NEW DIRECTIONS IN MATHEMATICS AND SCIENCE EDUCATION

Putting Theory into Practice

Tools for Research in Informal Settings

Doris B. Ash, Jrène Rahm and
Leah M. Melber (Eds.)

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PUTTING THEORY INTO PRACTICE

NEW DIRECTIONS IN MATHEMATICS AND SCIENCE EDUCATION
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Scope

Mathematics and science education are in a state of change. Received models of teaching, curriculum, and researching in the two fields are adopting and developing new ways of thinking about how people of all ages know, learn, and develop. The recent literature in both fields includes contributions focusing on issues and using theoretical frames that were unthinkable a decade ago. For example, we see an increase in the use of conceptual and methodological tools from anthropology and semiotics to understand how different forms of knowledge are interconnected, how students learn, how textbooks are written, etcetera. Science and mathematics educators also have turned to issues such as identity and emotion as salient to the way in which people of all ages display and develop knowledge and skills. And they use dialectical or phenomenological approaches to answer ever arising questions about learning and development in science and mathematics.

The purpose of this series is to encourage the publication of books that are close to the cutting edge of both fields. The series aims at becoming a leader in providing refreshing and bold new work—rather than out-of-date reproductions of past states of the art—shaping both fields more than reproducing them, thereby closing the traditional gap that exists between journal articles and books in terms of their salience about what is new. The series is intended not only to foster books concerned with knowing, learning, and teaching in school but also with doing and learning mathematics and science across the whole lifespan (e.g., science in kindergarten; mathematics at work); and it is to be a vehicle for publishing books that fall between the two domains—such as when scientists learn about graphs and graphing as part of their work.

Putting Theory into Practice

Tools for Research in Informal Settings

Edited by

Doris Ash
University of California, Santa Cruz, USA

Jrène Rahm
Université de Montréal, Canada

and

Leah M. Melber
Lincoln Park Zoo, USA

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DORIS B. ASH AND JRÈNE RAHM

1. INTRODUCTION

Tools for Research in Informal Settings

Putting Theory into Practice offers a toolkit of theoretically-grounded methodologies, methods and imaginaries showcasing ways of pursuing research of learning for life in a vast array of settings. The book makes the case for theoretically well-grounded methods that can help us understand learning as it unfolds over time and across space, attesting fully to its messiness and complexity. The chapters that follow offer unique insights into how theory and method constitute one another and how a focus on their interplay strengthens our understanding of the role informal settings play in learning for life. The chapters also give voice to children, youth, visitors, educators and other professionals who make these settings what they are. We collectively emphasize the rich diversity among learners and educational settings, a product of our modern era of globalization and movement, which can present both challenges and rich opportunities for the current educational infrastructure and our society. As such, that toolkit is not bound to any one particular context of the informal learning infrastructure, nor is it bound to one particular content area of learning or one particular population. We want to promote attention to the full complexity and richness that such study involves. The chapters that follow offer a diverse set of theoretically well-grounded and methodologically rich approaches to conducting in-depth research in locales like museums, aquariums, afterschool programs, gardens, and university outreach programs, with some of the chapters also addressing research across such settings. We offer a variety of perspectives on what such research might look like, and we wish to be especially clear on the theory that surrounds such practices. Thus the title *Putting Theory into Practice*.

While this book offers tools for the study of learning in out-of-school settings, and is essentially about methods, the chapters also allude to the methodologies or broader frameworks tied to epistemological commitments that guide the ways of seeing and pursuing research. Hence, the chapters are grounded in somewhat different discourses on methodologies, yet globally, have their roots in naturalistic inquiry. The chapters share a theoretical commitment to sociocultural theory and the learning sciences. That theoretical grounding mediates in yet other ways a strong alignment in the chapters' methodological and methodical framing.

The past 15 years have seen a tremendous increase in research on learning and teaching that takes place outside of traditional classroom environments, especially in museums, and more recently also in gardens, afterschool, and community programs. This field, known as informal learning, free choice learning, or out-of-school time, has grown exponentially. Despite such rapid growth, there is still a

D. Ash et al. (eds.), Putting Theory into Practice, 1–13.

need to further explore and more deeply understand how people interact, participate and learn in such settings (Banks et al., 2007). Such research requires theoretically informed research methodologies and methods that better illuminate what learning is and what it looks like in and across such settings. We contend that studies of learning in informal settings at large have avoided complex learning theory; rather, they have advanced a learning-by-doing view that only weakly relies on general constructivist notions of learners making sense of phenomena and objects, often in isolation (Paris & Ash, 2000).

The chapters in this book make the case for grounding the study of learning for life in sociocultural theory, asking what museum going, museum teaching, engagement in an afterschool, university outreach or gardening program entails; how engagement is socially organized; and how engagement can be understood in light of the activity system or systems in which it is embedded, and therefore explored at many levels simultaneously within and across practices, and in light of the social relations in which the individual is embedded (Martin, 2007).

Studies exist of both front end and other forms of evaluation in informal settings (American Association of Museums, 1999; Diamond, 1999). These have been primarily aimed at understanding program effectiveness or single exhibit use. Other studies have contributed more broadly to understanding general learning (Bekerman, Burbules, & Silberman-Keller, 2006), or science literacy development in particular (Crane, Nicholson, Bitgood, & Chen, 1994). Building on these earlier efforts, and grounding our pursuit in sociocultural theory, we are embracing a broader, more interdisciplinary approach towards the study of learning in everyday settings. The National Research Council (2009) has argued that "more widely shared language, values, assumptions, learning theories and standards of evidence are needed to build a more cohesive and instructive body of knowledge and practice" (p. 305). In light of this, "other kinds of research and data are needed … to build and empirically shape a shared knowledge base" (p. 305). The objective of this book is to begin that conversation.

To move towards shaping an empirically shared knowledge base, we align ourselves with others who have made the case that the next decade of research on learning in museums and other out-of-school settings needs to focus more "on creating a conduit between researchers and practitioners with the primary goal of affecting practice." In addition, in order "to do so, research must be collaborative and cross disciplinary boundaries, and include learning theorists, sociologists, anthropologists, museum evaluators, exhibition designers, interpreters, developers and educators from the museums [and other settings] in which the research is being conducted" (Falk, Dierking, & Foutz, 2007, p. xv).

Putting Theory into Practice essentially expands upon the fundamental idea that "a good education requires education about diversity in a diverse environment" (Bowen & Bok, 1998, cited in Banks et al., 2007, p. 8). The chapters allude to the richness of that diversity in both the variety of educational settings studied, as well as the learners that make these settings what they are. The chapters also bring to the foreground the need for a diversity of methods to capture learning in diverse settings and among diverse people. The main goal of this book, then, is to help fill

the need for innovative and expanded research methodologies and methods that explore learning in informal environments in its full complexity by:

(1) Building upon new and established theories of learning and teaching,
(2) Providing information on robust methodologies and methods appropriate for research within informal learning institutions, and
(3) Offering examples from a number of learning settings tailored to/ constituted by diverse audiences/participants.

It should be noted that although the terms research and evaluation are often used in the same sentence, the chapters we include here fall into the research category. Though there are many ways the two can be defined and differentiated, for the purposes of this work the key distinguishing factor consists of looking past merely "judging the worth or merit" of an activity (Worthen, Sanders, & Fitzpatric, 1997). Instead, we propose the pursuit of empirically and theoretically grounded research that explores in depth the unfolding of learning "in ways that put human agency, values and engagement with social practices at the center" (Penuel & O'Connor, 2010, p. 268). Thus, we take for granted that people are active agents and organizers of their lives. We are interested in the manner in which they organize their forms of participation in diverse practices, or how they participate, contribute to and constitute practices. Treating learning as a cultural practice makes possible the asking of questions that help us arrive at a more complex and nuanced picture of what happens in and across spaces driven by learning for life. In light of this human sciences perspective, we need to carefully consider what makes for "significant, investigable questions" and, especially, "from whose perspective" (p. 269).

This volume then offers new ways of thinking about the relationship between the researchers and the researched, emphasizing the ways in which they co-construct the actual research endeavour, driven by acknowledged values that are made explicit from the beginning. The chapters offer possibilities for research grounded in this human science approach by also making explicit "the scope and limits" of studies of learning for life within and across a vast array of settings. Finally, the chapters strive to make explicit the kinds of decisions made (sometimes in situ) about the end-goals of such learning and research. In light of this, they include and give voice to the learning activity actors—learners and practitioners—people often excluded from conversations in and about research. Such actions are designed to shed light on, challenge, question, and make explicit the power structure that constitutes research and practice in informal settings.

KEY COMPONENTS OF A THEORY INTO PRACTICE APPROACH

Grounding in Sociocultural Theory and Learning Sciences

The chapters draw upon a variety of theoretical and methodological frameworks that are loosely grounded in sociocultural theory, the learning sciences, and their extensions (O'Connor & Penuel, 2010; Vadeboncoeur, 2006). What unifies these approaches is the notion that learning *emerges from social activity*, including talk, *and interactions* with objects that the learners see, touch and talk about with one another. While learning is understood as a process and as emerging from activity, it is also tied to people's history, and to the knowledge they bring to the activity, both of which they mobilize as tools to make sense of their current activity or form of engagement. Learning is understood as situated in local contexts, as constrained and enhanced by local affordances, constraints and the culture of the environment or institution in which it takes place, while it is also mutually constituted by the institution and its community. The goal is to understand human action and the manner in which such action is shaped by the context and social practices from which it emerges (O'Connor & Penuel, 2010). In practice, a focus on *participation* in learning activity means that collaborative sense-making must be monitored in detail as it happens, naturalistically, and over time. Methods, therefore, have had to shift, to become more fine-tuned, to track learning in detail over time, over sites, and across contexts. These cannot be captured in self-report, surveys or even in many interview formats. A focus on actual learning activity implies the daunting challenge of capturing and analysing learning in detail, as it occurs, interruptedly and discontinuously over time, within and beyond specific moments and settings. It also implies a multi-level analysis that moves beyond the micro-level analysis towards the macro, which allows the exploration of the manner in which global affordances and constraints, and political agendas and constraints, constitute and mediate activity and learning. Hence, the methodological tools or methods need to be varied and rich; they include, but are not limited to, ethnography; detailed digital capture of talk, gesture and embodied action; a variety of interview formats using multiple representations as impetus; reflective dialogue with participants; and action research. Most of these methods and their methodological grounding are described in the following chapters.

Next to activity and participation, the *identity,* or perception of oneself within a given context or place or in relation to the activity in which one is engaged, further constitutes learning activity, and is explored in certain chapters. Through engagement in informal settings, people do not only activate their knowledge, while making meaning of an activity; they also construct new meanings together and, as a result, are also potentially changed through such engagement. Learning, therefore, can lead to changes in perceptions of self and group. That interplay of activity and identity is at the heart of a sociocultural perspective; this has led to the daunting challenge of exploring the manner in which informal settings, and the objects, exhibits and people that participate within them, mediate engagement in

the activities and the authoring of self and the positioning of others (i.e., identity work; Holland et al., 1998).

Research grounded in sociocultural theory and the learning sciences also discusses the role of *agency* for learners, visitors, museum educators, institutions, and for the researchers themselves. Many would argue that the sense of agency for each participant shifts and changes through participation in joint activity, and that this must be taken into account throughout the research (see Anderson, Ash & Lombana, Kisiel, Rahm). In this view, learners, educators and researchers act, construct and transform continuously, and it is the recognition of that agency among participants and researchers that enriches, yet also makes more complex, any study of learning. Thinking that such human interactions are non-agentive, simple, direct or interpretable in only one way has often served to provide narrow data that are not very informative. Many of our chapters, therefore, suggest that agency constitutes activity (what we do and say), yet also transforms that activity in important ways (see Anderson, Ash & Lombana, Kisiel, Mai & Ash; Rahm). What we mean by this is that educators, visitors, and others who are involved in the research change themselves, as well as are changing the context within which they are working. Such a view reflects the mutually constituted state of individual and community, each informing and changing the other reciprocally.

In light of this approach, we suggest that the researchers' values and the dispositions driving the research need to be made explicit. We contend that "accounting for values in accounts of human action is a fundamental aspect of the contemporary 'interpretive turn' in the social sciences" (O'Connor & Penuel, 2010, p. 4). By this we mean a critical assessment of our stance as researchers and the manner in which we see things or design learning environments, attesting to our subjectivity as researchers. For this reason, the authors must *foreground the values, judgements and decisions* that accompany their working trajectories at different research sites. This also suggests that we need to critically examine, and make explicit in our accounts, the values and judgements that guided the research, and the ways we came to the study and to interpreting it in certain ways and not others. Certain visions of what an informal setting should be like may have guided the way we designed a learning environment, or our interpretation of it; these possibilities need to be made explicit and critically examined. Moreover, the values and subjectivities of the consumers of informal settings also constitute their forms of engagement and actions, and need to be discussed. Each chapter in this volume accounts for these dimensions.

In light of all these dimensions, which are loosely tied to a theoretical grounding in sociocultural theory and the learning sciences, the eight chapters may also be read like *stories* about the study of learning in informal settings. As will become evident, the trajectories of these stories are far from linear, underlining the subjective struggles of the researchers and researched. The latter are given voice and not excluded from the analysis; rather, they are integrated and they ground the analysis in important ways. Simultaneously, the theoretical foundation of each story is made explicit, acting both as a constructive means but also potential bias to the aspect of research that is being pursued. Research is no longer just about the

other, who serves as the object. Instead, research in this view is a collaboration among the actors involved, including visitors, researchers, educators and others. Hence, the book attempts to offer new stories about empirical research, methodologies, and methods, in informal settings in a language that can be assimilated and shared by the field.

Movement Beyond the Formal/Informal Dichotomy

Another aim of this text is to step outside the traditional boundaries of the typical formal/informal dichotomy. The international scholars contributing to this volume have all had extensive experience in and out of the classroom, conducting research on how people learn and how people teach. The authors assume that learning is a "life-long, life-wide and life-deep" phenomenon; it thus unfolds over time and across settings and is understood to be marked by beliefs, values, ideologies and orientations (Banks et al., 2007). The authors examine learning in designed spaces such as museums (Anderson; Ash & Lombana; Mai & Ash), aquariums (Anderson, Kisiel, Rowe, & Bachman), environmental centers (Tal), programs in community-based organizations (Rahm), partnerships among schools and informal institutions and programs (Anderson, Kisiel, Tal), and at home (Rowe & Bachman).

As suggested by the recent synthesis of current research on science learning in informal settings by the National Research Council (2009; see also Fenichel & Schweingruber, 2010), there is enough evidence to suggest that learning does happen in such a variety of spaces—an issue taken up and further supported by the chapters in this book. Yet, as proposed in the report, the goals that drive such learning and its evaluation are contestable; they should neither focus only on the academic (formal) or the subjective (informal), but instead should be grounded in the practices. As suggested earlier, the stories we tell about learning in these settings emerge from the practices studied. Yet, the stories also need to be stretched to go beyond case-based studies of the informal to explore in what ways belief systems and ideologies of other places that the participants bring with them constitute their participation and activity. The physical navigation of participants, and the kind of expertise in multiple cultural meaning systems this entails, also must become an objective of study. Moving beyond the dichotomy of formal and informal entails a research focus on what such navigation implies in terms of physical movement among and between learning settings, how it can be facilitated and supported, and, how it can most effectively be studied. The chapter by Kisiel, for example, is an effective example of what navigating between school and museum implies for teachers and students. Similarly, Tal offers insights into ways navigating from formal into informal settings by student teachers might be supported. Finally, Rahm explores the implications of navigations for research, by proposing multi-sited ethnography as a tool and method for its capture. Yet, as already suggested, even a study of a single site or practice entails an understanding of that navigation, since participants and researchers already come to that site with ideas and knowledge drawn from the many practices they have navigated in the past.

Putting Theory into Practice diminishes the dichotomy between the formal and informal, using both lenses and their underlying epistemologies, methodologies and methods to address learning and change in programs and settings to support learning for all.

Emphasis on Diversity and Equity in Informal Settings

We also highlight methods and theory that can help researchers, practitioners, and institutions to more effectively incorporate the knowledge, resources and voices of people who less typically visit such settings or whose voices have been marginalized in research and institutions that make up the informal infrastructure. Such work implies attending to diversity in terms of race, ethnicity, linguistic diversity and socio-economic status, but also in terms of perceived insider status and membership in communities of practices that constitute the informal science infrastructure. Inclusion may happen through the joint development of tools and materials. Such joint production of research is central to many chapters in this book. Through such engagement, insights may be gained into the persisting inequities in out-of-school settings, an area of research in need of further studies (NRC, 2009).

It is often argued that informal settings may be particularly important for learning for diverse groups (NRC, 2009); yet more needs to be known about how to empower learning for diverse groups through informal settings. Some chapters address that question through a focus on a methodology and method that no longer treats diverse learners as objects of the study but, instead, as active contributors (Anderson; Mai & Ash; Rahm). Other chapters speak to the value of "[p]artnerships between science-rich institutions and local communities… for fostering inclusive science learning" (p. 301; Tal, Ash & Lombana). Still other chapters focus on the "learning, growth, and change at the level of a group, organization, or community" (p. 312; Rahm; Anderson), offering further insights into many dimensions of diversity and equity in informal settings.

OVERVIEW OF BOOK

Having introduced the framing of the book overall, we now highlight certain threads and leitmotifs that hold the chapters together. These include a focus on communities of practice (Ash & Lombana, Kisiel), teacher research or action research (Ash & Lombana, Tal), the value of design experiments and reflective hermeneutics (Anderson, Ash, & Lombana), paying close attention to learners' voices (Mai and Ash, Rahm, Rowe and Bachman), the needs of diverse learners (Mai & Ash, Rahm), and research across contexts (Kisiel, Rahm, Tal). The chapters focus primarily on science education, but the methodologies and methods are applicable in any number of informal learning sites focused on cultural, artistic, and/or historical interpretation and conservation.

The first half of the book is concerned with changes at the institutional as well as at the smaller social group level, such as museum educators, teachers on field

trips, and museum/university partnerships. These four macro-level chapters look at the kinds of activities typical of different aspects of a museum or school culture, and they work towards integrating these aspects into a common cultural whole. The second half of the book shifts to a more micro-level focus on the learner/participants in out-of-school settings.

Each chapter introduces its line of inquiry and methods deeply rooted in an explicit theoretical perspective, uniting practice with theory, and typically starts with a vignette to set the stage for the arguments being presented throughout that chapter. At the end of each chapter Leah Melber, co-author, initiates discussion through a brief summary that ties the chapter's message to experiences grounded in practices and personal experiences of her own, given her position as a well-seasoned informal education expert and practitioner. Discussion points follow for both individual and group dialogue. These *Theory into Practice* sections seek to provide a personally relevant touch point for practitioners at all experience levels, facilitating engagement with the core methodological concepts of each chapter.

BRIEF CHAPTER DESCIPTIONS

The chapter by David Anderson, *A reflective hermeneutic approach to research methods investigating visitor learning*, offers a theoretical framework that relies on a dialogue between the 'researched' and the researcher, in order to arrive at a contextualized understanding of informal learning and its underlying processes. It is presented as a contrast to the dominant positivist paradigm, which holds the methods of a study fixed throughout the course of data collection. Anderson argues that this new dialectic, reflective, and hermeneutic approach emphasizes the ways in which data that is being collected and interpreted by the researchers can dynamically inform modification and choice of methods used in subsequent rounds of data collection. Anderson further posits that such a hermeneutic approach allows for deeper insights, given the methods and tools employed. Also, since the researchers' interpretive lenses are critically and iteratively honed, the final results may offer deeper insights, when compared to fixed methodological approaches. He goes on to explore how such approaches have the capacity to provide researchers with increased opportunities to reflect critically on methods used to explore learning and to refine the individual and collective capacity, responsiveness and fruitfulness of the methods. The chapter then offers examples of qualitative-interpretive studies. The message of Anderson's chapter, that research methods evolve along with the research itself, is central to all chapters in the book. This kind of dialectic between research and methods is often forgotten, but Anderson claims, it is particularly crucial and insightful for understanding the natural ecology of a learning environment. Interviews of visitors influencing learning in museums, or having visitors self-select video samples of their visits for discussion, are just two examples of the tight link between researched and researcher and the evolving nature of research in this chapter.

The chapter by Doris Ash and Judith Lombana, *Methodologies for reflective practice and museum educator research: The role of 'noticing' and responding,*

provides a powerful comparison with Anderson. Both chapters describe design experiments, but they have very different ways of theoretically grounding their work. Ash and Lombana collaborate with museum educators in a community of practice (Lave & Wenger, 1991) designed to foster reflective practice based on noticing and responding to what learners and other teachers are doing. The REFLECTs model that they describe is one example of an iterative redesign collected over time, using grounded enhancements with each iteration, much as Ann Brown and Alan Collins first suggested in the early 90s. It is also reminiscent of Anderson's reflective hermeneutics. Ash and Lombana describe four phases that constituted the change in practice in which museum educators became researchers of learning on the floor but also critics of their own practices. Such constant redesign led to the development of specific teaching tools museum education researchers could then share with others in their museum and beyond. The described professional development collaborative was embedded in a design experiment that empowered and gave voice to museum educators and museum visitors. Thus, Ash and Lombana argue that research with a focus on learners and learning, as well as on teaching, has sharpened their insights about how museum educators, in the process of becoming increasingly reflective practitioners and teacher researchers, can learn to both 'notice' learners in new ways, and respond to these learners with flexible scaffolding, rather than relying only on predetermined disciplinary content, scripts or standardized questions. The chapter offers a model for professional development in the museum in which museum educators are change agents and co-constructors of interventions and generative action on the museum floor and in the institution.

The chapter by Jim Kisiel, *Reframing collaborations with informal science institutions: The importance of communities of practice,* also paints a large vision of how research should be conducted in informal learning settings, this time emphasizing partnerships with other institutions such as schools. Kisiel makes an important distinction between collaboration, defined as the interaction of institutions, and partnerships, which entail the mutual exchange of benefits. It is the latter he explores in the chapter by pointing to the kind of work needed to nurture their success and overcome the inherent challenges and tensions that are always present, regardless of how bright such prospects look at the onset of the collaborative process. Kisiel's theoretical grounding in the communities of practice approach makes possible an exploration of what happens when the cultures of two (or more) institutions come together at many levels. By relying on Lave and Wenger's (1991) view of a *community of practice* as a 'set of relations among persons, activity, and world, over time and in relations with other tangential and overlapping communities of practice' (p 98), Kisiel takes us on a journey of laying out the many steps it may take us as researchers and collaborators to work our way into practices that make up the collaboration. By drawing on stories from an Aquarium School Partnership research project he describes learning about the community, a first step to make it accessible, as an "immersive boundary encounter" (p. 59). Kisiel then explores crucial dimensions and tensions in terms of the form mutual engagement took, what marked the joined enterprise, and in light

of the shared repertoires that could be identified, essential components of communities of practice (Wenger, 1998). By looking at the whole infrastructure at work in collaborations, and by juxtaposing the design for effective partnerships with actual data at all levels, Kisiel offers a rich context for the discussion of boundary objects and brokers that facilitate partnerships among institutions.

