observing and describing artworks with

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other dialogical methods aimed primarily at teaching art history (see Rice & Yenawine, 2002). The study found that while the first approach effectively engaged students with the artworks and empowered groups of young adults as "meaning makers" through a rich dialogical process, there was no evidence of conceptual development in the discipline of art history, which was the curricular goal of the field trip. Students' difficulties developing disciplinary concepts based solely on interactions with exhibits and one another are a common finding in science museums as well (Achiam, 2012). Analysis of the other approaches in the study suggested that introducing advanced art historical concepts or "leading" information may guide the interpretative process too strongly, similarly stifling learning through students' rejection of interpretations that they did not dialogically develop as their own or were outside their zone of proximal development.

Beyond the educator-led tour, perspectives on creativity and learning motivate a broad range of hands-on educational activities for field trip students that involve games, role play, making, and experimentation. Hands-on activities are often integrated thematically with the guided tour and worksheet activities on field trips in art, history, and science museums. But there is surprisingly little research on learning through such hands-on activities, and much of the literature is anecdotal (Ramey-Gassert, Walberg, & Walberg, 1994). Instructional approaches that involve students in game playing, generating content, making art, and constructing experiments have nonetheless become central in the design of digital technologies for learning on field trips (Hauser, Noschka-Roos, Reussner, & Zahn, 2009; Pierroux, 2013).

Mobile social media, smartphone technologies, and ubiquitous Internet access are pivotal developments in research on how to effectively support inquiry and dialogue within and across school and museum contexts (Naismith, Lonsdale, Vavoula, & Sharples, 2006; Pierroux, 2011; Tallon & Walker, 2008; Wishart and Triggs, 2010). Challenges related to the use of mobile devices as learning tools in museums were identified early on, including problems of "heads-down" behavior, isolation from other group members, and an overall decrease in talk and interaction (Grinter et al., 2002; Heath & Vom Lehn, 2001; Hsi, 2002). There is a history of failed interactive devices and design experiments in museums, and problems are perhaps compounded when applications for mobile devices are designed for field trip use. In a recent study of augmented reality games on mobile devices for zoo field trips, students using the game focused largely on staying on task, spent less time looking at animals than a control group, and talked more about the game than the exhibits (Perry & Nellis, 2012). At the same time, the formal instruction approach in the game design increased the students' conceptual understanding, attitudes, and beliefs in science. Such findings are common and illustrate the need to clarify learning perspectives and aims in the instructional design and to account for users' needs and expectations regarding technology use in museum spaces.

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In an early study exploring the potential of mobile phones to support learning on field trips, a class of 23 students used a Web site and phones to access, record, collect, and produce content before, during, and after a museum visit (Vavoula et al., 2009). A three-stage evaluation process based mainly on interviews, observations, and questionnaires found that the mobile application was more motivating for student learning in the museum than traditional worksheets, supported productive on-task interactions during the visit, and effectively prompted students to engage with both their collected material and museum online resources during post-visit activities back in the classroom. Apart from technological issues, the study also identified challenges in designing tasks that aided students in producing their own interpretations rather than merely collecting information provided by the museum. There were also problems for students and teachers to shift from collaborative learning activities in the museum setting to individual work and assessment in the classroom.

Similar studies have since explored how tasks combining mobile phones with social media may be designed to support learning on field trips (Pierroux, Krange, & Sem, 2011). The design approach in the Gidder project emphasized the significance of interactions with authentic objects and other resources in the museum setting for developing art historical interpretations (see Wishart & Triggs, 2010), and explored the potential of student-generated content from the museum to motivate and support critical reflection and analysis back in the classroom. In two design iterations, six classes and more than 150 students were observed over seven nonsequential weeks, with video recordings, blog texts, and data logs as the main empirical material. Working first in small groups in the museum, students collaboratively formulated interpretations of artworks, using their mobile phones to take pictures and make films, record conversations with museum docents, and write text messages (SMS). These were sent to a blog and became chronological entries accessible to everyone in the class. Each group had its own workspace in the blog, which included tasks and resources provided by the museum educator. The classroom task required each group to use the blog entries to create a multimodal summative interpretation, with peers, teachers, and the museum curator an implied audience of "receivers" and "commenters." Assessment was based on the quality of the interpretations in the blog entries. Findings suggested that the direct and abbreviated format of initial text messages motivated students to collaboratively edit, expand on, and clarify their interpretations from the museum, and that blog entries were treated as utterances in dialogues that were open to others (Pierroux et al., 2011).