Tali Tal's chapter *Action research as a means to learn to teach in out of school settings* addresses another important issue and offers yet another methodological tool that helps put theory into practice. Professional development of museum staff, as addressed by Ash and Lombana in chapter 3, is one way to explore the changing role of adults in informal settings. Professional development opportunities for teaching in informal settings is another, which is at the heart of Tal's chapter. Professional development programs seldom prepare teachers to develop or use suitable pedagogies in out-of-school settings. In this chapter, Tal illustrates how the methodology of action research can enable the improvement of teachers' best practices in out-of-school settings, and at the same time allow for deeper understanding of the teachers' challenges and practices in general. Like Anderson (chapter 2), Tal stresses the importance of feedback and reflection central to action research. In fact, action research is a methodological tool particularly well suited for the development of out-of-school teaching expertise since it blends theory and practice. As suggested, through a feedback loop of preparation, action, reflection and evaluation, action research makes possible change grounded in critical reflection, initiated and owned by participants. Explorations and reflections upon one's teaching in informal settings also helps teachers move towards a learning-centered orientation in their teaching, as other studies have explored (see Anderson, chapter 2; Kisiel, chapter 4).

There is an interesting parallel between the student teachers in Tal's study and the museum educators in the Ash and Lombana chapter. Both have agendas that were not originally aligned with those of the students (and teachers) on fieldtrips or those driving family visits to museums. This hints at a disconnect that Kisiel (chapter 4) also explored in his study of a partnership among institutions and practices. But instead of focusing on communities of practice, Tal explores ways whereby classroom teachers' navigation into the informal setting can be supported and enhanced. Tal's study also points at the usefulness of informal educational settings on University campuses that can then be leveraged as laboratories for effective professional development programs for teachers on site. It makes possible embodied experiences of field trips by student teachers which, as suggested, can play a crucial role in making them part of a teacher's toolkit for the teaching of science later on in the classroom.

In *Tracing our methodological steps: Making meaning of diverse families' hybrid "figuring out" practices at science museum exhibits,* Thao Mai and Doris Ash detail research that actively explores scientific sense-making from the point of view of the learners, ethnically diverse families from underserved communities who were invited to an urban museum of science and industry in south central Florida. Their chapter traces the steps that drove the development of a complex analysis scheme that made possible an understanding and appreciation of the full

range of family participants' museum practices. They suggest that in order to understand families' sense-making activities, what families actually do at exhibits needs to be explored in its full complexity. This has led to the observation of families' complex weaving together of personal narratives with the exhibit, a "hybridization" that created a unique space for learning and participation. This hybrid space did not look like what the museum designers expected from families, thus Mai and Ash designed new ways of segmenting, coding, and analyzing discourse-based data, as well as new ways of thinking about family interactivity, relying, in part, on activity theory. The chapter helps expand our views about what counts as science when coding scientific talk and action. They show the seamless manner whereby humour, social and science talk are intertwined and constitute a family's visiting practices, figuring out of exhibits, and sense-making of science. The kind of micro-analysis of dialogue engaged in by the authors is also apparent in other chapters and is essential for moving towards an appreciation of the full complexity of learning, which is embedded in practice and is constituted in complex and not always transparent ways by repertoires of practices. Essentially, the chapter is a vivid example of the point Anderson makes in chapter 2: "research methods evolve during the course of interpretive research studies" and entail an ongoing cycle moving from research, to interpretation, and methodological revisiting. This is at the heart of a hermeneutic approach, and it enables deeper insights into what is happening in situ.

In *A multi-sited ethnography: A tool for studying time/space dimensions of learning and identity work in science*, Jrène Rahm advocates the use of multi-sited ethnography. Youth today, she argues, encounter science learning across a variety of environments and contexts, and through multiple dimensions of time, necessitating a methodology and method that is equally as dynamic. To illustrate this point, Rahm follows an individual, in this case Lya, as she moves across a variety of settings, including museums, after-school programs, and summer camps. Offering examples from three different informal science practices, Rahm then explores the time/space scale in yet another manner by tracing youths' engagement in science in informal settings across space. Multi-sited ethnography as showcased, she argues, is a method well-suited to research grounded in sociocultural theory, as it accounts for the horizontal and vertical, yet also dynamic nature of learning. Rahm suggests that the dialectic between the researchers and researched is essential; other chapters have emphasized this also (Anderson, chapter 2, Ash & Lombana, chapter 3, etc.). The term research imaginary, as invoked by Marcus (1998), resonates with the idea that research evolves (Anderson, chapter 2), and takes form over time (Ash & Lombana, chapter 3). To look at that research also implies different angles in terms of time and its spatial layout, as is also hinted at in chapter 7 by Rowe and Bachman. In fact, all chapters in this book entail research that took time, and that evolved over time. While the spatial scale remained local in most chapters, Rahm suggests that pushing that spatial scale holds much promise in understanding science literacy development and in designing for it. Rahm's proposition, as well as others in this book, all clearly move us beyond dichotomies in every sense of the term, in terms of the people involved in research and doing

the research and the sites studied and relationships among sites. Rahm contends that such a systemic approach to research holds much promise to answer fundamental questions and to fully grasp the complexity of lives today in an era marked by globalization, diversity and movement.

In *Mediated action as a framework for exploring learning in informal settings,* Shawn Rowe and Jennifer Bachman make the case for mediated action, an epistemology that makes it possible to study the emergence of learning. They perceive of mediated action as neither a method of data collection nor of analysis, but as a research approach that addresses simultaneously the individual and the learning contexts and tools of learning, in an attempt to capture the richness of learning in informal settings. They briefly outline three key components of sociocultural theory: grounded perception of learning, alluding to the social origin of knowledge in interaction; its mediation by signs; and its emphasis on the interdisciplinary nature of research. They offer insights into the use of a mediated action approach in the context of a family dialogue that accompanies action in and around a touch-tank in an aquarium, and a family dialogue around science in the context of a home schooling event and play with a chemistry visualization kit.

They offer novel ideas on how to plot learning as emerging over time and as taken up by different speakers simultaneously, while also exploring key dimensions of a mediated action approach. For instance, they discuss the difficulty yet importance of capturing talk and action simultaneously in interactions, offering illustrations of how the two form a dialectic and constitute the meaning making that is evident in the two examples. With a focus on talk and action, one may be able to derive the participants' goals that drive participation, yet also explore the kinds of cultural tools that mediate thinking and action. One may then explore agency in light of the cultural tools that are being used and by exploring the form engagement takes with those tools in context. Most important to the authors are the kinds of affordances and constraints that come with cultural tools and contexts. In conclusion, the authors acknowledge the use-value of large-scale studies that focus on the individual without much concern about context (the medical model). However, they argue that case studies, such as the two they presented, need to be pursued simultaneously, in order to arrive at an understanding of genuine learning in out-of-school and everyday settings. According to the authors, only these latter types of studies, digging deeply and simultaneously into complex dimensions of learning, will help us move forward in the field of informal learning, making such studies worthwhile despite their complexity and time-consuming nature.

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DAVID ANDERSON

2. A REFLECTIVE HERMENEUTIC APPROACH TO RESEARCH METHODS INVESTIGATING VISITOR LEARNING

INTRODUCTION

This chapter advocates for the study of new research methods that allow researchers a more unbounded-responsive approach to qualitative – interpretivist studies of visitor learning in informal settings. The focus is on the utility and merits of research methods that *evolve* during the course of interpretive research studies; such methods have considerable potential for researchers to more deeply understand emergent experiential visitor learning in informal contexts. Many research studies, typically situated within a positivist paradigm, often establish methods and hold them fixed throughout data collection. This static approach to data collection has historically been seen a virtue, and is celebrated for the scientific rigor it brings to research design. This chapter looks critically at traditional positivist research, arguing that a repetitive, dialectic, hermeneutic[i] approach may be more effective when research questions seek understanding of the nature of learning in informal settings.

The extended quote below illustrates how my own research has benefited from this approach:

> We learned a great deal about our own approaches to research and the nature of visitor learning we were investigating in the museum by just thinking and repeatedly reflecting on the ways which we were conducting the research. Our repeated reflections allowed us to become all too aware of the many factors which were shaping the assumptions inherent in our research methods, which were at times preventing us from seeing the learning phenomenon more clearly. These repeated reflections not only made us more knowledgeable about the visitor learning we were investigating, it changed our underlying beliefs and freed us to see better ways of conducting the research we could not previously see, and in turn led us to deeper and richer understandings of learning itself. (Anderson, 2008, p. 4)

A repetitive, dialectic, hermeneutic approach, such as the one described above, is characterized by permitting the interpretation of data to dynamically inform modification of the methods used in subsequent rounds of data collection. Researchers can derive deeper insight as their methods (tools), understandings and views (epistemological stances) are critically honed through successive rounds of data collection and analytical interpretation. Repetitive feedback loops of collection and analysis can result in a deeper appreciation of learning than fixed methodological approaches or dogmatic epistemological stances. The repetitive,

D. Ash et al. (eds.), Putting Theory into Practice, 15–25.

dialectic, hermeneutic approach provides an opportunity for researchers to reflect critically on their research methods and to refine their capacity for responsiveness. Such an approach has the capacity to yield much better and more detailed understandings of visitor learning.

In the sections below, I use a dynamic, hermeneutical lens to look at research on learning in museums. I begin by defining what is meant by learning in this type of research and go on to introduce several methodological approaches. I then focus on the complex interplay of data interpretation, methods and epistemology inherent in reflective feedback approaches. Finally, I introduce three research examples to illustrate the reflective hermeneutic approach.

NATURE AND DEFINITIONS OF INFORMAL LEARNING

There is no one comprehensive definition of "learning," but a variety of definitions to suit different contexts, world-views, and research questions. Beliefs about what counts as learning are strongly aligned with the researchers' paradigm,[ii] embedded in their ontology (belief about the nature of truth and reality) and epistemology (belief about how knowledge comes into being). Thus, what one believes about the nature of "truth" and the nature of "knowledge" are key factors in how one defines learning in the museum or in any other context (Anderson & Ellenbogen, 2012).

Contemporary definitions of learning in the field of *visitor studies* frequently span multiple domains—cognitive, affective, appreciative, aesthetic, social, moral, and identity, to name a few. These encompass a far broader range than the most dominant domain of investigation in research on learning: the cognitive domain. However, it is important to appreciate that all the domains named above are inextricably and holistically inter-linked with each other. It is necessary to understand "the parts" in order to understand "the whole," but no single part is a valid representation of the whole. Beyond a domain specific framework, which has its origins in a largely product-based conceptualization of the phenomenon of learning, there are views of learning that conceptualize it in terms of process (Anderson, 1999). Most learning researchers, particularly those who subscribe to a constructivist-based view of learning, regard the nature of learning as being dynamic and in a state of continuous development or construction.

No single learning experience is mutually exclusive of others, rather every life experience is interpreted in the light of who we are and our dynamically developing socio-cultural identity(ies). As much as this relational perspective holds true for interpreting learning within a framework of visitor learning, it also holds for how a researcher of learning might change his/her understandings of learning with successive experiences of investigating learning. The researcher, as an investigator, is not immune to change and transformation within his/her own epistemology of learning. In fact, such transformations hold the potential to shape a better and deeper understanding of learning.

One tension then, within the study of visitor learning in informal settings, springs from viewing learning as epistemologically linear and instantaneous in nature without consistent regard for the notion that learning is an ongoing dynamic

phenomenon. Such linear views narrow the focus of visitor studies on the effects and impact on visitor learning of unitary events like using an exhibit, exploring a gallery, or visiting a whole museum. This isolated view of learning is reflected in the methodological approaches used, for example, exit interviews seeking to understand visitor experiences of the museum in the past few hours, or naturalistic observations that seek to understand the immediacy of visitors' behaviors in the gallery. These approaches, in isolation, do not reflect the view that learning is a dynamic and on-going phenomenon. The impacts of museum experiences (or any life experience) are noted in the continuous construction and re-construction of events, words and ideas, so we would expect that outcomes arising from a museum experience change over time, or longitudinally. The changes that manifest longitudinally occur as the visitors engage in subsequent conversations about the experience, read newspapers, watch television, surf the internet, and connect the experiences of the museum or informal context with other subsequent life experiences (Anderson, Storksdieck, & Spock, 2007). Thus, studies seeking to understand visitor learning connected with exhibitions or in-gallery experiences need to appreciate that instantaneous measures only tell part of the story. Hence, multiple measures or interpretive snapshots over time have considerable merit in understanding the emergent holistic nature of learning present in visitors' experiences.

Most scholars would agree that learning in informal contexts involves visitors' construction of their own meanings and understandings; such constructivist views have become prevalent over the last several decades. The meaning and understanding constructed vary greatly depending upon the background, experience, interests and knowledge that visitors bring to the experience and is also influenced by the visitors' social groups and their socio-cultural identities and physical context of the institution itself (e.g., Falk & Dierking, 2000; Hein, 1998). Hence, a museum exhibition or a museum program alone does not predict visitor learning. Rather, it is a dynamic interaction between the diversity of factors intrinsic to the visitors themselves and their personal interactions in the museum that results in myriad of learning processes and outcomes.

A second methodological and theoretical tension arises from the fact that current visitor studies research typically uses the individual (visitor) as the unit of analysis even though most visitor learning occurs in a social context. Therefore learning research is focusing more and more on social experiences, noting the impact of the exhibitions on whole groups as a more valid way of interpreting and understanding learning. For example, several studies have investigated the impact of museum experiences on family groups (Borun, Chambers, & Cleghorn, 1996), or even an entire community (Jones & Stein, 2005; see also chapters by Ash & Lombana; Kisiel, Mai, & Ash; Rahm, and Rowe for examples of research using social groups as unit of analysis)

Given this short overview, it is clear that the learning phenomenon as contextualized within the domain of visitor learning is highly complex learning is not a singularity, but rather a rich, dynamic, multidimensional mosaic in a state of continuous development. On the surface, the inherent complexities may be

daunting to comprehend, let alone investigate. However, the rewards for deeper understanding of visitor learning are immense since deeper understanding of learning has the capacity to better inform the design and development of exhibitions and programs from a grounded theoretical perspective and hence improve the quality of visitors learning in formal and informal contexts.

METHODOLOGICAL APPROACHES TO PROBING AND UNDERSTANDING LEARNING

Although there are many ways in which to conceptualize the documented research on learning in informal contexts, from an archetype and methods perspective, the literature on visitor studies can be thought of in terms of two broad categories: *positivist-decontextualist* and *revelativist-contextualist* paradigms (Brewer & Collins, 1981). Positivist-decontextualist studies are characterized by research that has been conducted by means of elaborate experimental designs and statistical analyses (Nelson & Narens, 1990), with an approach to research that seeks simple answers to the complex world of the visitor as learner within the museum environment. Such approaches often set out to eliminate contextual factors and any resultant ambiguities (Popkewitz, 1984) and often use one method within the research design to reveal and/or understand visitor learning (Anderson, Thomas. & Nashon, 2009b). However, studies embedded in the *relativist-contextualist* paradigm regard such factors as being highly influential and important in relation to the development of visitor learning. Some of these factors include visitors' agendas, motivations, and socio-cultural identities. *Relativist-contextualist* studies consider the natural ecology of the learning environment in which the learner is embedded as holding a vitally important set of parameters with which to understand the learner and his or her learning. Studies aligned with this paradigm are typically qualitative and interpretivist in nature. These studies acknowledge the complexity of learning and the learning environment, and incorporate it into their research methodology. In addition, they frequently utilize multiple data forms that emanate from the use of diverse research methods to better interpret and describe the nature of learning in informal contexts. This paradigm engenders the kinds of research questions that can most fruitfully assist educators and museum staff in improving learning and learning outcomes. A renewed and on-going scrutiny of the methods used for collecting and analysing empirical data gathered in a naturalistic manner is needed for a richer and deeper understanding of visitor learning.

The Interplay between Interpretation of Data, Methods and Epistemological Stances

There is a diverse suite of traditionally categorized research methodologies in the social sciences (i.e., ethnography, phenomenology, experimental designs) that can provide frameworks for understanding learning experiences in informal settings. Embedded within these frameworks are a wide variety of research methods (i.e.,

interviews, focus groups, questionnaires, web-surveys, behavioral observations and tracking). As a general principal of social science research, the research question determines the methodology and the appropriate methods to be employed in the study, bounded by the researchers' own paradigms, which are shaped by their ontological and epistemological views. In visitor learning studies, where the focus of research is to better understand the phenomenon of learning itself, a qualitative-interpretivist framework may be best suited to elucidate the complex richness and depth of the phenomenon. A repeated dialectic hermeneutic approach to the methods of such a research investigation could better reveal the complexity of the phenomenon in ways that a static, non-responsive design cannot. The term *dialectic* in this case refers to the practice or art of arriving at the "truth" by the exchange of logical argument; in this sense, it is a method of argument or exposition that systematically weighs contradictory facts and ideas in an attempt to resolve their real or apparent contradictions.

At the heart of *hermeneutics* is the process of interpretation, or making meaning from the stance of the interpreter. Hence, repeated logical argumentation (dialectic) amongst one's own interpretation of meaning (hermeneutic) has the capacity for arriving at deeper truths. A core assumption of this approach is a research design that has provision for multiple stages of data collection and hermeneutic interpretation over the course of the study. These approaches require built-in opportunities for the researchers to reflect dialectically between successive stages and critically examine their epistemological stances. These reflections in turn permit the researchers to hone and refine their research methods in the successive stages of data collection and hermeneutic interpretation.

Within such interpretivist approaches, the methods should not be fixed, but dynamically responsive to a) the study's research objectives, b) the developing relationship of the researchers to the phenomenon being studied, and c) the evolving epistemologies of the researcher(s). This last condition requires several pre-conditions: First, the researchers need to be critically aware of their own epistemological stances and the views they hold about the learning phenomenon under investigation. Second, the researchers need to see their own epistemology not as fixed, rigid or inflexible, but rather as something that changes with increasing understanding of the environment(s) in which they are contextualized (i.e., a museum) and the learning phenomenon under investigation. Third, the researchers need to be willing to allow their own epistemological stances and the values to be challenged by their developing understanding of the phenomenon studied (Guba & Lincoln, 1989). Such epistemological evolution is valued within the relativist-contextualist paradigm I have proposed.

Through hermeneutic interpretation of data and dialectic exchange of perspectives among the research team, the researchers' epistemological stances around the phenomenon can be critically evaluated and challenged, allowing them to evolve. From these evolving epistemological stances a more enlightened critique and evaluation of the methods (tools) being used emerges. Although the researchers might initially construct a well justified set of complementary methods within their initial epistemological stances with which to understand visitor

learning, the opportunity to repeatedly reflect critically on their methods, with the benefit of increased understanding of the phenomenon and context, permits ongoing refinement and evolution of both epistemology and methods, and a reciprocal increase in the capacity to understand the phenomenon and context. This collective evolution can increase the synergy between the different methods and further increase the researchers' depth of understanding. This results in the emergence of more fruitful methods with increased capacity and responsiveness.

Underlying the approach described above is the notion of the hermeneutic method. At the heart of this method lies the ability of the researchers to understand the meaning of a phenomenon from the frame of the visitor, and to appreciate the cultural and social forces that may have influenced the nature of that phenomenon (Guba & Lincoln, 1989).

EXEMPLARS OF REFLECTIVE HERMENEUTIC APPROACHES TO METHODS

In order to exemplify in a concrete manner some of the repeated dialectic hermeneutic development of research methods, a recent major research study entitled "Metacognition and Reflective Inquiry (MRI) Collaborative" (conducted between 2003-2008) that investigated metacognition and learning in and resulting from experiences in informal settings will be explored (Anderson & Nashon, 2007[iii]). The MRI research study sought to understand the nature of visitor (student) learning and metacognition (awareness and executive regulation of learning strategies) across numerous cases of experience in informal settings. The study was conducted in multiple phases, with each phase informing the next phase's methodological approaches, and with the researchers' evolving views of the phenomenon and changing epistemological stances informing a better resolution and understanding of the phenomenon itself.

Example 1. Researcher Driven Interview Discourse to Participant Driven Interview Discourse

Many interpretive studies of visitor learning employ some form of interview method in order to understand the learning derived or emergent from visitors' experiences. This method is often driven by researchers, who are most likely the primary interviewers, with the aid of an interview protocol comprising a set of predetermined questions. Semi-structured interviews are a common approach within qualitative-interpretivist investigations utilizing interview methods since they afford the opportunity for the interviewer to dynamically respond to the participants' answers, and to capitalize on unpredictable issues that emerge in the course of the conversation. Hence, the semi-structured interview reveals deeper understandings of visitors' experiences than more structured interview protocols.

However the extent to which the visitors' experience of participating in the interview itself can influence their own learning should to be acknowledged (Anderson, Nashon & Thomas, 2009a; Anderson et al., 2009b). This realization holds lessons for those conceptualizing research methods aimed at understanding

learning. Specifically, the methods used to gather information about learning inherently hold for the interviewee the capacity to initiate high order learning itself. In the case of the MRI study, the researchers' collective hermeneutic self-reflection on the interview methods caused a re-evaluation of the utility of researcher-driven discourse embodied in the semi-structured interview protocol. Here, initial rounds of the semi-structured interviews conducted with visitors permitted the interviewer to dynamically respond to the participants' answers and to capitalize on issues that emerged. With the opportunity to reflect on the data, and the research teams' realization that the interview itself was influencing the interviewees own learning, the researchers' epistemological stances about the learning phenomenon shifted and evolved. It was this shift that permitted the semi-structured interview research methods in the subsequent rounds of data collection to change.

Special attention was directed in particular to opportunities during the semi-structured interviews for the participants' own discourse to become the subject of self reflection and repeated self analysis. Practically speaking, the researchers' (who were the interviewers) used participants' own reflections made during the interviews to assist the participants in revealing the nature of their own learning. In this way, researcher driven interview discourse (the original method) was modified to incorporate participant driven interview discourse (the evolved method), resulting in better resolution of the phenomenon of the visitors' learning.

Example 2. Individual Units of Analysis to Group Units of Analysis

Previous research on visitor learning has tended to focus on the individual as the unit of analysis. The reasons for this is are in part rooted in the historic traditions of educational research and educational assessment systems that have focused almost exclusively on the measurement of individual achievement. Most educators, however, recognize the value of group work for meaningful learning, and social constructivists commonly consider groups as the units of analysis. Yet group units are rarely considered in studies of visitor learning outside of "family learning" research. Ultimately, both individual and group units have the capacity to yield valuable insights about learning.

In the initial phases of the MRI study, the researchers' epistemological stance was one that sought to understand the nature of learning and metacognition predominantly through the unit of the individual embedded within a group setting. But the researchers' later interpretations revealed that they were not only individuals engaging in metacognitive strategies, but that the groups in which individuals were situated behaved and learned in ways that demonstrated collective metacognition. The outcomes of the MRI study reported in Anderson et al. (2009b) demonstrated that students are aware of, monitor, evaluate and control their engagement within the cognitive (learning) task (completing teacher-assigned activities) and social domains (their own working group environment). These three meta-domains are, for many participants, engaged actively and simultaneously in group activity. Additionally, individual and group engagements were dominated by

meta-social influences, which involve, for example, the maintenance of overall group harmony and the social status of individuals within the group.

Following the initial rounds of data collection and subsequent analysis, the research team's reflections on the evidence for collective group metacognition led them to realize that this phenomenon is under-researched, and its effects on learning and behavior underappreciated. Moreover, the researchers' realizations about group metacognition and simultaneous group monitoring of learning, task and social condition challenged their epistemological stances about the nature of metacognition and learning as predominantly a feature of the individual embedded within a group setting. These changing epistemological stances resulted in the team modifying their analytical and methodological approaches to understanding metacognition and learning in order to consider both the individual *and* the group as valid and important units of analysis. This in turn led to changes in the way participants self-selected critical incidents by group consensus as part of a stimulated recall approach, and also in the kinds of questions posed in the semi structured interviews. Specifically, in addition to the probing questions intended to examine their individual learning, questions were posed to the whole group derived from the critical incidents that had been selected by the collective group.

Example 3. Researcher Selected to Participant Selected Incidents of Whole Group Interactions

Researchers in the MRI study replayed video excerpts of participants' engagement in the informal setting as means to stimulate recall of their learning during follow-up interviews with the participants. This required the research team first identify and select several incidents from the video data of participants' activities. The rationale and justification for selection of critical incidents for stimulated recall was based on researcher-centric criteria. For example, incidents were selected that appeared indicative of the deployment of learning strategies, cognitive struggle or impasses, and individuals' engagement of higher order learning. Researchers discussed and ranked the capacity of these incidents to engage participants and generate self-awareness and elaborative discussion regarding various aspects of their own learning.

When participants were interviewed after this process, they were shown researcher-selected video data of themselves containing critical incidents, and they were interested to see their personal and group interaction in the informal setting. However, there are several challenges involved in relying on researcher-selected critical incidents—challenges that the researchers did not foresee in the initial rounds of interviews. With the benefit of a better understanding of the phenomenon, and the opportunity to dialectically reflect, the limitations of these methods were revealed. The method was therefore modified to better understand the phenomenon in later rounds of data collection.

The hermeneutic reflections following the first round of data collection and analysis focused on a number of realizations. First, the researchers came to the realization that the visitors were, for the first time, being asked to see and hear

critical incidents that they had likely not reflected upon until that moment during the semi-structured interview. Consequently, they were not always able to recall or appreciate the meaning or significance of an incident for their own learning in the ways the researcher had anticipated. As a result, the participants' responses in relation to what the researchers considered to be critical incidents were not as informative as the researchers had hoped. Second, the researchers were sometimes baffled by the lack of response to incidents they had judged to be appropriate for stimulating reflection about the participants' own learning. Subsequent critical self-reflection about the lack of resolution around the phenomenon drove the researchers to question whether this might be a consequence of the participants' lack of familiarity and sense of association with the critical incidents selected.

This led to several conclusions, which challenged and later changed the researchers' epistemological stances and methods in subsequent rounds of data collection. First, because it was clear that the participants were being asked to see and hear a critical incident for the whole group that they had not necessarily ever reflected upon before, the researchers decided that opportunities to preview the critical incidents prior to the interview might afford opportunities for more meaningful participant reflection and insights. Second, the researchers questioned whether the incidents to which they had ascribed importance, significance and relevance were congruous with what was important, significant or relevant to the participants' perspectives of their own learning experiences. This speculation was, in part, based on previous research (Anderson & Lee 1997[iv]), which demonstrated that student perspectives of what is important in a learning environment may vary from those of teachers and researchers, and that students should be given a voice in the research process. Therefore, the researchers decided that opportunities for participants to self-select their own critical incidents would better reflect their learning and interactions during their field visits, resulting in more fruitful conversations and results.

As a consequence of their hermeneutic reflections between data collection stages, the MRI researchers modified their approach to provide an opportunity for the participants to self-select the incidents used during stimulated recall and discussion. The researchers also used a smaller set of researcher-selected critical incidents that were not identified by the participants, but that the researchers ultimately felt were important to investigate. We concluded that both approaches have the potential to provide deeper understandings of the learning phenomenon.

CONCLUSION

These three examples, drawn from the MRI Collaborative Study, help describe and explain in practical terms how a staged approach that embeds opportunities to dialectically reflect about emergent interpretations of the data between stages, can allow researchers to hone their methods while at the same time reciprocally honing their capacity to understand the phenomenon being investigated. Although these examples were specific to the methods used in the MRI study, the principles of

repeated reflection through dialectic hermeneutic approaches can be applied to all kinds of methods being used to understand and interpret visitor learning.

In this chapter, I advocate the benefits of an unbounded-responsive approach to qualitative-interpretivist studies of visitor learning. The value of this approach to research design is its capacity to further refine research methods as understanding of the phenomenon under investigation increases. Inherent in this premise is the notion that a more enlightened critique and evaluation of the methods (tools) being used to understand learning phenomena can only be employed after the emergence of new understandings of the phenomenon and with the new *versions* of the epistemological stances held by the interpreters. Scholars in the field of informal learning often identify the need for new and more effective research methods with which to understand visitor learning, and they often call for the pioneering of new methods. The approach advocated in this chapter has the potential to provide the field with new and continuously evolving effective methods for investigating visitor learning.

NOTES

[i] Hermeneutics (English pronunciation: /hɜrməˈnjuːtɨks/) is the study of interpretation theory, and can be either the art of interpretation, or the theory and practice of interpretation.

[ii] A set of assumptions, concepts, values and practices that constitute a way of viewing reality for the community that shares them.

[iii] See also Anderson, Nashon and Thomas (2009a), Anderson Thomas and Nashon (2009b), Thomas, Anderson and Nashon (2008), and Nielson, Nashon and Anderson (2009); for an elaborated exploration of the examples of "within-study" methodology changes that are discussed, see in particular Anderson, Thomas and Nashon (2009b).

[iv] See also Baird and Mitchell (1987), McRobbie and Tobin (1995) and Thomas (1999).

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AFFILIATIONS

David Anderson
Department of Curriculum and Pedagogy
University of British Colombia
david.anderson@ubc.ca

LEAH MELBER

PUTTING THEORY INTO PRACTICE

ANDERSON'S A REFLECTIVE HERMENEUTICAPPROACH TO RESEARCH INVESTIGATING VISITOR LEARNING

The museum community has embraced the importance of critical self-reflection—methodical and sound approaches to measuring the impact of our programs and exhibits. Established study protocols and analyzed data reaching peer-reviewed publications have helped us document, to those inside and outside of our field, the nature of the visitor experience and the impact a museum visit can have. As our field continues its theoretical march forward, however, we have shifted our focus beyond simply the length of time spent in an exhibit space, or ability to recall an example of a vertebrate. Instead we are seeking to truly understand the learning going on within these spaces. In this piece, Anderson asks us to consider how a more flexible approach to methodology might allow us to better capture the true complexity of the learning process through a reflective, hermeneutic approach.

Many of us have scientists as workplace peers who view fixed, quantitative methods as the method of choice for exploring the visitor experience. Others of us have completed a thesis or dissertation, where a suggested deviation from protocol has the potential to throw a committee into a tailspin. In sum, it is likely that our own theoretical grounding is heavily steeped within a traditional, positivist approach to research. For example, as a brand new graduate student, I supported a colleague of mine and recent graduate on an exhibit evaluation study. She set a stack of open-ended questionnaires in front of me and began to lead me through the process of thematic category construction. She explained we would do a first level analysis, the categories would then be revisited, and we could discuss expanding or collapsing before moving on the next phase. I tried to conceal the horror on my face as I asked her, "You mean we might change things?!"

We spend much of our professional life preparing for change, supporting colleagues through change, and adjusting to change. Just as we might change protocol within the non-research aspect of our work in museums, Anderson makes a clear case that change and evolution is a necessary part of the research side as well. He reminds us that just as the process of learning is complex, and our understanding of the process constantly evolving, the methods by which we measure this learning must be equally as fluid and dynamic. We as museum professionals are serving as internal evaluators exploring these topics ourselves, or administrators overseeing the efforts of external researchers; Anderson's work provides us with a different lens through which we can view methodology and methods, in order to adjust our own expectations about the importance of rigidity

D. Ash et al. (eds.), Putting Theory into Practice, 27–28.

over self-reflective methodological adjustment. He also provides a reliable and substantial framework that can help us educate our own peers and stakeholders about the validity of a reflective, hermeneutic approach to the study of museum learning.

DISCUSSION QUESTIONS

1. Recall a prior research project steeped in a traditional, positivist approach. Did you experience any challenges that might have been remedied by a reflective, hermeneutic approach?
2. What do you think is the most effective way to help stakeholders understand the importance of a reflective, hermeneutic approach over traditional protocols that might be more familiar to them?
3. Is there anything about this approach that might cause you some discomfort? How could that discomfort be addressed and alleviated?

DORIS B. ASH AND JUDITH LOMBANA

3. METHODOLOGIES FOR REFLECTIVE PRACTICE AND MUSEUM EDUCATOR RESEARCH

The Role of "Noticing" and Responding

INTRODUCTION

We argue in this chapter that research focused on learners and learning, as well as on teaching, has sharpened our insights about how museum educators, in the process of becoming increasingly reflective practitioners and teacher researchers, can learn to both 'notice' learners in new ways and respond to these learners with flexible scaffolding rather than with predetermined disciplinary content, scripts or standardized questions. We base this argument on research conducted over the past five years using a sociocultural theoretical framework to inform methodological decisions. Our work and that of others (Tran & King, 2007, for example) and Kisiel's and Tal's chapters in this book have underscored the need for theoretically grounded practices for those teaching in informal science institutions (ISIs).

Our research is set in the context of a newly emerging field of study: professional development for informal science educators. As is typical of such new fields of study, new theories and methods are just now appearing in the science education research literature. One purpose of this chapter, then, is to present a new research-based method for modeling responsive teaching in out-of-school settings. We emphasize both sides of the learning and teaching equation—family and student learning and teaching, and museum educator learning and teaching—arguing that they are intimately intertwined. The professional development design we propose focuses on museum educators' *noticing* of what families do, learning how to flexibly respond to what they notice, reflecting on their own and others' practices and, finally, becoming teacher-researchers.

Because our chapter focuses on methodological tools that evolved, we also want to be particularly clear how certain approaches came into being. We have relied on multiple phases of data collection (family visits-unmediated, family visits-mediated, reflective practice, etc.); each layer has been designed to substantively inform the others, allowing us to focus and refocus our efforts in new ways, typically transforming the ways we analyze new data. As with all good design-based research, we understood from the beginning that we have needed to regularly feed the results of earlier phases into the next levels of analysis, in order to design an effective new approach to professional development. As findings became available, they were used to design subsequent new methods. This approach is also consistent with Anderson's hermeneutic approach, proposed in the previous chapter of this book.

D. Ash et al. (eds.), Putting Theory into Practice, 29–52.

In order to highlight some of the themes we will address in this chapter, we begin by introducing Kevin, a museum educator who took part in the showcased professional development program grounded in reflective practice. Kevin began his own development at a point where he began to change how he viewed visitors' interactions with exhibits.

> There's a level of patience [now] associated with dealing with people because [I understand] they're not just there messing up the exhibits, they honestly have no idea how to do anything.

This quote by Kevin allows us a glimpse into his (and perhaps others') early thinking about family activity in a museum of science. Kevin's original concern was that families might be "messing up" the exhibit because they didn't seem to recognize how these science exhibits were supposed to work. Such thinking implies that there may be a right way to "do" exhibits and that museums educators and exhibit designers expect families and other learners to conform to such norms. If a family does not "do" or interact with the exhibit in the way(s) the designers expected, then the museum educators may interpret the family's actions as inappropriate or wrong, or they may even discount what the family actually does do with the exhibit.

Such assumptions could have remained implicit and unexamined had Kevin not had ample practice in collaborative reflection with his peers and mentors. He was a collaborator in our year long research-focused, museum-university collaborative partnership, which involved establishing a new community of practice intended to provide a new model for museum educator professional development. This model, aspects of which were borrowed from successful classroom-based research and which has come to be called the REFLECTS model, is predicated on the tenets of ongoing reflective practice as well as museum educator/teacher research. Classroom-based reflective teacher research has suggested that teachers trained in these methods progress rapidly toward more sophisticated teaching practice, especially in their ability to see and 'notice' nuanced interactions. The research described in this chapter will demonstrate how this same progress is true of museum educators/teachers as well.

Professional development began with Kevin and his colleagues spending a great deal of time watching both real and video taped family activities (not mediated by museum educators) at four carefully selected science exhibits (Dino-saurus, Museum Magnified, Bed of Nails, and Pendulum). Kevin and the others learned to take careful ethnographic notes of a variety of social activities. He then engaged over many weeks in reflective discussions (both written, and in small and large groups) about the activities, talk and ideas in these episodes with his 15 peers and a facilitator. Through these reflective practices, Kevin came to realize that the families were sometimes mystified by the exhibits; they did not know exactly what they should be doing with them. One child voiced this succinctly by saying, "What are we supposed to do here?" Kevin also noticed, as did his peers, that many families tended to spend a great deal of time 'figuring out' the exhibits. By 'figuring out' exhibits we mean taking time to discuss, ask each other, play with

and try out different aspects of the exhibit. These activities typically occurred before family members actually moved toward understanding the science content (see Mai & Ash, chapter 6).

Kevin and his colleagues then watched short, carefully selected 1-3 minute digital video activity segments, which showed pre-trained museum educators (from prior years) mediating family activities. The newly emerging community of practice then collectively reflected on what had worked and what had not, discussing styles, strategies and expected outcomes. They discussed and read about the notion of scaffolding among themselves and with other researchers from both museum and university settings. They then looked at more video activity segments, searching explicitly for examples of successful and unsuccessful scaffolding.

Over time Kevin and the others began to wonder whether it was even appropriate to 'deliver' science content without first watching how learners approached and 'figured out' each exhibit. Once they formulated that question, they had seen video and real life (on the floor of the museum) examples of other educators delivering science content, some in moments when it was unclear if that was an appropriate strategy. This questioning of the appropriate role of a museum educator, and the transformation in world-view that Kevin and his peers experienced through their professional development, are the primary focus of this chapter.

With continued reflection and discussion, followed by watching even more videos, Kevin and his group recognized that relying only on the strategy of delivering content knowledge often had poor results, for example, if the family did not engage in dialogue or ask questions, especially with families who were less accustomed to museums. Kevin came to see that every family approaches exhibits in its own way, and that, if he spent time watching, listening to, and seeking to understand family strategies, he would be more successful at his job in the long run. Kevin talked, then, about his role as a museum educator researcher, or MER:

> When families interact with a museum educator researcher (MER), it becomes a structured environment with a distinct leader; they (the family) have a harder time exploring the exhibits, whereas when they are at the exhibit without a museum educator researcher they discover on their own. The museum becomes a formal teaching session with the introduction of the MER.

Kevin gradually came to understand that families need specific and sensitive scaffolding, which should take into account the individual family's words, actions, culture, power structure and overall level of readiness to learn the material, the content in the exhibit, as well as an exhibit's (the museum designer's) intended goals and operating procedures. He came to trust his developed ability to flexibly respond to learners, saying:

> Trusting yourself that you know where you are and where you need to start; whereas, before you might just rush in there and hope for the best, now [after reflective practice] you can see what has worked.

Over time Kevin and the collegial group of 16 museum educators co-constructed a community of practice centred on shared goals, practices and language. Such shared practices included designing new tools for diagnosing and mediating family activity, which we describe later in this chapter. They reflected on when, how, and why to support family science learning in museums. At one point Kevin said:

> I really feel proud of my work here and the work of the entire group. I feel like the dynamic is so strong and has yielded some really interesting results.

One of the things Kevin came to appreciate was the difficulty his initial stance (that there is a right way 'to do' an exhibit) presents for a mediator such as himself. This stance had led him to suspect that families who did not follow the museum exhibit designer's particular way were 'messing up' the exhibit. He began to look beyond traditional approaches to family interactions, which he now saw as often one-sided, content driven, and presenting didactic information from the top down, from the educator to the family.

Kevin could really see how that old way of thinking got in the way of what he might accomplish as a MER. Once he realized this, Kevin opened to other possibilities. He came to appreciate the depth of meaning making families could achieve with their own social strategies and existing resources.

> Your (family learners') way of understanding is not wrong, it is different. Let me help you understand the way we understand and together we will see the world in a way, which is only possible to see with this exact combination of perspectives.

The process of reflective practice and research on practice, which Kevin's story illustrates, was the focus of our professional development program. Our goal in this chapter, in reflecting on the results of that professional development program, is to re-envision what we mean by teaching in museums, asking the question: How can we help educators in informal learning settings to decide how and when to scaffold social activity of groups and individuals during their visits?

In the sections below, we first provide, based on our theoretical grounding in sociocultural theory, an account of the main aspects of our initial methodological design features and their rationale. Following the natural evolution of key turning points, as each phase of the research organically informed subsequent phases, we describe the evolution of the professional development model we propose (PD). We use this new PD REFLECTS model as a backdrop to illustrate the museum educator transformation we discovered in our implementation and evaluation of the model. Finally, we discuss the implications of such approaches.

THEORY AND METHOD INTERTWINED

We need powerful theoretical grounding to design effective and long-lasting professional development, such as the reflective practice and research on practice framework used to guide Kevin to know when and how to scaffold family groups

as they engaged in scientific meaning making. Our work is set within a sociocultural framework, which reflects socially, culturally and historically situated views of learning and teaching. We incorporate the findings of the community of practice literature, modern theories concerning the zone of proximal development and scaffolding, current views of reflective practice in both classrooms and museums, and also activity theory, which guided our selection of the basic research unit of analysis, the 'scaffolding scene.' The emphasis in all this research, which includes our own, is on collaborative social activity, negotiating multiple pathways towards goals, and honoring multiple interpretations of meaning.

The MERs, university researchers, and museum practitioners together established an ongoing community of practice with shared language, practices and identities; these three were intertwined with peoples' roles within the community. Most importantly, we may think of the members and the community as mutually constituted (Lave & Wenger, 1991), which means that the members form the community and the community forms the members. Being part of such a community of practice, in this case, was made visible within the larger context of the informal science institution (ISI) by the MERs' clothing; they each wore a bright blue shirt carrying the logos of the museum, university, and NSF with identification as researcher on the sleeve. Membership in the community was visible from its inception. Different levels of socially organized activity characterize such communities of practice; in this case, these levels were most obvious in differences among members in having had prior teaching experience, either in museums or classrooms. Approximately half the members (8 of 16) had had such prior experience. Wenger (1998) contends that the coherence of a community of practice depends on mutual engagement, joint enterprise, and shared repertoire. Kisiel addresses these in depth in chapter 4 in this volume. We will see many examples below of shared enterprise and repertoire while members were mutually engaged in learning how to become more responsive and less didactic with learners.

We have relied on contemporary scaffolding theory as a focus for the professional development for several reasons. First, scaffolding research is common in classrooms but it is much less studied in informal learning settings. Second, we view museums as rich learning contexts where we might observe naturalistic scaffolding, rather than the more formulaic, top-down teacher-to-student practices. Furthermore, we have found that scaffolding is practiced by both family members and by museum educators (see Mai & Ash, chapter 6). Finally, scaffolding is a key component in sociocultural views of learning, especially Vygotsky's (1986) "zone of proximal development" (ZPD); and scaffolding is also related to theories of learners' participation in mediated activity. In this way we draw on both cultural historical activity theory and communities of practice research for the foundation of our methodological design.

We view scaffolding as a temporary support system, that enables members of a social group or "ensemble," to "perform at a level that is beyond the unassisted level of one or all the ensemble members" (Granott, 2005, p. 144). When discussing scaffolding we explore the same set of underlying tensions that have

emerged from our prior research: issues of cultural diversity and who owns meaning; issues of when to intervene in dialogue and gesture; issues related to how much science is enough, and issues related to power and hierarchy (see Mai and Ash, chapter 6).

To avoid a crude 'one size fits all' teaching strategy, we have chosen instead to match the educator experience to the family and exhibit, through sophisticated reflective practice (Schön, 1987). We have specifically adapted the reflective practice "noticing" models developed for classroom teachers (van Es & Sherin, 2002) for our museum educators. van Es and Sherin have argued that pre-service teachers who learn to notice become more discerning in what they "see" more rapidly, resembling mature teachers. This reflects Bakhtin's (1981) recognition of the social nature of language and learning, as it emphasizes the importance of the "dialogic," even in professional development programs, over any methods of didactic "telling." For the museum educator this means matching both the level of readiness of the family and the scientific information the material exhibits offer with appropriate scaffolds. Wells (1999) and other cultural historical activity theorists (CHAT) view scaffolding as a "way of working in the ZPD." We view museum educator interactions with families using exhibits (words and gestures, etc) as mediational means to be an ideal frame for the learning and teaching activities we most wish to understand.

Later in the chapter, we will describe methods we have developed for locating and labelling distinct forms of scaffolding activity by noting particular scaffolding scenes, within which people interact with multiple mediational means in order to reach a goal. These activities consist of families learning how to 'do' an exhibit, and museum educator researchers (MERs) learning how to scaffold family activity. In the section below we track a narrative of transformation as it occurred over time during several phases of research.

METHODOLOGICAL DESIGN

There were five main phases to this research project. To date, four phases have been completed, and the fifth is underway. These phases have included:

- Phase 1: Observing families' scaffolding behaviors with museum educator mediation (N =42).
- Phase 2: Observing pre-training museum educator scaffolding behaviors (N=10).
- Phase 3: Analyzing Phase 1 and 2 data to reveal information to feed into Phase 4:
    a. Identifying the four tensions of *content*, *acculturation*, *power* and *roles*;
    b. Analyzing the discrepancy between pre-trained museum educator and family agendas;
    c. Designing the scaffolding scene as unit of analysis for the professional development program
    d. Highlighting the skill of "noticing" and "responding" as central components of future PD

- Phase 4: Long-term Professional Development (PD) for MERs (N=16) to notice and respond flexibly, including:
  a. Design a family noticing tool (MERs create the cues chart and MERtrix)
  b. Reflect on other museum educators activity (MERs create the 10 Super Strategies)
  c. MER reflection on their own scaffolding activity with a and b in mind
- Phase 5: the creation of MER PD program for dissemination to other ISIs

The initial two phases of the research consisted of capturing digital video of 42 families, some mediated by 10 museum educators and some not, and analyzing the activities, the scaffolding and the learning that did and did not take place. As noted in the brief outline provided above, major outcomes of the first two design phases included: development of *the four tensions*, *scaffolding scenes* and the *discrepancy between expected outcomes and goals between museum educators and families,* which led, in turn, to the *noticing* focus of the PD program. We describe each briefly below.