Field trip research emphasizes the importance of taking advantage of the unique experiences and interactions of the museum learning environment, and also the need for interventions and resources by teachers and museum educators to scaffold the visitor experience so that it contributes to the development of disciplinary knowledge (Pierroux, 2005, 2010). As

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new technology and social media are increasingly integrated into museum education activities, studies suggest that the most effective designs for learning on field trips have a moderate level of structure and guidance from curators and teachers, with tasks that allow time for inquiry, dialog, and collaboration. These findings are similar to what learning scientists have discovered when studying how to best integrate learning technologies into classroom settings; these studies also show that even the most advanced digital learning environments need to be supplemented with contextual resources and teacher support (Furberg & Arnseth, 2009). The most effective designs for learning on museum field trips will take into account the unique resources provided by museums, will integrate the complementary roles of the teacher and museum educator, and will provide tasks that support collaboration and social interaction.

Looking Forward: 21st-Century Museums and the Learning Sciences

In the coming decade, we expect to see dramatic progress in our ability to conceptualize and assess learning in ways that are rigorous, scalable, and appropriate for museums. Immediate learning impacts are relatively easy to create, observe, and measure in museums. But we suspect that the real value of museum learning revolves around distal outcomes such as fostering a passion for learning, promoting the growth of inquiry skills, learning how to observe, or learning how to talk about science, art, or history – outcomes that are not possible to achieve in a single museum visit. These are habits of mind that need to be cultivated through sustained engagement over time and place. Yet the typical museum learning experience is just a few hours long. The true impact of museum visits might not be fully apparent until visitors have left the museum and had a chance to talk about, wonder about, or use whatever knowledge and practices they learned in the museum.

This is an instance of a general problem facing learning sciences researchers: to explain how a series of relatively short experiences might develop into something much more significant – whether single class sessions or single museum visits. How does a museum visit contribute to longer-term learning trajectories? In retrospective accounts of learning trajectories, we often see adults reporting that their earliest interest in disciplines such as science began in out-of-school settings, including museums (Crowley, Barron, Knutson, & Martin, in press). For many children, early expertise rooted in informal learning experiences will be the first time they encounter the power of discipline-specific knowledge and the first time that they (and their parents) recognize that they might have an interest in pursuing a specific discipline such as science, engineering, or art. Museums, with their rich resources and highly designed learning environments, can be places for engaging deeply with

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a discipline in ways that are not available in schools or at home. Museums function as learning environments similar to the ways that digital games function as learning environments (Steinkuehler & Squire, Chapter 19, this volume) – both are self-reinforcing and motivating, support deep investigation and learning, encourage the growth of out-of-school learning identities, provide communities of practice for learning and advancement, and can result in considerable engagement throughout a learner's life. As we write this chapter, we see new longitudinal studies of informal learning being launched that focus squarely on transfer between museum experiences and other parts of a child's learning ecology, formal and informal. New pathways are being designed that help connect museums to other learning environments and bring new groups of children into contact with museums.

Although our chapter has focused on how museums can help children learn school subjects, museums are also working to better engage adult audiences. Many museums in the 21st century are struggling to remain relevant and financially viable as adults and children alike turn increasingly to digital resources for out-of-school learning. Recognizing that their 19th- and 20th-century practices are increasingly out of step with audiences who expect to participate and shape their learning experiences, museums are experimenting with ways to reinvent their collections, exhibits, and buildings to act more like town squares, cultural hubs, and more personalized environments for adult learning (Watson & Werb, 2013). One area of active experimentation is in the innovative use of social media (Kelly 2010; Russo et al., 2007) to motivate visitors to share their knowledge and views on museum collections, exhibitions, and events and to engage the museum as discursive partner (Giacardi, 2012; Marty, Sayre, & Fantoni, 2011). Other efforts involve positioning museums as boundary-spanning spaces where disciplinary experts and publics can meet in joint dialogs about data, progress, and civic and social concerns (Irwin, Pegram, & Gay, 2013; Louw & Crowley, 2013; Selvakumar & Storksdieck, 2013). Adults are an important part of museum audiences, but comparatively little learning sciences research has focused on the adult experience in museums.

Museums are generally open to experimentation, are interested in issues of learning, and are becoming familiar with the field of learning sciences. There are still many unanswered questions to be addressed, and we look forward to another decade of rapid progress.

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