Four emerging tensions were identified through Phase 1 and 2 data analysis, informing subsequent research in fundamental ways. These tensions: Roles, Power, Content and Acculturation (see Table 3.1) were abstracted from a variety of data sources, including both museum educator-mediated and non-mediated family scaffolding scenes. We used these tensions as the fundamental underpinnings of MER PD, reflecting and retuning to these at every major negotiation. This theoretical frame was later explicitly included in the 'tools' designed by MERs to enable them to notice these tensions in action. For example,

Table 3.1. The Four Tensions

Roles
How do families negotiate the exhibit and each other (who leads, who speaks, who does not)
Gender, age considerations
Power
Who has the power; how do we know?
How/if people relinquish power?
Mother, father, children, MER (Museum Educator Researcher)
Content
What kind of content are families doing or talking about?
Families learning how 'to do or figure out' vs. disciplinary content
Whose disciplinary content
When is it acceptable to not 'tell' the answer?
Acculturating to museums
Culture matching, language, dialects, slang,
Belief systems (creationism, evolution)
Educational background
Museum goers
Attitude, engagement, motivation

We used the tensions to help select appropriate scaffolding scene videos for professional development, and as the starting categories for both reflective practice and noticing protocols.

Scaffolding Scenes

While analyzing family activity in Phase 1, we were challenged methodologically to determine a new unit of analysis for viewing and coding what we perceived as scaffolding activity units. A major turning point occurred as we developed what we have termed 'scaffolding scenes,' a theoretically based practical tool for segmenting ongoing family, physical, and dialogic activity at exhibits. Our selection of such 'scenes' was informed by activity theory, specifically by thinking of each scene as an enactment of mediated action by people toward some particular goal or outcome. These segments, which were also later used for detailed micro-coding of family scaffolding (see Mai & Ash, chapter 6), also became a fundamental cornerstone for reflective practice professional development training sessions. The theory behind scaffolding scenes is discussed in more detail in the Mai and Ash chapter. Our short definition for scaffolding scenes is:

> Any interaction or exchange between at least two people that involves guidance, leading questions or comments, and/or direct teaching, with positive or negative educational outcome. They include identifiable exchanges involving at least two people that include at least one turn. An exchange is defined as an initiation of talk or gesture that solicits a response in the form of talk or gesture. Such scaffolding is designed to fade over time, as learners have advanced in the collective ZPD.

We used Studiocode to identify and capture the scaffolding scenes (see Figure 3.1 for an example of a Studio code segment) for both, MER reflective practice and professional development. Studiocode is an innovative video analysis technology that allows for segmenting and coding digital video data in flexible ways. We initially focused on family interactions at each individual exhibit; we then segmented these larger pieces (4-20 min) using Studiocode, into digital videos of family interaction and MER/family interactions at the intermediate level (short 1-2 minute segments meeting the criteria for scaffolding). Scaffolding scenes were then further coded again with two different coding schemes (content & noticing codes) for further analysis.[i]

Discrepancies Led to Noticing

Our Phase 2 data analysis identified fundamental discrepancies between how pre-training museum educators viewed their work and how families acted in museums. Analysis of many hours of museum educator-mediated video data revealed a myriad of teaching styles, some applied to families whether they wanted the science content or not. Pre-interviews with a sub-group of those same pre-professional development museum educators or MERS also suggested that they

were less invested in, or discerning of how people learn, then they were in knowing the content and being able to deliver it. These museum educators' goals were more closely aligned with making people happy, providing content knowledge, entertaining them and allaying any fears they may have. Such interests are typical of many informal setting educators with access to few opportunities for professional development. This analysis is different from that of Tran and King (2007), who conducted a study in English museums. This difference no doubt reflects the training museum educators may have received there.

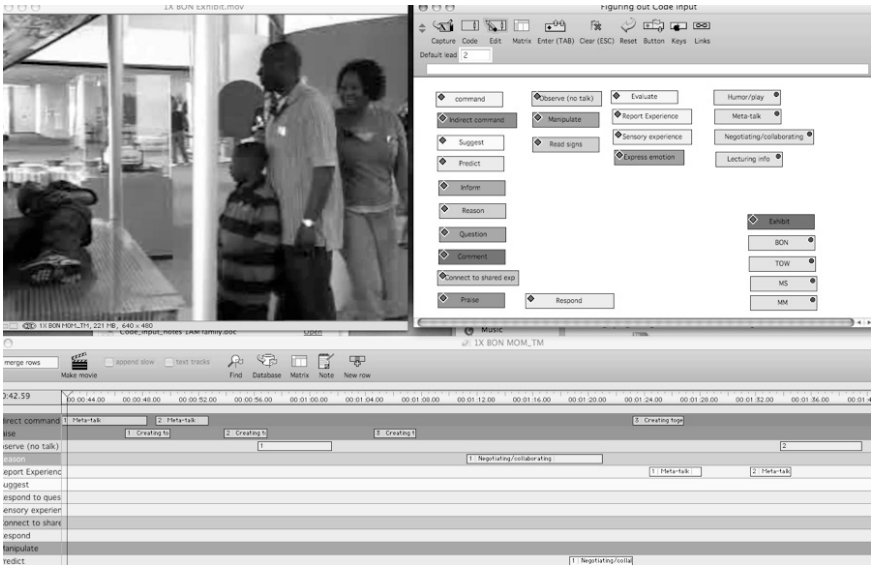

Figure 3.1. Studio Code Example

Such teaching behaviors as providing content knowledge and entertaining did not, however, fit well with how families interacted with exhibits as we had identified in Phase 1. These prior results indicated that families frequently designed their own experiences at exhibits, often co-opting the official curriculum. The participating families typically were not seasoned museum visitors; they had been invited to participate through their Title I school. They represented a full spectrum of urbanity, education, ethnicity, language, and experience.

We noticed that family members scaffolded each other's participation, often inventively creating alternative curricula for the exhibits. Such non-adherence to the official curriculum, as Kevin said at the beginning of this chapter, could be perceived as 'messing up.' Families often did speak about the particular science content and ideas intended for each exhibit, but not always in the ways intended by the museum (see Mai & Ash, chapter 6). We were struck by the disconnect between the museum educators' goal of wanting to teach specific content and the

families' goal of wanting to create their own learning experience. Prior to professional development, museum educators often struggled, unsuccessfully, to impose and re-impose the museum's agenda, failing to recognize the family's ability to use an exhibit for its own learning experience.

Once we recognized the nuanced and subtle ways that families re-designed the exhibit designer's content goals, we felt it imperative to design ways for museum educators to recognize when and how this occurred. Phase 1 and 2 results required us to design a practical way to translate our new-found knowledge of how families morph exhibit experiences into a trustworthy set of PD protocols supportive of close scrutiny of learning by the MER's. We did this by carefully selecting *digital video scaffolding scenes*, which we then presented as the raw material for guided reflective practice in tandem with discussions of the four tensions. In short, we needed to guide the museum educator to "notice" what we had just spent two years discovering through data analysis.

Insights we learned from Phase 3 implementation were fed into Phase 4, the professional development for future museum educator researchers (MERs). We invited a new group of sixteen museum educators to take part in reflective practice, using the four tensions as underpinning, and offering carefully selected scaffolding scenes. The new MERS then participated in reflective "noticing" for themselves of how families actually "figured out" how to "do" exhibits. Kevin was one of this first group of 16 MERs.

Evolution of the Components of the Professional Development Program

To develop our professional development program, we turned to recent teacher development programs centered on reflective practice. The collected research of Sherin and van Es (2002) was particularly useful given its focus on pre-service teacher professional development through analysis of digital video and reflective prompts. Such research suggests that when teachers pay close attention to what learners do and say, they become more discerning and aware of the nuances of teaching. We view "noticing" as partial diagnosis and partial 'tuning' of the involved educator to the families' roles, hierarchy, content, and issues of acculturation (language, for example). The elements of the PD model (which we have termed the REFLECTS Model) are illustrated in Figure 3.2.

Over the 40 weeks of professional development, the work of "noticing" generally focused on three data sources: actual activity on the museum floor, digital video scaffolding scenes, and real-world activity outside the museum. MERS first learned how to take ethnographic notes on the museum floor and at home, simply recording events without interpreting them. They began to understand early on, after comparing notes on their observations, that they did not see the same things and that each missed certain details and nuances that others had noticed. They worked in four groups of four to tackle the detailed pieces of close observation, taking notes, and then negotiating meaning during both small and large group discussions [see Appendix A for the schedule of 40 training sessions (TS) weeks].

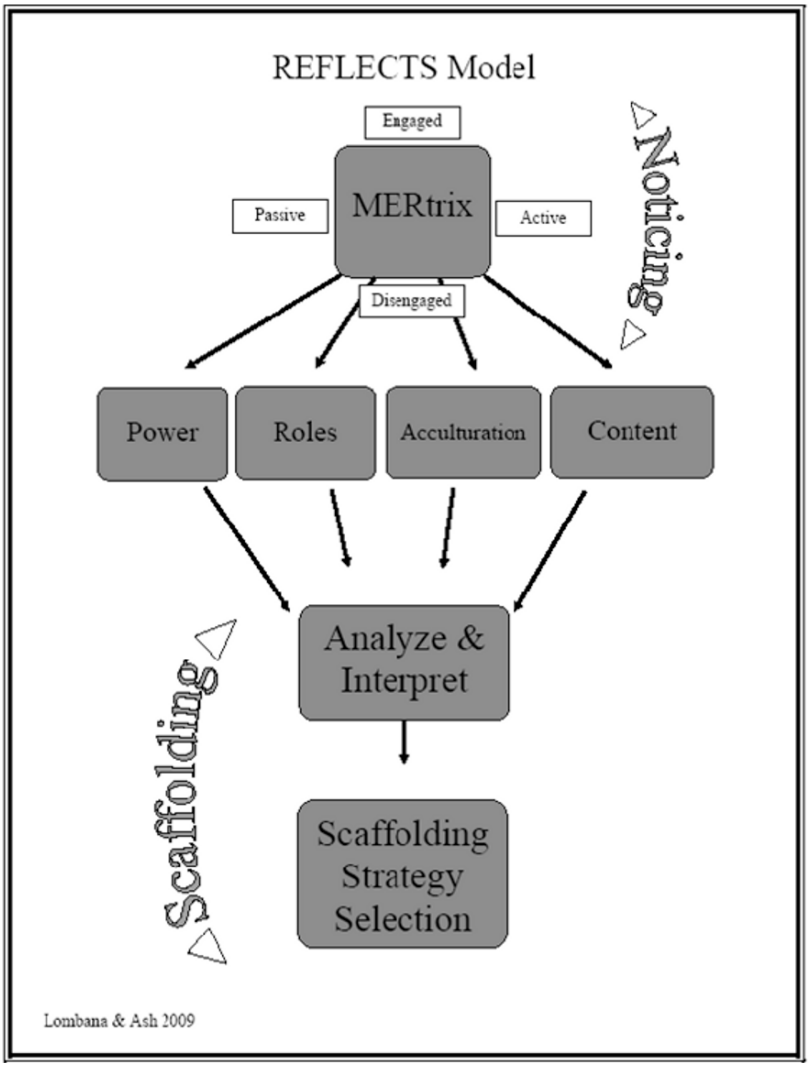

Figure 3.2. The REFLECTS Model

Professional Development Session (TS) Details

Each week, MERs worked for 6-7 hours, meeting with a trainer/mentor and sometimes with university researchers. They viewed videos, wrote written reflections, conducted interviews with families and with each other, and worked in small and large groups to discuss outcomes. The MERs selected for the professional development program had a wide range of experience levels, ages (17 to retired), demographics, and cultural representation. Criteria for selection included previous experience in informal or formal education and/or educational studies, ability to write well, experience in public speaking and/or theatre experience and a commitment to continue with the project for its full two-year duration. Candidates were also judged on being adaptable and motivated to participate as a team in a fast-paced research environment. As noted already, two types of candidates were selected for participation in the project: some who had already been working as educators at the museum and others who were new to this setting. All MER positions in this study were paid part time.

Professional development began with a semi-structured interview with each MER as a baseline measure. Then each MER was videotaped mediating one Title I family at two of the four selected exhibits, again as a baseline data point for later analysis of the MER's own practice. MER-mediated family activities were also followed by a post interview with the MERS and a survey for the parents. The early interviews queried MERs' assumptions about their role as educators in a museum setting. Early professional development sessions, as well as the semi-structured interviews, focused on the following ideas: qualities and perspectives that MERs bring when interacting with visitors; the exhibits and how families' prior knowledge is useful; reflections on each MER's personal own style of interaction and past experiences in education (see Appendix A for a complete taxonomy of the training sessions [TSs]).

Every MER-mediated family interaction (before, during and after professional development) and every MER training session (TS) was video-recorded with two cameras onto a MiniDV, transferred to backup hard drives, and translated to quick time and mpeg formats as needed for transcription and analysis. Such TS data capture allowed both MERs and university researchers to revisit discussions, reflect on practice and to change direction where necessary. This data review specifically enabled the university researchers to change the design of the professional development model and its direction, giving more or less time, as well as providing data for more in-depth analysis of MER transformation. The MER-family mediated interaction tapes were used to:

– Allow MERs to become more comfortable with viewing and analyzing themselves on video.
– Record the level of expertise of the MER at the time.
– Allow for ongoing reflection upon practice, especially comparing before and after training video exemplars

– Provide data for the university researchers to better understand the MER trajectory of change

The professional development model incorporated the community of learners model and dialogic inquiry (Wells, 1999), which together involve overlapping participant structure (small group, large group, web-based communication, etc.), MER research into their own practice, abundant dialogic interchanges between participants, and strong design principles. Beyond the professional development sessions, MERs communicated via Webex or regular email; they wrote weekly prompted reflections on their work; they coded their own data; and they worked collectively to understand the data they were seeing. Table 3.2 includes a sample reflective activity based on scaffolding scenes and the context of the day.

Table 3.2. Outline of a Professional Development Session

Session Topics:
Noticing Scaffolding in Family Dynamics
Responding and Stepping into the Space: Developing Strategies
9:30am-10:30am – Group Discussion
Last Week's Session review of scaffolding theory
Research Paper "Understanding Scaffolding and the ZPD in Educational Research" by Irina Verenikina
Jrene Rahm Scaffolding Example / Shawn Rowe Scaffolding Examples
10:30-11:00am - Complete Activity [20.1]
"Writing a Response to a Video Segment" (see below)
10:30-12:30pm – Break into four groups and work on Activity 20.2
Exercise on Noticing: Scaffolding Practices
12:30pm – 1:30pm –Lunch
1:30-2:30 – Break into groups A & B and Complete Activity 20.3
"Using Science Process Objectives to Enrich Your Interactions"
2:30-3:30 – Group Discussion / Experimentation
Responding / Stepping into Space
Role Play
Creating and Testing Strategies
3:30-4:00 – Wrap Up

Writing a Response to a Video Segment
Complete the following activity after you have viewed the video segment:
– When the scene has stopped, write your individual impression on [name of scaffolding scene or segment].
– Next, get into a small group (4) and review each person's impressions (approximately 15 min).
– After discussing, write if and how your impression has changed as a result of the discussion. Include why did it change and did your group reach consensus? Do you know why your views may have changed, if they did? Discuss as large group.

Findings from Phase 4

We found that the mixture of short *digital video scaffolding scenes* created a rich platform for deep discussion and reflection for university researchers, MERs and other museum professionals. MERs also relied upon written transcripts of scaffolding scenes to test their ideas and to see more detail. Over time we saw the following changes:

– MERs developed an ever more nuanced ability to observe salient features of learners' activities along with more nuanced reflection skills.
– MERs increasingly saw themselves as researchers, continually negotiating their roles with each other and the families. They reframed their own roles as educators, becoming more collaborative and deliberately less 'powerful' with learners.
– MERs gained increasing reflective-practice sophistication while developing an "improvable object" (Wells, 1999), a new tool—the MERtrix—for analyzing and describing family dynamics, as reflected on continua representing the four tensions.

Major Outcomes

Using scaffolding scenes and the noticing curriculum involved a fundamental shift from prescribed science content toward 'noticing' what families actually do. MERs have come to value explicit professional development opportunities in "noticing," often saying how much it has changed the way they do their work. Alex said:

> Sometimes it's hard to think on the spot what to do and later when you ruminate over the interaction you see it differently every time; with a video you're not adding in any weird details or thinking you missed something, it's all right there. You are free to reflect and go back and watch specific segments over and over again and you notice more and more every time.

Mandy said:

> I've never had a chance to look at interactions in such a way. I'm able to observe behaviors that will alter my way of interacting with families and with exhibits.

These comments reflect the increasing importance MERs now place on discerning observation, keeping inferences out of their initial observations, as well as the value of the process. They have become more nuanced. As Sandy said:

> Family noticing involves a lot more than the traditional methods. It allows us to identify specific traits and cues, which lead to individualized strategies. This takes into account our own styles and how they match up with the families.

They identified as researchers:

I feel more bound to the body of research and more personally responsible for failures and successes.

I see my role much more as a researcher. Professional development on reflection has made a huge difference.

I see myself as a research tool.

They developed and used new teaching tools:

The MERtrix tool provides a fairly objective way to measure where someone is as they interact. It should allow us to see how someone moves on the graph over time to see if scaffolding techniques have an effect.

I think that the MERtrix tool could be used to identify people that both would benefit from scaffolding and would be receptive to it. Furthermore it can help us fine-tune the actual scaffolding experience and adjust it to individuals and families, all so they can get the most from their museum visit.

In addition, MERs dialogically negotiated their role as researchers. The section below from TS 7 exemplifies MERs' beginning interrogation of the research process as well as their self-reflections in terms of their role as researchers. The MERs had just watched a pre-MER trained, museum educator-mediated scaffolding scene at the "Bed of Nails" exhibit. Many MERs had voiced their view that the museum educator controlled and led the family's activity (e.g., by directing family's attention) and critiqued her tone as condescending and problematic (e.g., by "talking down" to the mother and daughter). "Caroline" started a discussion about doing research:

[start 32:55]

Caroline: I have a general question about how when this is all happening [activity at the exhibit] in the moment and they're (untrained museum educators) not really thinking about all this the way that we (MERs) are, so I wonder if sometimes we over-analyze their actions and put too much weight on their (museum educator) intent.

[1 turn]

--because especially when we talk about…the MER taking over power (Power is one of the four tensions) as a one-man show… this might not be what is going through her head because here, we're sitting here with our purpose of interpreting the video, ...I don't know when we over-interpret because we almost give it a malicious intent when we talk about it… because it's all happening so quickly that I don't think they're analyzing the situation the way we are.

Facilitator: There are museum educators who never go through these noticing (professional development) where these dialogues (like the one the group is having now) never, never happen. … It's what I said earlier, it's not about intent, but about issues of power.

Caroline: No, I understand that it's about issues of power, but sometimes I think we give them intent (pre MER training museum educators) that may not have been—because …we're talking about her taking all the power and controlling everything and asserting her power, but in her head, maybe she was just teaching, but it wasn't her intent to have the one-man show and in her mind, "the camera's on me and I have to" –

Ken: But her idea of teaching might be that "I'm the one in power and I'm going to teach you" and there's no other way around it.

...this is how we're trained (in the past) as museum educators, that's how we give the show, that's what we're trained to look for. …She [MER on video] didn't get this (reflective) training.

[4 turns]

Terriann: I think at the very beginning I was taken aback by how much detail we go into and I always thought that maybe we are doing analysis too deep but then I keep going back to the—that's kind of our role and that's why it's so important that we keep it locked up in secret because what we eventually want to do is take that training that the other museum educators have, which is what it is right now, and change it. Ok that's what we did before but now be conscious of your own power.

Such dialogue, sometimes quite heated, indexes moments in which MERs grappled with their power position as producers of knowledge and indicates a shift in their identity from teacher with power to negotiator who listens.

Finally, MERs have gained increasing sophistication in analysis and were able to identify workable principles and strategies for noticing over time, even designing several new tools to help them diagnose where each learner (and an entire group) is positioned at a given moment in the zone of proximal development. One of the most useful tools was the MERtrix. The MERtrix (see Figure 3.3) grew out of the need to understand where learners' collective and individual activities placed them in relation to possible scaffolding. The MERtrix was developed from a need to quickly 'see' where individuals and families appeared in relation to the four tension attributes, such as role in activity, interest in content, or use of power and acculturation. Through a rigorous iterative process using over 250 observations, the MERtrix grew out of the measurement of specific Social Activity

and Engagement behavioral cues that family members illustrate (see Table 3.3, MERtrix Cues).

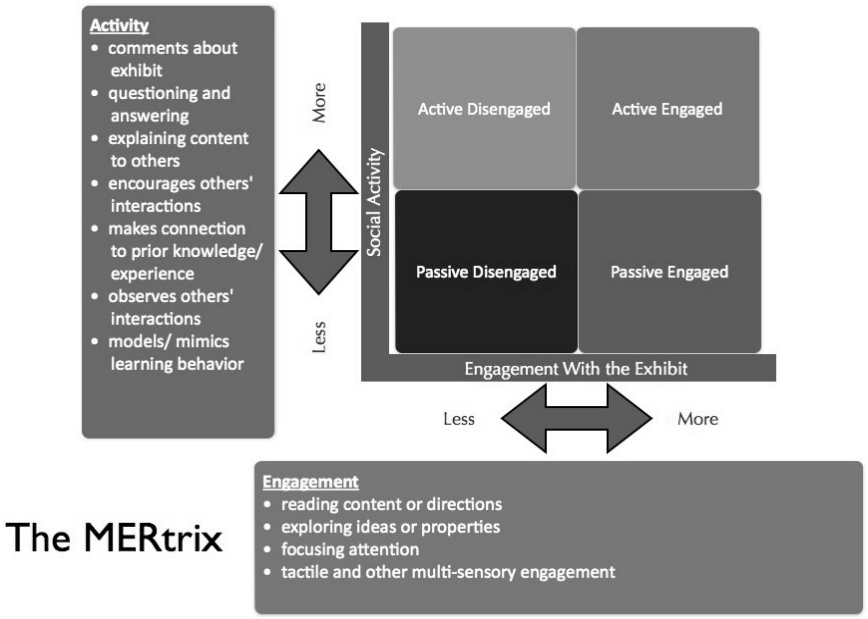

Figure 3.3. The MERtrix

The MERtrix condenses social behaviors along the vertical Active and Passive axis and the horizontal Engaged and Disengaged axis The MERtrix cues of Engagement with the Exhibits, which are assessed horizontally and the Social Activity cues that are assessed vertically together allow MERs to quickly diagnose the readiness of any family or individual for potential further scaffolding along a number of planes. Like all action in the ZPD, once the initial target has been reached new goals need to be formulated. This moving target approach characterizes 'working in the ZPD' using a variety of mediational means.

Through collective negotiations, groups of educators were able to see the cues and MERtrix both as a tool and as a method for honing noticing skills, for research and for setting the stage for responding by scaffolding. Designing a new tool requires measurable criteria (Table 3.3, Cues) as a way to represent these so others can understand (translation). As the MERtrix evolved, it became well understood after multiple observations and MERtrix form and function revisions and iterations, that the presence or absence of cues was the strongest indicator of MERtrix placement. As they worked to identify the relevant cues, they had to examine many different activity segments. There also needed to be a process for revising

when data did not match predictions (research). The MERtrix encapsulates the major gains made by these museum educators.

Table 3.3. MERtrix Cues

Name:
Date:

CUES	
Conversation / Facilitation (Social Activity)	
1) Makes Comments about Exhibit	
2) Questions & Answering	
3) Explaining of Content for Others	
4) Encouraging Others' Interaction	
5) Makes Connections to Prior Knowledge / Experience	
6) Observes Others' Interaction	
7) Models / Mimics Learning Behavior	
Exploration / Investigation of Content (Engagement)	
1) Reading Content or Directions	
2) Exploring Ideas & Properties	
3) Focusing Attention	
4) Tactile and other Multi-Sensory Engagement	

Once proficient in its use, museum educators *internalized* the cues and the quadrants, quickly characterizing individual family members (or group) interactions before making informed choices about how they might wish to interact, which person to select, and the overall goal of the interaction. The cues and quadrants help define family engagement sufficiently to initiate a response. During the development of the MERtrix the use of video and the process of revisiting the session allowed the researchers to discover that early discrepancies in MERtrix results were being caused by fatigue and by lack of expertise in its use, which over time could be managed. This iterative process of data analysis and revision as well as development of expertise typified the research overall.

The cues and MERtrix representations, designed to help explain and negotiate their ideas, gave the MERs something tangible to get their hands on, using real data. Wells (1999) would call the MERtrix an "improvable object" a real or symbolic object, like a conversation or a graph, a text or a boat, so a thing that is collectively improved upon during collective and progressive negotiation. In this particular community of practice the design of the MERtrix was such an object. The museums educators have used it to test, examine, and prove their ideas, thoughts, and observations, testing it often to see if it holds up. It has been revised many times.

The MERs are also a perfect example of a community of practice whose members mutually engage in activity (tackling the daunting task of how to put the four tensions into a codified activity), as a joint enterprise (designing, improving,

revising and using the cues and MERtrix), leading to a shared repertoire (learning how to notice in order to respond by using the new tools).

The MERtrix is interesting for both practical and theoretical reasons. First, it was a methodological tool created by MERs to help explain, represent, and codify observations. Second, it is also a practical exportable device, which can be used by other museum educators and institutions. We have proved its usefulness. The second level of importance is that the practices and products of the unique method we have used, such as reflective practice based on scaffolding, have formed a community of practice made up of museum educators that are deeply engaged in designing, refining, testing and creating an improvable object. We know that learners can make great progress when they take their learning into their own hands, are highly motivated to change the status quo, and are fired with a feeling of belonging to a research community. By creating the cues and MERtrix representations, these MERs have co-designed their own curriculum. This latter inquiry activity is very important in and of itself, even if the MERtrix would have never proven successful.

Becoming adept at "noticing" sets the stage for a MER's decision on how and when to actually engage with a family. After noticing and diagnosing what families do using the MERtrix, museum educators have now begun the next piece of their work, incorporating the family agenda(s)/agency into that of the museum. This aspect of the research and the professional development, called "responding" will be discussed in subsequent papers.

DISCUSSION

We have focused in this chapter on theoretically informed methods for informal learning settings. The goal is to create a new model for museum educator professional development, specifically using teacher reflective research (video-based models developed over the past decade to explore ways in which flexible scaffolding might become the norm for teaching in informal settings). We wish to re-envision what we mean by teaching in museums by asking the question: How can we help educators in informal learning settings such as museums, zoos, aquariums, gardens, and field trips know how and when to scaffold the social activity of groups and individuals during their activities in these informal settings? Our analyses suggest that the outcomes of museum educator reflective research on their own practice include:

- an increased ability to pay attention to learners' activities;
- an increased sense of self efficacy as researchers;
- an increased sense of empowerment and agency;
- an increased sensitivity to the resources learners bring with them to the museum;
- an increased desire to enter into dialogue with family members at museums.

Such transformations, we believe, allow museum educators to become change agents in their own museums (see Ash et al., in review). The noted transformations

in the trained MERs were based, in part, on a set of methodological advances made during the first four phases of this research project. The first advance was the construct of the scaffolding scene, collective activity segments meant to convey collaborative negotiation by families (both with and without MERs). We used these scaffolding scenes as a major piece of our detailed analysis of how families negotiate meaning (Mai & Ash, chapter 6) and how MERs scaffold families, but also, as highlighted here, these scenes became the major teaching tools for MERs. This flexible multi-purpose construct lends great promise to the field as a potential ready-made teaching tool for those who want to understand what typical family activity looks like, but who also want a firm theoretical backing for selecting such segments. These scaffolding scenes are grounded in scaffolding and activity theory, as well as in Vygotsky's notion of "working in the ZPD." Such an all-purpose method could prove quite valuable. The idea that university researchers and museum educator researchers can use one and the same unit of analysis in their work is quite powerful, reflecting the basic premise of communities of practice, which are made of members who share and transform practices as well as themselves. This interplay between research and practice is part of each of the major methodological advances.

A second methodological tool was the "noticing" curriculum itself, which, in turn, was partially based on watching and reflecting upon scaffolding scenes. The noticing curriculum also applied the four tensions (as well as findings from Phases 1 and 2), as the basis for observing specific behavioral cues. These tensions are theoretical constructs, which emerged directly from the practices we had observed in action. Noticing protocols are now being refined in order to identify crucial aspects of family dynamics, including existing roles, issues of power, types of dialogue, who initiates it, verbal and non-verbal cues, and issues of culture. It is clear that the kind and amount of scaffolding must emanate from the 'noticing.'

A third key component of the method that emerged was the community of practice created and maintained by the museum educators, university researchers, museum researchers, as well as their shared practices, language and products. Such a community of practice is similar to that described by Kisiel (chapter 4) within which experts from different arenas can share ideas, language and practices in safety and dialogue. Such contexts place more of the responsibility for change on the educators involved and less on the leaders. Such a system of shared responsibility puts into practice a community of practice ideals.

With shared ownership and responsibility, MERs also were able to design improvable objects (teaching tools) for themselves, as well as for others in their field. Participation in this community accounted, in part, for the changing identity of the MERs, as the community itself changed. In such communities, we speak of the members and the community as mutually constituted. In other words, "noticing" and scaffolding activities and changing relationships have the potential to not only change one's way of teaching but also one's way of being in a community. The TSs provided the context for putting these methodological advances into practice, while listening, speaking, and testing ideas with one another.

A fourth theoretically informed advance in methods was the creation of the teaching tools themselves, in this case the MERtrix and cues table, improvable objects that were defined and revised by continuous negotiation. Museum educators in a variety of settings can use such teaching tools. We are currently planning ways to disseminate this reflective practice professional development model, incorporating these tools.

We see museum educators as researchers, helping us to define and use "noticing" for decision-making as they enhance their own practice. Such a model for professional development puts the emphasis on what people are actually doing in museums rather than strictly following a museum's pre-scripted agenda. The implications for equity are obvious—such an intervention gives voice not only to staff in museums but also to its visitors.

APPENDIX: AN OVERVIEW OF THE PROFESSIONAL DEVELOPMENT SESSIONS

Professional Development Activities

Sessions: T2-T4, Introductions
Practice in ethnographic note taking, museum floor and home
Discussion of same

Introduction to Noticing: How to Best Observe Family Dynamics
Sessions: T5-T10
After viewing and reflecting on their own experiences (video), MER's tackled the concept of "noticing" (van Es & Sherin 2002). "Noticing" is essential to what a MER does, and it is one of the foundations of what good interactive practices should be. "Noticing" provides a starting point for a scaffolding moment. How do you engage a group? Why? Should there be a goal? How can the MER use the noticing along with his or her style to create a teachable scaffolding moment? Or not?

MER Style of Interaction
Session: T11
As a continuation of exploring the reflective process, MERs took a close look at their own individual styles. As a basis for this exploration, we invited guest presenter to lead the MER team on self-reflection by using the DiSC model to aid in identifying personal styles. We then took this information and used it as a tool for discussion on how MERs might 'intuitively' respond to a family at an exhibit compared to how one might respond based on the principle of noticing family behaviors before engagement.

MER Building of a Noticing Tool (MERtrix)
Sessions: T12-T19
As MERs reviewed data through video segments on mediated and unmediated families, MERs identified a set of cues that occur in every interaction. These cues

were consistent and the possibility of measuring them became apparent. The identification of cues allowed for structured conversations and exercises. This led to the idea of creating a "noticing" tool to gauge the frequency and intensity of those cues that were being observed. Moreover, it allowed the MERs to have a common language for discussion/interpretation and create strategies of how to best engage the visitor.

MERs had to create, develop, refine and implement the MERtrix with the goal of making the tool reliable and teachable to other museum educators. During T19, Dr. Doris Ash visited the Science Museum and the MER team and presented a Powerpoint on scaffolding. This presentation led to in-depth discussions about the definition of scaffolding and what constitutes a scaffolding moment within the family.

Exploring Scaffolding
Sessions: T19-T24
MERs explored scaffolding strategies and techniques that have come out of discussion and data evaluation. MERs became much more cautious as to how to enter the visitor's space and how to engage in order to maximize the learning experience of the visitor. These sessions required a lot of evaluation and self-reflection.

Responding and Stepping into the Space (Building Strategies)
Sessions: T20-T24
During sessions T20-24 MERs began to compare and contrast their research against other educational theories and research by noted professionals. One such example of this is the paper "Understanding Scaffolding and the ZPD in Educational Research" (Verenikina, 2003). They also reviewed the Jrene Rahm/ Shawn Rowe examples, members of the Advisory Board who had previously offered examples of scaffolding. These papers served as a springboard for using the devised MERtrix tool in noticing scaffolding in family dynamics and developing entering strategies to respond to these behaviors.

They focused on using science process objectives to enrich their interactions. Some examples are: Categorizing, collaborating, communicating, comparing, counting, describing, generalizing, recording, and relating to prior/and or current experience and using tools. This led to the creation of a list of top strategies that could be used to enter family interactions based on the observable cues that were present using the MERtrix tool. These strategies were then tested on the museum floor with families and were eventually streamlined to the ten "super" strategies.

Guest Acculturation and Customization of the Experience
Sessions: T25-T26
The concepts of guest acculturation and customization of the experience evolved

through group discussions with the goal of offering a MER the opportunity to view the visitor experience through the point of view of the visitor.

Combining Strategies and Tensions with the Reflective Process
Sessions: T27-T29
The combining of strategies and tensions with the reflective process showed that the style, content and "noticing" of the MER needed to be customized to the needs, behaviors, and agenda of the family to maximize the experience of the visitor and, thus, reach optimum scaffolding.

From these discussions, a new thought on power began to emerge. The MER team began the conceptualization of "construction zones" or "zones of power" inspired by Vygotskian notions of the ZPD.

Field Research and Noticing (MERtrix) Testing and Refinement
Sessions: T30-T36
Our MER team had the unique opportunity to apply developed observational and scaffolding strategies to families in the travelling exhibit: "Bodyworlds III:" The Story of the Heart during its final weekend at the museum. This opportunity gave MERs the chance to evaluate their tools in an environment that was less hands-on than the traditional environment created for families at the museum, which is primary hands-on and exercises the constructionist model of learning.

Addressing the Four Tensions and Designing Entering Strategies: The REFLECTS Model
Sessions: T36-T40
MERs re-evaluated the four tensions of interactions that were identified early on in the research project during T3. When looking at the tensions and their definitions it became apparent that the MERtrix tool gave us clear indications on a family member's power, role, level of acculturation and grasp of content. By including this discovery into our process of family observations and entering strategies, the MERs created the REFLECTS (Reflective Educational Formulas for Lasting Encounters in Collaborative Teaching by Scaffolding) model.

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NOTES

[i] Our criteria allowed analysts to disagree *within 2 to 4 lines* of the transcript. We had three pairs of analysts who practiced on one family visit, discussed disagreements, and then established reliability with two different family visits. Inter-rater reliability of scaffolding scenes selection was 80%. See Mai & Ash, chapter 6, for the extended description, coding protocol and examples.

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AFFILIATIONS

Doris B. Ash
Department of Education
University of California Santa Cruz, CA
dash5@ucsc.edu

Judith Lombana
Museum of Science and Industry, Tampa, FL
judithL@mosi.org

LEAH MELBER

PUTTING THEORY INTO PRACTICE

ASH AND LOMBANA'S METHODOLOGIES FOR REFLECTIVE PRACTICE AND MUSEUM EDUCATOR RESEARCH

Ash and Lombana's contribution to this work addresses the impact key research methodologies and methods can have on professional growth among informal educators. Providing front line educators the opportunity to actively engage in video and transcript review, empowering them to do the actual analysis, allows young professionals to take charge of their career growth and immediately see the impact change in their performance can have on visitors.

I remember very early in my career when professional development as outlined by Ash and Lombana would have made a significant difference in my practice. Serving as a floor educator in a children's discovery center, I was convinced that the scientific specimens I was so excited to touch and explore were equally captivating to the center's young visitors. I was especially fascinated by the slick feel of a sea lion pelt and decided to make that the object I used to greet our visitors. And while some visitors were equally fascinated and eager to touch, others had a different agenda for exploring the space. Yes, I think there were instances when my enthusiasm might have actively driven them from the space, though I'd prefer not to remember it quite that way. Imagine how the opportunity to watch video of my over-enthusiastic interactions and engage in non-threatening and rich discussions with peers might have altered my instructional approach.

I did, as we all do, eventually learn through traditional avenues of professional development to better read visitors and support them in exploring their own agendas. Much of this growth did come from the critical self-reflection and action research that is naturally part of a doctoral program. Conducting evaluations of my own programs, being open to information gained and changing my practice accordingly was a part of this. In reading Ash and Lombana's work however, one can't help but consider if some of these lessons might have been learned exponentially more quickly through early exposure to structured and institutionally supported self-reflection such as this described model. How much more effective might video review or transcript analysis be to encourage personal change over likert scale rankings on a program post-survey?

We often say a picture is worth a thousand words. Visual exposure to our own practice can make a significant impact. Creating opportunities for front-line educators to immerse themselves in video analysis, engaging in a form of visitor studies research as it relates to their own instructional methods, parallels the very learner-centered model they are learning to embody in order to best meet the varying agendas of visitors. This empower model of professional development is

D. Ash et al. (eds.), Putting Theory into Practice, 53–54.

aligned with what we know to be best practices in professional development of formal educators. Ash and Lombana's work demonstrates how this theoretical approach is equally applicable to building professional competency among informal educators and clearly outlines the methodologies and methods through which success can be achieved.

DISCUSSION QUESTIONS:

1. How might you consider using video analysis with your peers or team members?
2. Can you think of a time early in your career where this type of self-reflection model would have been especially helpful or informative?
3. What would be some critical considerations in using this methodology to ensure it is a positive experience for team members and visitors alike?

JAMES KISIEL

4. REFRAMING COLLABORATIONS WITH INFORMAL SCIENCE INSTITUTIONS

The Importance of Communities of Practice

INTRODUCTION

Understanding how people learn science demands consideration of a variety of factors such as interests, opportunities, and interactions that potentially influence learning across the lifespan and throughout multiple contexts (see also Anderson chapter 2). Facilitating such a process, through different settings and different situations, is not really the sole responsibility of an individual or single organization; rather, it likely involves a conglomeration of entities affording connections across and between ideas and interests, past and present (see also Rahm, chapter 7). In some cases, collaborations span several organizations that explicitly support such learning activities across different environments (see Ash & Lombana, chapter 3), including both formal and informal learning environments. In these cases, it becomes critical to understand how (and even whether) different institutions can actually work together to achieve a shared goal of science teaching and learning.

This chapter seeks to highlight the importance of examining the entire learning infrastructure when considering the success of a new educational program or reform effort, in particular those involving informal learning institutions. Such analyses can provide insights that improve our practice, both as science educators and researchers, and inform decision-making aimed at improving science learning, regardless of setting. For the purposes of this chapter, I will focus specifically on collaboration between a school and an informal science institution. Although more information on this particular collaboration and the research findings will be discussed later, it is important to recognize that this is not the only type of collaboration that might exist, nor the only type that needs be studied.

To introduce some of the tensions involved in such collaborations, I first offer a short vignette that might exemplify the perspectives of an informal science educator who is part of a collaboration with a local school district.

Vignette 4.1

It's 7:20 on a Monday morning. Joe, a museum outreach instructor, enters the empty museum to pick up equipment and materials for today's outreach programs. According to the schedule, the first session, for 29 first graders, is set for 9am. Joe remembers that he got a little lost getting to the site last year,

D. Ash et al. (eds.), Putting Theory into Practice, 55–75.

> so wanted to be sure to leave early enough to set up and go over the lesson. As he inspects the kit of materials containing a few animal skulls, some pelt samples, and picture cards with animals and habitats, he notices that the last instructor to use the kit forgot to replace the student and teacher handouts needed for the program. He restocks the copies, checks his whiteboard for messages (discovering a 2pm meeting for the development of a new program for homeschooled kids), and heads to today's school. As he drives, he reflects on his last visit to the school, remembering how well the teacher had prepared the students for the session. Her students' excitement and familiarity with concepts like *habitat* and *ecosystem* made it much easier for him to get these messages of conservation across to the students. But this kind of preparation seemed rare in his experience. Why couldn't other teachers be as on-the-ball as this one?

This brief depiction provides some insight into the issues inherent in working across institutions involved in science education. We see how instructional goals and expectations may differ, and how communication is a critical, if overlooked, component of these interactions. Joe hopes the teacher and students are really ready for his visit, but he remains unsure. The classroom teacher probably hopes that Joe is a reasonably good teacher who can "handle" her kids. Joe wants to be able to help students understand science concepts that he feels are very important; the teacher may share this goal, but also needs to be very aware of state and federal mandates and testing in other subject areas such as reading and mathematics.

In the sections below I examine some of these tensions at several levels of analysis, starting with a presumption about the importance of collaboration in science education reform—something both Joe and the teacher are likely to have some interest in—and the need to study such interactions. I then explain how a *community of practice lens* may provide a useful way to determine whether implementations of collaboration have indeed been successful. Methodological approaches and concerns for obtaining the data needed to define and understand communities of practice are addressed. The final portion of the chapter uses a particular case of a school-aquarium partnership as a way to further illustrate the theory and methods described.

COLLABORATIONS TO IMPROVE SCIENCE LEARNING

The present push for improving national competitiveness in science and fixing the leaky science career pipeline has led many funding agencies to encourage schools and universities to find new and innovative ways to address these concerns and improve student success and interest in science. One often-touted way to do this is through collaborations with community institutions that have similar educational interests. Science museums, aquariums, and other informal science institutions (ISIs) are a logical choice for such partnerships. The National Science Education Standards (NRC, 1996), as well as the National Science Teacher's Association, point to ISIs as potentially important resources that can support instruction and

draw students into science. The National Science Foundation, in its efforts to promote change, strongly encourages multi-institutional partnerships in many of its calls for proposals. The Institute of Museum and Library Services (IMLS) has noted the need to "build a fabric of social agencies that facilitates lifelong learning among learners of all ages and circumstances. This fabric should weave together all institutions … including schools, libraries and museums—into a seamless learning infrastructure" (2005, p. 7). Such views echo John Dewey's ideas from nearly a century ago of an ideal school that weaves together classrooms, museums, libraries and the outside world to create an effective learning experience (Hein, 2005).

Yet what would such a collaboration look like? How might the mission of a natural history museum or the perspectives and expertise of museum educators contribute to student science learning and help address broader issues such as the science pipeline? Such collaborations need to be conducted with mutual trust, open communication and shared goals. Yet these qualities are not automatic. Creating and fostering the seamless learning infrastructure recommended by numerous agencies and by Dewey is no small task. It's not enough to say "Let's partner!" without considering the potential challenges associated with developing new relationships. Too often success is defined singularly in terms of student outcomes: improved understanding, higher test scores, increased enrolment in science classes, or even increased interest. Yet before we can look at how such a collaboration impacts individual learning, we must develop a better understanding of the forces that shape these collaborations and the learning experiences they purport to provide. Such an approach requires us to establish a different framework and new priorities for examining and assessing the success of such efforts. Throughout this volume, the authors provide a variety of unique perspectives and methods for studying learning in out-of-school settings. In this chapter, I explore how one might examine the big picture or overall context of the collaborating institutions in an effort to better define some of the mess of variables that ultimately influence learning.

Research and real world experience tell us that institutional collaborations and partnerships are challenging and require nurturing for their success, regardless of how bright such prospects may look on paper. The very nature of collaboration, however, requires us to consider how the cultures of two (or more) institutions (such as the museum where Joe works and the local school he is visiting) might facilitate or interfere with the desired goals. In a sense, we must consider learning at two levels—the outcome level, where we look at the desired changes for the learners, and the implementation level, where we examine how institutional members learn to interact with different organizational cultures and ultimately develop a sustainable collaboration. To study only student outcomes, in the instance of a school reform partnership, ignores the challenges faced by informal educators, scientists, teachers, administrators, students, and any other stakeholders. Such institutional variables have considerable impact on the life of the collaboration, which, of course, will impact learning outcomes! It becomes critical, therefore, to examine more closely the cultures, concerns, and day-to-day practice

that define each of these stakeholders, as the key to success may lie within the ability of these groups to effectively adjust to new interactions with other groups.

Throughout the chapter, I will use *collaboration* to refer to the interaction of institutions. The term *partnership* implies a specific kind of collaboration, one that involves a mutual exchange of services or benefits. Too often, it seems that arrangements described as *partnerships* are, in reality, one-sided. For example, a university that obtains a grant to support math teacher professional development at a local elementary school is unlikely to receive an equivalent benefit from the participating elementary school or teachers, although the university may benefit from the positive public relations that are generated. This is not to say that such an arrangement is bad, rather that it is somewhat lopsided. As such, *collaboration* would seem to be a more appropriate term for purposes of this discussion.

THEORETICAL FOUNDATIONS

In order to better understand the challenges inherent in collaborations such as those between formal (school) and informal (museum) learning institutions, it is useful to reframe the discussion from a sociocultural perspective as this allows for consideration of a complex system that relies on a variety of interactions among a variety of participants with different perspectives. Lave and Wenger (1991) describe a community of practice as a "set of relations among persons, activity, and world, over time and in relations with other tangential and overlapping communities of practice" (p 98). Lave (1991) further suggests that communities of practice are a form of socially organized activity where thinking, learning and knowing are shared and negotiated. Membership within a community of practice consists of more than having a shared knowledge of how things work within the group; participants share a common language and patterns of discourse as well as a common identity that is intertwined with their practice, their experiences, and their roles within the community (see also Ash & Lombana, chapter 3). The vignette described at the beginning of this chapter provided an example of a practice that might be shared by a team of museum educators—their goals, their actions, and even the objects they use together define a particular community of practice. As part of that particular "museum educator community," Joe takes part in common activities (such as collecting kits of materials and driving to schools), has similar perspectives (such as praise for teachers who prepare), and demonstrates a shared identity (distinguishing him as an informal educator, rather than a classroom teacher).

Wenger (1998) proposes that the coherence of a community of practice depends on three dimensions: mutual engagement, joint enterprise, and shared repertoire. *Mutual engagement* refers to the actions and interactions that community members share. The relationships among community members rely on both professional and social interactions as they engage in a particular enterprise. For instance, Joe and his fellow museum educators participate in similar activities (teaching programs for school groups, driving to school sites), interact with similar visitors (elementary age students and their teachers), and follow particular administrative procedures

(rotating schedules, daily meetings). This is not to suggest that everything is done exactly the same way, but that members of the community share a common practice overall—it is this set of common tasks (i.e. preparing the outreach kits, checking the schedule, etc.) that creates coherence within the community. *Joint enterprise*, another characteristic of a community of practice, is the set of goals or requirements for the practice, as defined and negotiated, informally, by members of the community. While "teaching students" may be a large part of this joint enterprise, other components might include "brushing up on content knowledge" and "obtaining positive evaluations from teachers." Finally, *shared repertoire* refers to the resources that facilitate practice—tools, artifacts, definitions, discussions, and shared experiences, for example. The polo shirt with the museum logo, the kit of animal skulls, and the scripts or outlines used to guide a particular program are all part of this repertoire that the museum educators experience and share, day after day.

It is important to note that a coherent community of practice is neither intrinsically beneficial nor harmful. The dimensions of community outlined above may help members to make meaning of new situations, to develop new forms of mutual engagement, or to shift priorities within their joint enterprise; they may conversely restrict them from seeing beyond the experiences that define the practice. It is not surprising, then, that implementing change may be challenging, as it may require modification of the actions, interactions, goals and resources that define a community of practice.

Communities of practice are not isolated entities; they are defined, at least in part, by their relations with *other* communities and the rest of the world (Wenger, 1998). They may have similar enterprises (such as helping students understand the connections in an ecosystem) and use similar artifacts (such as reference materials or videos). Such interactions may be as simple as a single event, such as a one-on-one meeting between individuals from each community (e.g., a principal meeting with a museum administrator), or they may be more lasting, practice-based interactions, such as a task-force made up of several members from each community interacting over time. In the case of a task force, we may find the formation of what Wenger terms a *boundary practice*—a setting where mutual engagement occurs. Interactions between members of different communities of practice may lead to the development of new or hybrid communities (Ash, Brown, Kluger-Bell, & Hunter, 2009), with characteristics of its parent communities, but distinct dimensions of mutual engagement, joint enterprise and shared repertoire.

Regardless of the relationship between communities of practice, it is important to recognize that relationships of some sort already exist. These relations are defined by discontinuities, or boundaries, that define (usually implicitly) each community of practice. For example, a museum educator may work with many students from many schools, while a classroom teacher remains in a more bounded setting, working with the same group of students from one particular school. Connections are also defined by continuities, or peripheries, that serve as access points for interaction (Wenger, 1998). A museum open-house, where teachers are invited to see what sorts of programs the museum has to offer, or a teacher focus

group, where museum staff are able to get feedback on the development of new programs, would both be examples of peripheries, where ideas and perspectives from one community of practice can be introduced into another.

Revisiting the goal of supporting science learning, we may now reframe a successful collaboration between formal and informal learning institutions as the intersection or overlap of two communities of practice. While some institutional collaborations can involve the establishment of simpler interactions, like task forces or advisory groups, more ambitious collaboration efforts, such as those geared toward educational reform, are likely to take greater advantage of the combined resources or expertise that each institution brings to the table, and to require deeper interaction. A collaboration between a museum and school, for example, with the goal of improving science learning at the school, may require developing new curricula and repurposing the use of museum objects. Such modifications require much more than peripheral interaction between members of these two communities, as they involve fundamental changes within each community of practice. Wenger suggests that an overlap between communities of practice occurs *when two separate communities share aspects of a common practice but still retain distinct enterprises and distinct practices*. To create a sustainable collaboration, then, we must consider what factors might facilitate and sustain such overlap without significantly disrupting pre-existing practice.

The overlap or connection between communities of practice is facilitated through *boundary objects* and *brokers* (Wenger, 1998). Boundary objects are those things—documents, terms, and artifacts—that help organize interconnections between communities of practice. For instance, an overlap between natural history museum educators and a local aquarium might be facilitated by fossil specimens (a natural object) that both groups use as a centerpiece for the development of a new family program. Brokers are those people who facilitate connection by introducing aspects of one practice to another. In the example described here, a collections manager might be responsible for speaking with aquarium educators and bringing their questions and concerns back to museum staff. In this sense, she is providing each group with perspectives from the other community of practice. It would seem, then, that a successful collaboration would not only rely on clarifying the potential boundaries between these communities of practice, but would also depend on the introduction of appropriate boundary objects as well as the utilization of brokering to create fruitful connections.

Wenger's elegant ideas related to characteristics of and interactions between communities of practice provide a useful framework for studying collaborations between institutions in a more systematic and systemic way. This perspective allows researchers to more clearly define the different communities of practice and to identify those variables that may be facilitating or hindering interactions between two or more institutions that may participate in considerably different practices.

ACCESSING COMMUNITIES OF PRACTICE

If the goal of the research project is to define communities of practice and identify overlap (or potential overlap) that might signal successful collaboration, it will be necessary to gather data from participants or stakeholders *within* each community of practice. These community members will be able to provide a clearer picture of their daily routines and activities, as well as the mutual engagement, joint enterprise and shared repertoire that define their practice. This may be stating the obvious, but too often researchers do not think carefully about the potential challenges and inevitable politics of gaining access, as an external investigator. Gaining access, or "getting in," as Lofland and Lofland (1995) describe it, involves gaining acceptance or at least tolerance from those whom you wish to study. Without buy-in from participants, the data collected, if any is actually collected, is suspect and may simply amount to weeks of wasted time. And needless to say, this holds true regardless of whether the research involves naturalistic methods (e.g., interviews or observations) or more empirical ones (e.g., questionnaires).

Gaining access is critical in order to effectively describe the *emic* perspective—those experiences and ideas of the stakeholders, or those operating within a particular community of practice. Contrast this with the *etic* perspective, or the views and ideas of the researcher operating *outside* the community of practice (Gall, Borg & Gall, 1996). Both perspectives are critical for understanding communities of practice. Accessing the etic perspective is fairly simple, although this easy access may bias observations, a phenomenon addressed later in this chapter. Accessing the emic perspective, however, requires negotiation and time, if it is to be done successfully. Even then, unless the researcher becomes a member of the community of practice being studied, it is difficult to fully appreciate and document an emic perspective. Members of the community may eventually be asked to help validate such data, if necessary.

METHODOLOGIES: WORKING FROM THE OUTSIDE IN

Why would a teacher take busy time out of her schedule to answer questions? Why should the director of education programming for a science center complete a two-page survey? The most brilliant or intricate of projects may never leave the proposal page if the researcher is unable to convince those who hold the information—the various members of the community that is the subject of the study—that the research is important, relevant, and worth their time. Part of the challenge that a researcher (or evaluator) faces when trying to learn about a community or culture that he or she is not a part of, involves gaining buy-in. When planning entry into a study setting, such as a museum education department or an urban elementary school, consider the following steps:

– *Contact administrators.* Even before these different community members are contacted individually, their supervisors or other "higher ups" must be made aware of the research efforts. Although this is typically part of the requirements

of any research involving human subjects, and reflects the importance of ethics in social research, it bears repeating as it also has logistical implications. If a researcher can't convince a director of a museum of the importance of her project, data collection will not occur. Conversely, however, having a principal be 100% supportive of a research project does not mean that staff at the school will automatically be convinced as well.

– *Provide information.* Good communication is critical for gaining access. A description of the research study, with offers to meet or speak via phone, can help stakeholders understand what you are trying to do and whether the costs (or risks) of participating in the project are minimal (or are outweighed by the potential benefits). Multiple versions of the project may be necessary—one that provides a general overview of the research as well as specific needs for potential participants may be more useful than a theory-rich, jargon-filled description. For example, you might present a one-pager at a weekly meeting of science center docents explaining why you are conducting the research and what you would be asking them to do. A more detailed description may be needed for the docent coordinator or education director who will have a better sense of how the study might impact overall operations, but more importantly a better sense of how the investigation might ultimately support the institution's mission.
– *Defer to the participant.* Even if community members are willing to help a researcher or evaluator, interest may wane if helping gets too difficult. As already mentioned, the researcher must consider what is easiest for the participant and must essentially flex to meet the participant there. If the project involves gathering information from museum outreach instructors, whose schedule may vary from day to day, it may be necessary to consider scheduling an interview during the instructor's lunch break at the school where he is teaching on a particular day. This requires looking at multiple schedules and an extra layer of planning. Yet Lofland and Lofland (1995) speak of the importance of common courtesy as the researcher negotiates entry—such efforts will ultimately make it easier for the participants to say yes.

We must keep in mind that learning how best to connect with members of the community is essentially learning about this community of practice. If we seriously consider Wenger's (1998) ideas, we might even consider this process of gaining access as an immersive boundary encounter, whereby the researcher, representing yet another community of practice, is interacting with another. This is certainly a different boundary relationship compared to the overlap described above, however. Regardless of how the process is framed, such efforts at entering the study setting and soliciting feedback are essential. By making these efforts at getting in, the researcher has already begun to develop a better understanding of the mutual engagement that will be involved in working together with that community of practice.

As research efforts in informal learning continue to grow, it is not unusual to find studies being carried out by those employed by such learning institutions (e.g., graduate student working as an educator in a natural history museum, internal

evaluator at an aquarium, etc.). Although gathering institutional information while working within that setting may seem easy, the potential for bias and even political conflict is considerable. An outsider researcher avoids this to some degree, while facing the challenge of gaining access to participants, as described above. However, if a researcher has experiences or expertise that overlap with those of the community being studied, the challenges of gaining access may be softened. In the case study described in this chapter, the researcher had prior experiences both as a classroom teacher and as a museum educator. The fact that the researcher had participated in similar communities of practice not only allowed for a more balanced perspective, but it also seemed to help him enter these communities and gain the confidence of participants more easily. This unique outside/insider status is not always possible, but communicating such personal experiences or perspectives to prospective subjects may indeed help the external researcher obtain a more valid emic point of view.

CASE STUDY: CONNECTING AQUARIUM AND SCHOOL

To better understand how a community of practice lens might be used to learn about how sociocultural contexts of learning institutions influence the implementation and effectiveness of collaboration, I now apply these ideas to a particular case. Such a theoretical lens should allow us to define the practice that makes up each participating community (e.g., mutual engagement, joint enterprise, and shared repertoire) and then examine how this practice changes or how new practices are subsumed within each community as the collaboration evolves. It should also allow us to determine whether there is truly overlap between communities, or whether program efforts are marginalized due to the inertia of current practice or the active dissuasion of overlapping boundaries.

A specific case of a school-aquarium collaboration is used to illustrate such a research approach. This study followed the development of a relationship between a large nationally-accredited aquarium located in an urban center, and a newly-opened elementary school in its immediate neighborhood. The broad goal for this particular project, initially proposed by the aquarium, involved the use of aquarium resources to enhance science education at the school. The proximity of the school to the aquarium (a 15-minute walk) made the collaboration even more desirable as it reduced logistical concerns (such as transportation) and, more importantly for the aquarium, exemplified participation and partnership within this urban community.

A variety of data sources were used to define these communities of practice and make sense of their new venture, including interviews, observations of aquarium-led classroom programs and other collaboration events, and member checks of researcher observations. Interview data was the primary source of information, obtained from members of both the school community and the aquarium community. Standardized open-ended interviews were conducted several times over the course of the first two years of the collaboration at the convenience of the community members and collected within each community (e.g., teacher's classroom, aquarium classroom, etc.) typically during the after school hours or

lunch breaks. These interviews were recorded and normally lasted 30 minutes. Participants were interviewed two to three times amounting to over 50 interviews over the two-year period. In addition, administrators and others closely involved in the project were also interviewed to provide additional perspectives and critical details regarding the components of the new program. For those unable to arrange interviews, questionnaires incorporating similar questions as the interview protocol were distributed and returned to the researcher directly, often via email (Interview questions are listed in the appendix at the end of the chapter).

Triangulation was used in this study to strengthen meaning developed from the sets of interviews (Patton, 1990; Yin, 1994.) This means that rather than relying on a single data point (one interview, for instance) to support a possible explanation, multiple data sources were used. In this case, comments obtained from members of both institutions (the school and the aquarium) at different times during the life of the project (year 1 and year 2) revealed convergent data that were used to effectively describe and provide perspective on the case examined here. A process of open coding was initially used to identify recurring themes in the data set (Strauss & Corbin, 1998). These emergent patterns were then compared with Wenger's concept of community of practice (1998), in order to determine whether that perspective was an appropriate frame for the phenomena described. Researcher observations of several aquarium-led classroom programs and other collaboration events were also documented and used to support interview comments. *Member checks* were conducted throughout the project (Isaac & Michael, 1997). This additional level of checking involved recruiting participants within each community to read over the findings to see if the descriptions and analysis captured their views and experiences—an important step in ensuring presentation of an emic perspective and a clear description of each community of practice.

Defining the Collaboration

The collaboration described here featured several activities intended to support student science learning. All classes at the elementary school were given free access to the aquarium, including entry as well as additional aquarium programming (classes, tours, etc.) which would normally require a fee. A second component of the collaboration included the implementation of an aquarium outreach program, whereby aquarium educators visited each classroom approximately eight times over the course of the year, providing 30 to 50 minute science lessons at the school site. Although most of these lessons were related to marine science, efforts were also made to align them with the state science standards. All classes at the school (grades K through 5) were *required* to participate in these aquarium outreach lessons. In addition to these two main components, the collaboration provided free access to the aquarium for the teachers (free family memberships), as well as reduced-cost admissions for student families. Aquarium educators also participated in other events at the school site, such as open house and back-to-school night.

While the terms of the collaboration seem straightforward, feedback from the two communities involved in implementing the program—the aquarium educators and the classroom teachers—revealed that neither community had much input into this initial proposal. While this may seem like a significant flaw in the establishment of a collaboration, such practice is hardly uncommon. Collaborations are often born of opportunity and a host of other variables. This does not at all suggest that proposals such as this are doomed to failure—without such 'arranged marriages' numerous successful programs might not exist. Rather, it further emphasizes the importance of paying close attention to the implementation of such collaborative efforts and considering how the process of collaborating may indeed influence the outcomes intended.

Defining the Communities

To understand how (and whether) these two communities might develop an overlap that supports the mutual activities of the collaboration, it was important to first discover the activities that each group engaged in, recognize their underlying goals for these joint actions, and identify the resources available to conduct the activities. These factors, the components of each community's practice, are not easily measured, and they are too frequently ignored as variables when examining the implementation of educational reform or other collaborative efforts. As mentioned earlier, this data was obtained primarily through interview and researcher observations.

Aquarium educators. The aquarium educators engaged in a wide variety of activities tied to the predominant joint enterprise of communicating ocean science. Related to this is a goal of exciting or even inspiring students and visitors with knowledge related to the ocean and ocean animals—the educators clearly valued such affective outcomes. Their responsibilities required them to interact with a variety of learners, from pre-school students to adults. Their day-to-day practice typically involved short interactions with a variety of learners for varying periods of time, lasting from a few minutes to a few hours. Such encounters were typically repeated at a later time with different groups of learners. These interactions followed fairly regular schedules each day and each week. Although different members of this community may have had specific responsibilities associated with particular programs (e.g., outreach van programs, pre-school family programs, etc.), each educator was capable of filling multiple roles, allowing the community to address multiple needs at all times. Instruction focused on science, and the use of objects (biological specimens, models, and other realia) was a key component of these efforts. In addition, members of this aquarium community had solid science backgrounds (bachelor's or master's degree in marine biology or something similar), although they may not have had any formal professional development in pedagogy. They were quite comfortable talking about science, and enjoyed common interests in marine biology and ocean conservation; their shared

knowledge and interest were an important component of their successful participation within their community of aquarium educators.

Elementary teachers. Although student learning is most certainly an overarching goal of the school community, elementary teachers' practice, unlike that of the aquarium educators, was guided more specifically by a desire, or, more accurately, a need, to prepare students to succeed in their high stakes testing. This joint enterprise of raising scores, shared by teachers in schools throughout the school district, defined the ways that these teachers engaged in their practice. Instruction focused heavily on language arts and math, which were the subjects more heavily tested and linked to school and teacher success, leaving limited time for other subjects like science. Unlike the aquarium educators, members of this community had gone through a teacher licensure program (a shared repertoire) and were familiar with different instructional approaches. The teachers did not, however, have a strong science background, or necessarily the same passion for science teaching. Mutual engagement in this community also involved working with the same group of 20-35 students over the course of an entire year; their understanding of these particular learners, through daily interactions, discussions with other teachers, contacts with parents, and different forms of assessment, is in sharp contrast to that of the aquarium educators.

Conflicts in Practices

Creating an overlap in two communities of practice is not easily managed, as inherent differences in the way that each group functions are likely to be incongruent with the practices of the other. Even when faced with similar limitations, subtle differences in practice can have a considerable impact in how such communities might interact. In the case described here, both communities of practice, for example, were strongly influenced by time limitations. For the teachers, a crowded curriculum with intense pressure for improving grades left them feeling that they did not have enough time to do everything they needed to. Aquarium educators felt a different kind of time shortage in that they were involved in so many different programs at their site and struggled to ensure that they had enough time allotted to achieve success for each project. These time limitations, prominent within the mutual engagement of both communities, led to considerable challenges in creating a new, mutual collaboration.

For aquarium educators, prioritization of projects was often determined by due date—projects received more attention as their deadlines drew near. The aquarium educators' deadline approach to time management meant that lessons developed for the partnership program might not be completed until right before the actual day when the aquarium educator was scheduled to teach the lesson at the school. This caused some tension for teachers, who often reported not being able to prepare their students for the aquarium session (a component of their mutual engagement) because they didn't know any details of what was planned, other than the broad science topic. Although lessons were ultimately completed, and seen as

positive additions to the curriculum, the different ways that projects were prioritized—by due date for example, for the aquarium educators—potentially diminished the value of a learning experience that might otherwise have been more effectively linked for the teachers to the overall curriculum.

Conflicting practices, such as the example described above, can restrict the development of collaborative efforts as well as illustrate how a new program or project can profoundly impact the practices of those most responsible for its implementation. As each community incorporates new activities into their practice, they do so in a way that is consistent with the different dimensions of their own practice (i.e., mutual engagement, joint enterprise and shared repertoire). Aquarium educators, for example, added the new tasks from the collaboration project to their regular practice of prioritization; they didn't change their practice. As each community builds these new activities into their practice, they may, as in this example, inadvertently create boundaries that limit the overlap needed for the collaboration to succeed. The aquarium educators' practice of prioritizing according to program date was inconsistent with the teachers' practice of lesson or unit planning. And while there will always be boundaries that separate and define communities of practice, such limitations can be softened if each community can *adjust* particular *components* of its practice to complement the other. In this case, aquarium educators eventually learned to engage in the preparation of the collaboration activities (lesson development, etc.) differently than other projects they were working on. While this was not a dramatic change in their day-to-day practice, this small change was necessary to maintain the joint enterprise shared by both communities involved in the collaboration.

What Happened (and Why It Eventually Seemed to Work)

While the introduction of this collaboration between school and ISI did not dramatically alter the communities of practice of the teachers or the aquarium educators, it did prompt changes within each community. The connections between these two communities were driven by the sustained practice implemented through a variety of activities (classroom sessions, aquarium visits, lesson planning, etc.). As already mentioned, Wenger (1998) suggests that such engagement where each community interacts directly, yet still retains its own enterprises and practices, might be identified as an overlap between communities of practice. This can be more easily seen if we examine each of the characteristics that make up practice.

Mutual engagement. Gradually, the aquarium sessions (science lessons led by Aquarium educators at the school) became part of the fabric of practice for *both* teachers and aquarium educators. Members of both communities were engaged in new activities in support of the new collaboration, in addition to their pre-existing responsibilities as teachers and educators. These new activities and shared experiences included:

- *Enthusiastic participation in science sessions.* Teachers, students, and Aquarium educators all participated in a series of eight 30 to 50 minute sessions over the course of the school year. Teachers reported great student enthusiasm for visiting the "aquarium room" or "science room" on those days. This positive response seemed to help drive both teacher and instructor buy-in for this activity.
- *Preparation for science lessons.* Both teachers and educators engaged in preparation activities for these lessons, including lesson plan development and review. Teacher preparation also included some level of pre-visit instruction while aquarium instructor preparation included materials management and set-up.
- *Communication with partner stakeholders.* Communication was a key component for establishing this mutual engagement; as dialogue between aquarium educators and teachers increased, both groups were better able to participate in these partnership activities. A more consistent use of email and the establishment of biannual meetings were often cited by members of both communities as critical components of the improved communication later in the partnership.

Joint enterprise. Over the course of the first two years of the partnership, members from both communities gradually became more aware of how the aquarium-led school sessions and the partnership overall would best serve the students at the elementary school. For most teachers and aquarium educators, their collaborative efforts provided supplemental science instruction that engaged students and built on science topics previously introduced in class. Teachers remarked that the 'aquarium lessons' reinforced prior topic learning, and provided real-life connections, often (but not always) using the ocean as a unifying theme. Several also commented on the improvement of students' use of academic language.

Because teachers and aquarium educators worked in grade level teams, the joint enterprise negotiated at each grade level differed slightly. Third grade teachers, for example, expressed an interest in having the aquarium educators present a lesson on prisms because this was a topic they knew little of and had no time to address. For that grade level team, then, the aquarium-led sessions supported a joint enterprise for introducing new science content, rather than reinforcing content already addressed.

Another shared, but perhaps understated goal of the partnership, included providing students with new opportunities for learning science. When asked to explain how the partnership impacted students, teachers and aquarium educators often referred to the student interest and excitement during the lessons.

> They just get really excited, you know, so you can see it, with their understanding, with the hands-on stuff. (Aquarium Educator 5, year 2)

> I think it has given them [the students] the experiences that I don't think they would normally get. I don't know how many of the families would take them down very often. I know that after the first few visits more and more of my kids have been talking about going with their families and they have been down there. (Teacher 6, year 2)

Providing opportunities for aquarium visits for students who might otherwise not be exposed to these experiences became an important joint enterprise for both communities.

Shared repertoire. As the partnership grew, so did a shared repertoire that helped to facilitate the overlap in practices. These resources supported both aquarium educators and teachers in making sense of what the partnership would and would not do. Several resources were developed or strengthened to facilitate easier communication between the two groups. Teachers and aquarium educators both reported greater success in email communication. Bi-annual meetings between educators and teachers, typically conducted in September and January, also became an important resource for sharing concerns, as well as providing new ideas for the science lessons. Content standard documents, science textbooks and the language arts curriculum, already part of the teachers' repertoire of instructional materials, became important components of the aquarium educators' efforts to develop meaningful lessons that would also meet school or district requirements and connect with pre-existing unit plans. The lesson plans developed by the aquarium educators also became part of this shared repertoire. By virtue of repetition, teachers felt more comfortable when lessons were repeated during the second year—they knew what to expect and had a better idea of how the lessons might connect with their curriculum.

At the suggestion of the teachers, the aquarium educators adopted a district-standard lesson plan format when creating or refining lesson plans. Teachers remarked that this modified format, which was already familiar to them, made it easier to utilize and plan for the aquarium-led sessions. While each community of practice had its own set of resources or strategies, the shared repertoire described here evolved in support of the activities and goals of the growing partnership.

Facilitating overlap: Boundary objects. If we frame this school/aquarium partnership as an overlap between two communities of practice (urban elementary school teachers and aquarium educators), then, according to Wenger (1998), we should be able to point to particular boundary objects or artifacts that enabled a successful connection. Most of the activities featured in this collaboration centered on the integration of aquarium instructor-led science lessons into the curriculum and general routine of the elementary teachers. As such, most of the boundary objects we consider are related to that aspect of the program.

– *Formatted lesson plans.* As mentioned, the lesson plans produced by the aquarium educators became, after feedback from the teachers, a key component

of practice for both communities. Teachers valued the use of hands-on activities and the introduction of "real stuff" to engage students in these activities. Most teachers also reported, by the end of year 2, that these lessons fit quite well with their classroom curriculum. These quality lessons, formatted in a district-recommended style, became an important resource in gaining teacher buy-in and in strengthening the partnership.

– *Biannual meetings.* These recurring meetings, beginning in the second year of the partnership, were frequently mentioned as critical components of curriculum planning. This designated time and space allowed educators and teachers to map out the science curriculum for the semester or entire school year, and offered an opportunity to examine how the aquarium could best support those plans.
– *The aquarium.* Unlike the boundary objects described so far, the aquarium was not developed specifically in support of the partnership. However, the site gradually became a source of common experiences which became critical to the functioning of the partnership. Teachers recognized the unique opportunity of using the aquarium site as often as they wished throughout the year, and many even felt obligated to take advantage of this, even if they weren't sure how to use it. Teachers often considered the special programs offered by the aquarium (e.g. aquarium classroom programs or auditorium presentations) as key components of the trip. Recognizing this, the aquarium staff created a schedule of programs for each grade level, recommending particular programs for different grade levels so as to avoid potential overlap from one grade level to another, from year to year. In order to create continuity between the aquarium visits and the instructor-led sessions at the school, aquarium educators often greeted their classes as they came to the aquarium, and in some cases, were able to conduct the aquarium programs as well. As teachers began to think about other ways to take advantage of the aquarium visits, they called upon educators to help devise scavenger hunts that might connect to topics discussed during the classroom sessions. In this way, the aquarium, which had always served as an educational backdrop for the aquarium educators, began to become a part of the elementary teacher's instructional toolbox, as well.

Facilitating overlap: brokers. We must also consider how brokering facilitated the overlap between communities of practice. Several key individuals helped mediate interactions and introduce components of one community to the other.

- *Aquarium coordinator.* The coordinator had multiple roles including assisting aquarium educators in their development of lessons, facilitating communication between educators and teachers (both individually and through the coordination of the biannual meetings), and serving as an additional resource and point of contact for any teachers having questions about aquarium programs or even marine science content. The coordinator's presence at the school, assisting aquarium educators and participating in school events such as open house and Read Across America days, helped to foster an aquarium presence at the school site, which in turn stimulated many of the teachers to think about how best to

use the resources of the Aquarium. Her role was probably the most critical in brokering the overlap between aquarium and school.

- *Teacher enthusiasts.* Although a community of practice may share common routines and goals, a diversity of perspectives coexist within any community. As the collaboration progressed, several teachers emerged as "aquarium enthusiasts." These teachers assisted the aquarium educators and program coordinator in getting feedback from the other teachers at the school. This is not to say that "non-enthusiasts" had negative perceptions of the program, but rather that the aquarium staff recognized the enthusiasts as points of contact and resources to help guide the development of lessons or other program components.
- *Outside researcher.* Data collected during years one and two of the partnership was used in part as a formative assessment to inform partnership progress. The researcher, who in this case was also the evaluator, provided both communities an outlet for expressing their satisfaction, concerns, and disappointments via the one-on-one interviews. The researcher/evaluator, therefore, might also be identified as a broker in connecting these two communities. His experience as both a teacher and museum educator (an outside-insider) made it possible to empathize with members of both communities, possibly helping them to express themselves more openly.

The potential for the researcher and/or evaluator to serve as a broker in facilitating the overlap of two communities of practice suggests a shift of perceived status from outsider to participant researcher. In this case, the researcher's repeated presence within both school and aquarium settings, and periodic communication with members of both communities, afforded opportunities to develop relationships supporting access to both communities throughout the study. For instance, procedures for meeting teachers changed. What began as a sign-in at the front office (including visitor pass), followed by the teacher coming to the office to meet routine, shifted to a routine of sign-in, visitor's badge, and then going directly to the teacher's classroom, with the possibility of greeting and chatting with other teachers along the way. This immersion within communities during data collection resulted in the acceptance of the researcher by teachers, office staff, and aquarium educators as a component of the collaboration. Yet, unless the researcher becomes actively involved in the overlap practice, or for that matter, becomes a more involved member of either community of practice, he or she should still be able to maintain that outsider status. Collaborations such as the one described here are often required by funding agencies to incorporate an external evaluator; to be an effective *broker*, however, the evaluator would need to be able to develop the emic perspective as well, via time and experience. Clearly, a balance is needed, one allowing for empathy with the participants in the collaboration, while also permitting a broader, bird's eye view of the entire operation.

DISCUSSION: SUCCESSFUL COLLABORATION AS SUCCESSFUL OVERLAP

The research reported here supports the notion that the concept of communities of practice, and the overlaps often created among such communities, provide a useful framework and perspective from which to describe and study partnerships or collaborations between formal and informal science institutions. Such a framework, as Wenger (1998) suggests, "acts as a guide to where to focus attention, what difficulties to expect, and how to approach problems" (p. 9). By reframing a school-ISI collaboration in terms of an overlap between two communities of practice, we have a better understanding of the challenges inherent to a new partnership and the strategies that lead to more successful collaborations. As with any educational program, there are different ways to define and monitor success. While student outcomes are clearly an important dimension of establishing the success of a program, including the school-aquarium efforts described here, this study focused on how the collaboration impacted the stakeholders responsible for student outcomes—the teachers and aquarium educators. Based on the data presented here, it would seem that this school-ISI collaboration, facilitated by brokers and boundary objects, reached a level of stability within which members of both communities were able to work effectively and even thrive because the overlap of practices created the conditions for successful collaboration.

The success of this venture can be attributed in part to the stakeholders' learning about one another's community of practice. As teachers and aquarium educators became more aware of the differences in each other's education practices, mutual engagement in the various components of the partnership became more congruent; and the instructional expectations of aquarium educators and teachers, which were somewhat disconnected in early stages of the collaboration, became more aligned. This is not to suggest that each community needed to change the core components of its practice. For instance, the aquarium educators still attended to their multiple responsibilities and multiple deadlines; that component of their practice did not change. Rather, they recognized that their interactions with the elementary school needed to follow a different time prioritization in order to meet the needs of the teachers. Similarly, many teachers recognized that they needed to introduce key science concepts and vocabulary prior to the outreach lessons. Teachers found themselves devoting a little more time to science as a consequence. These adjustments serve as evidence for the formation of overlap between communities of practice.

As educational agencies, funders, and researchers continue to look more closely at innovative learning experiences that happen both inside and outside of school settings, it becomes equally important to consider forces influencing what happens within such different learning contexts. Wenger's concept of community of practice is one example of a theoretical construct that can be used to frame research efforts and evaluations involving the development of a collaboration between institutions. Ogawa, Crain, Loomis and Ball (2008) have noted the importance of examining the relationships between learning and the social contexts of formal organizations. In their discussion, they encourage researchers to closely examine

the theoretical frameworks that might more effectively describe the nature of these relationships as well as the empirical evidence that documents and supports such frameworks. The study presented here furthers these recommendations by interpreting data collected throughout the initial stages of the school-ISI collaboration in terms of Wenger's concept of communities of practice. This reframing serves as a guide for researchers and practitioners in both settings to help explain the challenges and successes of establishing collaborations in support of learning.

APPENDIX

Interview Questions: School Teachers

Part 1: Science planning

1. How often are you able to teach science?
2. How do you decide which science topics to teach and when you would teach them?
3. Did working with the aquarium educators affect your decisions regarding what science was taught, when science was taught or how science was taught? Explain.

Part 2: Aquarium-led outreach lessons

1. On a scale from 1 to 5, how would you rate the success of the aquarium outreach sessions in your classroom. (1=unsuccessful, 5=successful) What makes you say so?
2. Were there any sessions you might have considered to be 'unsuccessful?' If so, why do you think they didn't work?
3. Do you feel that the aquarium educator-led sessions at King Elementary (pseudonym) were more, less, or just as successful as they were last year? What made them more/less useful to you?
4. On a scale of 1 to 5, how well did these lessons fit with your science curriculum? (1=poor fit, little connection; 5=excellent fit) Why do you say this?
5. In what *ways* did these lessons fit with your curriculum?
6. Do you feel these classroom sessions benefited the students who participated? If so, how did the students benefit? How do you know?
7. Do you feel these classroom programs benefited you as a teacher? Why or why not?
8. How were your experiences with these classroom programs this year different from last?

Part 3: Other aspects of the partnership

1. How often were you able to visit the aquarium as a class this year?
2. What sorts of things did you do when you visited?

3. Consider the partnership overall (class sessions, visits, membership access, etc.). In what ways has this partnership benefited the students (your students) at King Elementary?
4. In what ways, if any, has this partnership changed the way you think about:
   a. Teaching science?
   b. Integrating science themes across the curriculum?
   c. Taking fieldtrips?
   d. The usefulness of aquaria or other museums in helping with instruction?
5. In what ways did the partnership seem different this year, compared to last (if at all)?
6. If another school was deciding to enter into such a partnership, what suggestions might you make?

Interview Questions: Aquarium Educators

Part 1: Science lessons

1. What topics have you been teaching this year?
2. How did you decide that you would teach these topics?
3. Did working with the teachers affect your decisions regarding what science was taught, when science was taught or how science was taught? Explain.
4. How difficult/easy was it to prepare these new lesson plans for these classes? Explain.
5. What about these sessions made them successful, in your opinion? How could you tell?
6. Did you have any sessions you might consider 'unsuccessful?' If so, why do you think it didn't work?
7. How do you feel these classroom sessions benefited the students who participated? How do you know?
8. How do you feel these classroom sessions may have benefited participating teachers? How do you know?
9. How were your experiences with these classroom programs this year different from last?
10. Did you find it any easier to touch base with teachers this year, compared to last? Explain.

Part 2: Other aspects of the partnership

1. Other than the classroom sessions, how did teachers and students benefit from the school's partnership with the Aquarium? How do you know?
2. In what ways did the overall partnership seem different this year, compared to last (if at all)? Give examples.
3. In what ways has participation in this partnership changed the way you think about:
   a. Science teaching in elementary schools
   b. Working with teachers here at the aquarium
   c. Your role as a science educator

4. Did participating in this program have any impact (positively or negatively) on your other responsibilities (teaching or otherwise) at the aquarium? Explain.
5. If there was one piece you could focus on to improve any part of this partnership, what should that be?
6. If another aquarium or museum was deciding to enter into a similar partnership with an elementary school, what suggestions might you make to the museum/aquarium educators involved?

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AFFILIATIONS

James Kisiel
Department of Science Education
California State University, Long Beach
j.kisiel@csulb.edu

LEAH MELBER

PUTTING THEORY INTO PRACTICE

KISIEL'S REFRAMING COLLABORATIONS WITH INFORMAL SCIENCE INSTITUTIONS

We as museum professionals are well aware that meeting the needs of a diverse audience and broad range of stakeholders requires an awareness and sensitivity to the unique culture not only of our own institution but also that of the organizations and individuals with which we work. Kisiel provides direction in understanding the theoretical framework behind the process of this interface and building these relationships, providing a robust scaffold from which we can propel our efforts forward grounded in the literature base.

Most of us will at some point find ourselves frustrated that an external stakeholder has expectations we can't possibly meet or disappointed that our carefully crafted program is being met without fanfare. We may find ourselves seamlessly united with one group of stakeholders in pursuit of a common goal only to find the following fiscal year that we are at odds with the same entity with regards to a different initiative. Kisiel's work provides the pedagogical lens through which to view these challenges in order to better understand how we can connect effectively with our stakeholders while staying true to our own mission as museum education professionals. First, the chapter helps us become more aware of the fact that we most likely represent different communities of practice and what that may represent. Second, and most importantly, Kisiel delves into how to cross these barriers, find overlap between our communities, and in doing so move towards more effective collaboration.

As a very young professional, delivering my first professional development workshop to elementary teachers, I found myself frustrated to see several teachers only half-listening as I tried to lead them through an investigation of the structure of a chicken egg. They rifled through stacks of student papers, assigning grades and adding comments, and recording scores in their grade book. Fast forward a year and after spending time exploring the community of practice of our neighboring public school system, I learned to strategically schedule professional development sessions so as not to coincide with when grades were due, which resulted in the same activity having a great deal more holding power.

Certainly this is the simplest application of the concept. Understanding your own community of practice as well as that of your stakeholders also includes knowing the most effective strategy for raising a concern, and who should be invited to which meetings. In academic circles it can mean knowing whose research to cite in a presentation, depending on which conference you are

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attending. It includes understanding which organizations have the potential to collaborate effectively, and which should never be combined under the same roof. When you wear your best suit to meet with the CEO of your organization, but khakis and sneakers to shadow a curator in the collection, you are working within your understanding of communities of practice and making choices accordingly.

Kisiel provides us with a snapshot of a collaboration between a multitude of overlapping communities, and a variety of situations during which this overlap led to challenges, and to success. By concluding with concrete approaches to resolving conflict with regards to this process, he leaves us not just with more questions, but some clear answers, readily applicable in a variety of settings.

DISCUSSION QUESTIONS

1. What are several defining elements you see as critical to the community of practice you most strongly identify with?
2. Can you recall a situation in your professional career where a challenge you experienced could be attributed to the intersection of different communities of practice?
3. What are some ways you have found successful in bridging different communities of practice? Do you find them to be situation specific or overarching techniques that can be applied to a variety of collaborative exchanges?

TALI TAL

5. ACTION RESEARCH AS A MEANS TO LEARN TO TEACH IN OUT-OF-SCHOOL SETTINGS

INTRODUCTION

One of the interesting challenges facing science education today is learning how to collaborate across different teaching and learning contexts, such as museum and classrooms. The out-of-school setting poses specific challenges to teachers, among them: the novelty of out-of-school settings, the possibility of unexpected events, teachers who are insecure about their pedagogical content knowledge, management issues and physical challenges (especially in the outdoors). All of these challenges place the teacher in a stressful situation, and yet she is expected to function as well as she does in her classroom.

To illustrate the possible impact of such demands, we refer back to the time when computers were first introduced to schools. At first, many thought that once the computers were there, teachers would immediately be able to employ the technology, tie it to a broader framework of educational theory, and successfully integrate the computers into their everyday teaching. But does anyone seriously believe that if a teacher surfs the Internet at home, she will immediately master web-quest teaching in school? Is it realistic to expect that a person who can complete a web-survey individually might know how to use technology to collect and interpret data for a science class? On the contrary, the research has made clear that only intensive professional development programs, focusing on theoretical as well as practical dimensions and strong academic and technical support, have enabled a gradual employment of technology in schools. Every new technology advancement tool has required providing teachers with enough opportunity to explore and experience it and then to adapt their everyday teaching in order to incorporate that innovation.

This example of using technology in the classroom highlights another related, unrealistic expectation, that teachers will know how to incorporate a field trip experience, professionally and thoughtfully, into their everyday teaching simply because they have gone on family field trips or participated in field trips as students. In reality, the teacher is usually stressed about students' safety and behavior, the challenges of teaching in an unknown environment, what to expect from the experience, and even what to do especially if a museum educator or a nature field guide is present and the teacher serves merely as support. Considering the accumulating research on teachers' challenges and the unique characteristics of the out-of-school learning environment, it is now clear and reasonable that teachers are better trained in incorporating informal settings by using a praxis approach; this

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means that teachers learn in action, by action, and by reflecting on action in order to improve their practice. In other words, engaging teachers in doing action research in out-of-school environments helps teachers learn to use out-of-school environments as part of their teaching skills and methods.

The vignette below, from a fourth grade visit to a natural history museum facilitated by a museum educator, introduces some of the challenges faced by teachers and museum educators alike.

Vignette 5.1

> In the first stage of the museum visit, the classroom teacher and the chaperone parents sat in the back while the museum educator taught using a lecture format. The teacher did not participate in the presentation other than by asking students to be quiet and to listen. The students then got their worksheets and were asked by the museum educator to explore the exhibit. The worksheet had questions that the students were expected to fill out in writing during their visit. Throughout this activity by the students, the classroom teacher was outside in the museum yard, talking on her cellular phone. When the students were asked to move into the museum classroom for another activity, the teacher was still outside talking. The exhibit floor was covered with the students' worksheets that were left behind. (Videotape ME041203/Y4)

The tension in this vignette arises from the lack of involvement of the classroom teacher in a museum learning experience. Although this may be an extreme example of the unclarified role of the teacher, this vignette introduces many of the tensions inherent in such situations. The teacher in this particular case exhibited patterns seen in other research studies. Research has revealed that teachers are often unprepared for museum visits; they sometimes do not know how to participate usefully. They often do not prepare their students for such visits, and they rarely pursue post-visit activities upon returning to the classroom (DeWitt & Osborne, 2007). When a museum educator takes the lead during a museum visit, the teacher often seems at a loss about whether and how she can participate. The subject of this chapter, then, is this misperception of possible actions and goals in such situations as well as a suggestion for how to alleviate such mismatches.

We know from past decades of classroom-based research that there are ways to change this dynamic, including better professional development in the form of action research. In this chapter, therefore, we use an action research approach to out-of-school teaching (by classroom teachers) because it has been shown to usefully blend theory and practice in a feedback loop of preparation, action, reflection and evaluation; it also allows a focus on the reflection-based development of the participant teacher (Carr & Kemmis, 1986). We have seen that the type of critical reflection required in action research results in teachers' moving toward a learning orientation in their teaching, rather than focusing on science content.

Action research is an active and transformative process in which the participants seek out the information they need, define their own problems, and develop a range of solutions suitable for themselves and their students (Keiny & Gorodetsky, 1996). Using action research, teacher participants typically collaborate with an outside researcher, whose task is to help create optimum conditions, facilitate praxis, bring in new information, and systematically collect the participants' experiences in order to document the research and disseminate the findings in other settings. The outside researcher not only helps the participants in their own inquiries by bringing in relevant educational theory, but s/he enables the development of theories that are grounded in praxis. It is through direct interaction with the participants in the "field" that the researcher is able to get a better sense of the problematic role of the teacher. The research reported here follows this model.

Framing the Problem

Various studies focusing on school groups and their teachers' behavior in out-of-school settings like museums, aquariums and nature parks have highlighted the roles teachers can play. Other studies examining teachers' interactions with explainers/interpreters in informal science institutions (ISIs) have indicated that teachers often have vague motives for taking their students to museums; as we saw above, the teachers tend to rely on the expertise of museum educators. Overall, there seems to be only a loose connection between learning in the classroom and in the out-of school setting. One common and obvious conclusion regarding this disconnect is that professional development programs in education seldom prepare teachers to use suitable pedagogies for out-of-school settings. In this chapter, I will illustrate how action research is a methodology that can enable the improvement of teachers' practices in out-of-school settings, and at the same time allow deeper understanding of teachers' challenges and practices in general.

Teaching in informal or mixed formal-informal settings involves the participation of both classroom teachers and museum educators, who may hold dichotomous views of teaching, assessments, learning, and its outcomes, as described in chapter 4 by Kisiel. Therefore, all participants need to collaborate in clarifying the roles of students and teachers and their relationships with ISI educators. In the sections below, I first review the research literature on teachers' practice in informal settings where I suggest action research and other forms of reflective practice to improve the professional development of teachers. I then describe two studies of teacher action research in informal settings and illustrate how teachers can use reasoning, acting and reflecting in order to distance themselves from traditional content and pedagogy obstacles. By taking responsibility, collaborating, and emancipating themselves from traditional perceptions, practice and roles, teachers can realize their unique capabilities, address insufficient knowledge, gain relevant new knowledge, work toward broader understanding of their role, and adopt a more proactive approach to learning experiences in out-of-school settings.

Research Findings on Teachers' Roles in Informal Settings

The field trip is an example of experiential learning that enables students to engage with real natural or sociological phenomena in a relevant context; it also hopefully allows educators to bridge the abstract ideas examined first in school to their authentic expression or form in the natural world. Field trips are typically arranged by schools, for educational purposes; they take place in engaging and interactive settings and have been shown to increase interest, motivation and other aspects of students' learning. One common perceived value of the field trip is to provide learners with a direct experience of tangible phenomena and materials, an opportunity to promote a gradual shift from using simple concepts to more complex ones, and an opportunity for hands-on experiences that lead to the assimilation and amplification of abstract concepts (Falk, Martin, & Balling, 1978).

The field trip allows students to practice the process skills of science, such as making observations, conducting short investigations and discussing ideas in a socially collaborative learning environment. Field trips are complex learning settings; ideally they permit connecting the more abstract school curriculum to the more concrete phenomena of the out-of-school environment and thereby combine cognitive, social and affective aspects of learning into one experience. Yet, although schools and teachers attribute high value to museum visits, the international literature has indicated that teachers rarely plan or enact pre-visit activities or summarize the visit in a thoughtfully constructed manner following the visit. In fact, teachers rarely perceive the museum activity as the engaging social and cultural learning experience it actually is, given that it is collaborative and encourages activity with shared responsibility among a community of learners.

One reason for teachers' disconnection from the positive potential of field trips is a lack of understanding of their importance, and a subsequent lack of preparation of the teacher and the students before the field trip. It is not enough to focus on schedules and instructions regarding clothing, food and desired behaviors. In her review of the research on school visits to museums, Griffin (2004) suggests there are many possible reasons for this pattern, such as time constraints, logistical difficulties, trying to meet diverse students' needs, and pressure for accountability that limits the teachers' ability, and willingness to provide proper preparation and post-visit activities (see also Kisiel, chapter 4). There have been exceptions to this pattern, and what these exceptions almost always have in common is the fact that they occurred within research settings where the researchers themselves were aware of the importance of meaningful preparation and follow-up activities. These researchers were themselves involved in preparing the activity with the teachers and/or the museum staff (DeWitt & Storksdieck, 2008).

DeWitt and Osborne (2007) have argued that the main problem associated with both insufficient teacher preparation and poor coordination between schools and museums is the lack of a theoretically based framework for museum practice. Consequently, they have adopted perspectives from Cultural-Historical Activity Theory (CHAT) which is based on the proposition that learning is a social and cultural process, rather than simply a biological process; therefore, in different

situations (e.g. classroom, museum, yard, work place) thinking and learning will be practiced and achieved in different ways. Those ways are not likely to be readily transferred from one person, team or organization to another (Engeström, 1999).

DeWitt and Osborne have also suggested a list of principles for developing resources for the museum activity, such as adopting the teacher's perspective, reducing the novelty space (the unfamiliarity of the environment in various domains), encouraging joint productive activity, raising curiosity and interest, and allowing choice and control. They have argued that applying these principles to the design of museum activities, including the preparation and wrap up activities, would improve teacher practice in the museum. DeWitt and Osborne have suggested that educators address the museum visit the same way they address learning in classrooms, which is explained and supported by theoretical ideas that are translated into specific teaching strategies. Despite this and other good models for preparing teachers for a particular museum visit, problems persist. These include lack of overall design, inconsistencies matching activities to principles, and a dearth of adequate learning materials.

In this chapter I argue that fundamental change should not focus on better activities, procedures, or relationships with a particular museum. Rather, efforts should center on building the teacher's capacity to engage in a variety of settings, regardless of the activities provided by a museum, science center or botanical garden. The teacher should be able to promote learning across institutions, curricular contexts, and activities, regardless of the informal institution collaboration (see Ash & Lombana, chapter 2; and Kisiel, chapter 4).

Instead of searching for or designing a "good" program or a set of activities, I suggest to focus on the basic ways teachers learn their practice and on how they may improve their practice based on lived experiences, design and critical reflection in and of field trips. This means looking for a framework that enables teachers to learn by action, by carrying out field trips and providing them with the opportunity to discuss and reflect upon their work in a supportive collaborative environment. The basic assumption here is that action research that addresses the entire cycle of planning, teaching and reflecting in an informal setting empowers the teachers and provides them with positive experiences that could impact future implementation in various settings.

Reflective Teaching and Action Research

Terms such as reflective practice, teacher research, and action research have been widely discussed over the last 60 years as critical dimensions of teachers' professional development. They are related to introducing change and improving a variety of practice-related issues. However, there is much confusion with regard to terms like reflection, critical, empowerment and collaboration, given the different meanings scholars ascribe to them. Overall, reflective practice refers broadly to a set of ideologies and principles of practice.

Action research, which relies on reflective practice, is really a family of approaches, used in a variety of fields, with a number of definitions (Leitch & Day,

2000). In education, action research is a form of self-reflective inquiry undertaken by teachers in order to improve their practices, their understandings of those practices, and the situations in which those practices are carried out (Kemmis, 1990). Zeichner (2001) refers to five major traditions of action research in English speaking countries that differ with respect to purposes and motivations, the conceptions of action research, the form and content of the studies, sponsorships and structures that support the research, and views about knowledge and learning. Acknowledging this diversity, I will try to avoid the pitfalls of any specific approach and follow the basic assumptions behind the advantages of any reflective practice. This means engaging the teachers in asking meaningful questions about their own practice, discussing these questions based on their practice, challenging and redesigning their teaching, and reflecting upon their experience individually as well as in a group of practitioners.

Schön's (1987) great contribution to the field of reflective practice was in highlighting the problem of ignoring professional knowledge and arguing that while (educational) theories were seriously considered in preparing professionals in various fields, the way these professionals eventually translate and apply such theories into practice in a particular context did not get enough attention. By suggesting the consistent framework of reflection-in-action, which is the implicit process of thinking while doing, and reflection-on-action, as a thoughtful consideration and retrospective analysis of performance in order to gain knowledge from experience, Schön made the research community and teacher educators recognize reflection as a significant and necessary feature of professional practice in education.

Another step forward was Liston and Zeichner's (1990) suggestion that teacher education ought to work towards developing teachers who are able to identify and articulate their purposes, choose the appropriate means, understand the content to be taught, understand the cultural and cognitive orientations of their students, and provide good reasons for their actions.

A third dimension of reflective practice refers to the scales and career cycles most suitable for encouraging reflective practice. In this regard, there is broad agreement that reflective practice should be fostered at the very beginning of a teacher training and throughout a teacher's professional career. In the past few decades, reflection has been added to many professional development programs in education, as well as to in-service professional development initiatives. Action research allows pre- and in-service students to engage the underlying theory related to their studies in a public way and under supportive conditions through guided reflection.

A *systematic inquiry* that is collective, collaborative, self-reflective, and critical differs from the more general ways of reflecting on teaching action research; it is undertaken to understand practice so that it can be improved. It has been widely claimed that teachers who engage in action research become more aware of their own practices, and of what their students are thinking, feeling and learning. Research also shows that action research improves teachers' reasoning capabilities, facilitates the development of dispositions to self, and monitors one's teaching

practice over time. Action research has also been found to be effective in introducing major changes in beliefs, dispositions and practices (Zeichner, 1993).

In science education, action research has been utilized in three domains: teacher education and professional development, research on science learning, and curriculum development and implementation. In all domains, teachers take on the roles of researchers, either studying their own methods of instruction and assessment, examining the cognitive processes of learning, or participating in the process of curriculum research and development. The definitions and approaches of action research can be classified along three dimensions: (1) theoretical orientation, (2) purposes, and (3) types of reflection (Rearick & Feldman, 1999).

1. In the theoretical dimension there is technical, practical and emancipatory action research.
   - *Technical* action research is commonly initiated by a researcher or a principal who wants to introduce a change and study its implementation. It is mainly deductive, focuses more on introducing efficient practice, and emphasizes orderly, sequenced research.
   - *Practical-collaborative* action research aims to improve practice through the collaborative process of defining a problem and applying practical judgment by teachers who are engaged in collecting their own data. Within this framework, action research is concerned with the process of teaching as an end product, and is focused upon building teachers' capabilities to self-evaluate.
   - *Critical-emancipatory* action research is rooted in critical theory. It aims mainly at empowering the participants by liberating them from compulsory social traditions and habits and encourages them to make radical changes in both views and practices (Kemmis, 2001).
2. The purposes of action research are professional understanding (e.g., staff development, adding to the knowledge base of teaching), personal growth (e.g., teachers becoming more familiar with the development of their knowledge and educational theories), and political empowerment (e.g., critique the nature of teacher's work, the school system and the social agenda; Rearick & Feldman, 1999).
3. The types of reflection are autobiographical, collaborative and communal action research. The autobiographical form is individual and the researcher is the main focus of the research. The collaborative reflection asks questions beyond the individual and is characterized by greater openness to understanding the perspectives of others. Communal reflection involves an interaction with others, in larger cultural, historical and institutional contexts.

In any action research project, one should consider these three dimensions and plan according to an explicit framework.

Action Based Professional Development for Out-of-School Teaching

There is only a limited literature base on professional development programs in education that provide the teachers with a theoretical framework and specific knowledge and experience necessary for teaching in out-of-school environments. One example of a comprehensive teacher training experience in informal settings was offered during a science methods courses for pre- and in-service teachers at three universities in Southern California (Olson, Cox-Petersen, & McComas, 2001). The teachers were provided with an opportunity to plan, carry out and summarize school field trips to a variety of settings. The student teachers observed an "effective" field trip, visited a zoo (together) to learn about the possibilities and obstacles of a possible field trip, and planned and facilitated their own field trips as part of their student teaching experiences. The main finding of the research was that the teachers were mostly concerned with technical managerial issues. Although the authors refer to action research and research projects carried out by the in-service teachers, the article does not address these issues, or explain why the experience the authors provided did not enhance deeper reflection among the teachers. Moreover, there was not any recommendation on how to further address professional development in informal settings to achieve better teacher engagement.

Another study, carried out by Anderson, Bethan and Mayer-Smith (2006), investigated pre-service teachers engagement in a meaningful teaching-reflecting cycle at a public aquarium (see also Anderson, chapter 2). They challenged the familiar picture of the passive role a teacher plays in out-of-school learning experiences as addressed by others (Tal & Steiner, 2006), and offered an intervention instead, that empowered the participating pre-service teachers. By investigating the impact of a practicum experience in an aquarium on pre-service teachers' pedagogy and epistemologies of teaching and learning, Anderson et al. (2006) also challenged the traditional classroom-based model of teacher education. In the example offered by Anderson et al., the teacher educators were concerned that the traditional school-based practicum was not congruent with broader definitions of teacher education, which focus on providing educators with a wide range of skills that can be readily transferable across contexts, inside and outside of school settings. The alternative model practicum included a three day orientation at the aquarium, and then, following the 10 week school-based practicum segment, a three week practicum at the aquarium that included observing the aquarium staff, planning, teaching, and designing pre- and post visit activities. Anderson et al. also refer to informal reflections carried out in the presence of aquarium staff members and weekly formal reflective discussion meetings with the university faculty advisors. Their data included focus group discussions, documentation, three pieces (per student) of reflective writing, and observations of the students. The authors concluded that participation in the aquarium practicum enabled a holistic view of teaching that went beyond the classroom borders, and was an experience that could aid the teachers in their professional careers. Furthermore, the dynamic and changing nature of the aquarium education context required the pre-service

teachers to be highly flexible in their pedagogy and responsive to the learning milieu. Finally, Anderson et al. claimed that the aquarium teaching experience and its embedded opportunities for reflection increased the students' self-efficacy and enhanced the pre-service teachers' development of positive identities as prospective teachers. Expanding upon this study, the next section discusses how action research can contribute to teachers' professional development for out-of-school teaching.

Action Research: Acknowledging Need into Practice

The work by Erminia Pedretti and Derek Hodson (1995) in Canada, who conducted action research with teachers in order for them to enact and implement a Science-Technology-Society (STS) pedagogy, convinced me to try action research in environmental education in Israel. The main argument for my choice to do so is that action research provides an opportunity to experience the complexity of STS teaching, which includes cognitive, affective and value-judgement aspects. Accordingly, I followed one pre-service teacher who challenged her own and her fellow course mates' perceptions of "a swamp" (Tal, 2004). As already discussed above, what began as a teacher's study of conceptual understanding developed into what I would now call a critical emancipatory action research project. The student, Nasarine, examined the reasons for common misconceptions regarding marshland, which she viewed as a place with filthy water and bad odors. She came to study this phenomenon as a result of a surprising productive field trip experience in a wetland. In her study, she realized the political context that affected the conception of marshlands in Israel.

Drying out the swamps was set in the context of a great Zionist effort, which was supported by an educational ethos that associated the swamps with malaria and other diseases. This was in spite of the beautiful and rich habitats swamps provide humans and wildlife. It is true that, at the beginning of the 20th century, malaria had caused casualties in Israel, but after the most heroic drainage efforts malaria was no longer present in the country in the 1950s. Nasarine, an Arab student teacher, had assimilated the canonical ethos (draining swamps) imposed by Jewish educators. When she visited the wetland, she faced a sort of cognitive conflict, which became the core of her subsequent action research study, in which she challenged fellow students' views of swamps before and after a field trip to the wetland. Nasarine's experience then led her to incorporate environmental education in her future practice as a chemistry teacher. As a teaching candidate, during a job interview, she tried to persuade a principal to allow her to teach both chemistry and environmental sciences. Eventually, Nasarine developed her own program in environmental education that she introduced to Arab schools in northern Israel, practicing mainly informal environmental education.

Following this initial action research case study in an outdoor environment, I shifted my own research to work with a group of teachers in different stages of their career designing an action research outdoor teaching project for pre- and in-

service teachers, for which an ecological garden in our university became its primary setting (Tal & Morag, 2009).

I initially adopted a practical-collaborative approach, aimed at both professional and personal development. We encouraged our five participants to identify challenges in outdoor teaching based on their experiences as students and teachers, to come up with questions and problems, to suggest and implement appropriate activities, to enact the activities while facilitating school visits to the ecological garden, and to study their implementation and to reflect upon the whole process. We used the practical and collaborative approach because we believed that pre-service teachers might not yet be aware of the liberating aspect of emancipatory action research, and because our group of five teachers consisted of both in- and pre-service teachers with mixed expertise.

This practical orientation reflects a realization that human activities are morally and ethically charged, and that the decision to act follows from the deliberation of alternatives. Collaborative group reflection goals included greater openness to understanding the perspectives of other participants in order to move the action researcher beyond subjective experience and towards shared experiences and mutual discourse. We focused on the process of action research as a means to encourage out-of-school teaching and thus refrained from classifying the teachers based on their level of reflection.

A CASE STUDY OF ACTION RESEARCH IN AN ECOLOGICAL GARDEN

The research project took place in an ecological garden (EG); a semi-natural arboretum on campus composed of a natural creek surrounded by various small areas of native Mediterranean vegetation and other cultivated and managed plots. Various ecological principles are demonstrated in the ecological garden. The EG is a safe environment that allows for the exploration of wetlands and ponds, Mediterranean chaparral, a pine-wood forest, and cultivated terraces. The constructed areas in the garden, the administration office, the classroom and the gathering area were built according to ecological principles, which are presented to visitors in various ways. In this project and in other courses, we use the EG as a "field lab" for our teacher training program in environmental education, and as a center that provides field-based inquiry activities for schools.

Three of the five participants in the project were undergraduate students in their senior year, with no teaching experience, except for the obligatory supervised practicum while the other two were graduate students and experienced teachers. The semester long project included: a) two meetings in which we discussed reflective practices and presented examples of a variety of reflection forms in science education; b) exploring and studying the ecological garden, its paths and habitats, and preparing the learning activities; c) consulting with the teachers of the visiting schools for pre-visit coordination; d) presenting the prepared learning activities, reflecting on them with the whole group, and then revising them; e) enacting the outdoor activities in the EG and collecting data; and f) analyzing the data, reflecting, and discussing the conclusions with the group.

The Project

Each participant was required to teach one 3 to 4 hour class (grades 1, 2, 5, ages 7, 8, 11 respectively) in the EG. After stage one of the project, in which our participants read literature regarding outdoor teaching and discussed the essence of collaborative reflective practice, and stage two, in which they explored the EG, each participant came up with a problem she identified and formulated a general research question or a concern that each teacher wanted to address. The questions addressed the following issues: learning scientific ideas in the outdoors; the (proper) nature of learning activities in the outdoors; students' perceptions of outdoor learning; making connections between the activities in the EG and school science; and affective experiences of the students. Accordingly, each participant planned educational activities that included short explanations, investigations that required students to work in small groups, asking questions, collecting data, and looking for evidence, and creative tasks, especially with the younger students.

Most of the questions brought up by the participants addressed learning in the outdoors; only a few addressed the visiting students' enjoyment and their perceptions of outdoor learning. Only one participant was interested in the way(s) the teaching experience in the EG was meaningful to herself, as well as to the school students and their teacher; no other student challenged her own practice in the form of a research question.

Following principles of meaningful preparation for out-of-school learning (Falk & Dierking, 2000), the participants, who will be referred to as "participant-facilitators," called the school teachers whose classes they would facilitate prior to the visit. They asked about the class characteristics, the students' prior knowledge, and about the context of the visit to the EG. They described the planned activity, asked for the school teacher's feedback and suggestions for improvements, and invited her to take an active part during the field trip. While at the EG, the facilitators enacted various hands-on learning activities.

Data Collection

Data collection and analysis were carried out in two cycles. In the first, each participant-facilitator conducted her own descriptive study. At the same time, we videotaped all the activities. The videotapes served as reflective data for our students; the videotapes also served the University researchers as a means to track learning about our students' practice. In addition, we conducted in-depth retention interviews with each of the five participants six months after the course ended, and we evaluated the final portfolio they submitted. The data was inductively analyzed by examining emergent themes and repeated patterns. Each theme was independently scrutinized by the two researchers. Member check and peer-debriefing, both common procedures that enhance the research validity in qualitative research (Guba & Lincoln, 1985), were pursued by: (a) presenting our main understanding to the five facilitators and asking them to critique and make

comments; and (b) engaging in discussions between the authors and other researchers.

Action Research as an Empowering Strategy

All five participant-facilitators reported a very positive experience, despite the differences between the five activities they carried out. Their positive experiences were related to their comfort in the EG, their preparedness, their level of exchanges with their students, and with the form the reflective practice took. Analysis of the participant-facilitators' reflections, apparent in their portfolios and the retention interviews led to the identification of four major categories that emerged from the diverse data sets.

Participant-facilitator/teacher relationships. All five facilitators referred to their collaboration with their cooperating teachers which they defined as good or limited, acknowledging that a certain degree of collaboration was necessary in order to carry out a good educational experience.

> In my project, I realized the important role, the professional teacher plays. She is a positive force that should be recruited to enhance learning in nature and to improve the entire experience. While respecting the importance of the content that should be taught, the most relevant ideas will be discussed only with the help of the teacher (Participant-facilitator S', written report).

Three facilitators elaborated on how the pleasant atmosphere, the collaboration and the involvement of the teachers contributed to the way they functioned in the field. One reported a teacher who could not manage her class, and students who disrespected their teacher, and one discussed how poorly her teacher was prepared for the natural environment and the way it affected the activity.

> The teacher in my field trip hardly grasped the rationale of the visit to the EG and the importance of outdoor learning. Even when I invited her to take an active part and asked for her involvement, I got no meaningful answer. All she said was that she wants the students to learn "something new in science." (Participant-facilitator H', interview)

Participant-facilitator/students relationships. All the participant-facilitators referred to their attempts to communicate with the students. Formal interactions occurred through questioning and answering when providing instructions, and as the students engaged in hands-on assignments. Informal interactions occurred while walking the trails, during small group activities, and during the snack-break. One participant-facilitator reported very low student motivation upon arrival, as well as many discipline problems. As H' indicated in her written report: "The kids were terribly disrupted. They yelled and had fights with each other. The presence of the teacher did not help as she [their classroom teacher] was quite helpless." Although the participant-facilitator was quite frustrated at the beginning, she re-evaluated the situation, changed her plans, and, at the end, reported high student

engagement and student curiosity. “Eventually, I managed to do it quite well, when I let them observe and come up with hypotheses … at that time, most of the students already cooperated” (H' written report). Two other participant-facilitators made reference to the students' enthusiasm and attentiveness. Except for one participant-facilitator, all the others referred to the students' interest and curiosity.

Collaboration within the group. All the participant-facilitators referred to the action research group work. They felt that presenting their work in two cycles for discussion seemed a good way to improve one’s work. They acknowledged the collaboration and support of the mentors (researchers), especially during the field activity.

The course group was tremendously helpful. I remember the first time I presented the activities I planned and everyone had comments. Initially, I felt discouraged, but then I revised them and understood the critique. I got very good ideas from H' and from Ha' and throughout the following stages I felt secure and supported by the group and the mentors, especially in the EG (Participant-facilitator V', interview).

This last point is interesting since our main support was offered prior to the field trips, and we decidedly remained passive during the trip. This implies that the facilitators had benefited mainly from our moral support, knowing that we were there to help if and when needed. The supportive relationships with the mentors were discussed mainly in the interviews, by referring to two types of support: the traditional support pre- and in-service teachers get in professional development programs that provide them with content and pedagogical content knowledge, and a unique “outdoor support,” that consisted mainly of just being there and helping if “they get lost,” if “someone falls down,” to suggest “free exploration of the wood,” and to “identify unknown organisms if needed.” Overall, the facilitators felt they were encouraged to try all the ideas they came up with during the group discussions prior to teaching in the EG.

Personal reward. As indicated earlier, only one student initially asked about what she might gain from the whole project. Once asked to return to her journal and reflect upon her question, however, she emphasized how empowered she felt to continue taking her students out to enact the learning activities by herself. As an example, she talked about pH testing and claimed that although this was a simple investigation that teachers do in class, the fact that the students took the water from the ponds and showed genuine curiosity about the results made a big difference. Finally, she emphasized the systemic outcome of the project: the cognitive (the students learned a lot), the social (they had to work with each other, communicate and share) and the experiential (they enjoyed … they were curious … they had adventures).

DISCUSSION

We learned a great deal about various aspects of outdoor teaching through the eyes of our five teachers. Their views of the content, pedagogy and organization of the outdoor activity improved our understanding of the main issue, which is finding ways to empower teachers to teach in the outdoors. The effort it took to work closely with the five teachers through all the stages of questioning, planning and enacting, and during the continuous reflection process suggests that teachers do not adequately function in out-of-school environments mainly because their training does not provide them with the necessary experience and support. Teachers are used to classroom teaching, to sets of objectives that are rooted in the standards and the curriculum they teach, and to definitions of learning that are related mainly to the cognitive domain.

Considering how important out-of-school learning environments are, it is clear that professional development initiatives and programs for pre-service teachers hold great potential to improve the way teachers plan, carry out and conclude outdoor learning. Our experience fits well with Anderson and his colleagues' study (2006) of pre-service teachers who engaged in a practicum at an aquarium. Their study showed that the teachers felt more comfortable in teaching at the aquarium, as well as in school, after having a meaningful practicum that bridged the two environments. Such programs address the insufficient professional development of teachers and their inadequate awareness of the specific barriers to learning in the outdoors (Dillon et al., 2006).

How to best support teachers' teaching in the outdoors, or how to prepare them to teach in informal settings is an issue that clearly needs to be explored further. The complex nature of out-of-school learning and teaching suggests that only intensive and on-going professional development may yield the expected results. The collaborative reflective framework we employed involving the five teachers and the two mentors, while time consuming and costly, was successful for all parties. The teachers benefited from our intensive support and we had the opportunity to document their difficulties and achievements throughout the process. We have shown that such projects can create a supportive and reflective environment, suitable for the specific nature of outdoor teaching. Our program for supporting teaching in a specific outdoor environment, namely an ecological garden, included three main constituents: content, pedagogy and affect. Support was provided in terms of these three dimensions at individual meetings with the participant-facilitators, and mainly, through the group meetings, which served as a medium for raising questions, and discussing the challenges the participants faced.

CONCLUSION

In this chapter, I offered a rich description of action research as a research methodology as well as a practice that promotes good teaching in informal learning environments. Even though action research is widely used for a variety of purposes, I believe it is particularly useful for challenging traditional teaching practices to arrive at more complex pedagogical methods (Keiny & Gorodetsky,

1996). Action research is a good means for studying a variety of questions related to teaching and learning in the outdoors. It makes for an effective tool for practitioners to come up with issues and struggles tied to their everyday work and is a means for working towards change. Mertler (2006) argued that action research is a process that improves education by incorporating change; it involves educators working together to improve their own practice; it is collaborative, participatory and supports critical reflection; and it is an open-minded and planned systematic approach to understanding the learning process. In light of this argument, I will bring this chapter to a close with a quote from one of our students who participated in the action research project at the ecological garden. She concluded her portfolio with the following paragraph, underlying change and not at last, hinting at the emancipatory nature of action research:

> First, I was hysterical as I never guided a field trip. I did not even know where the ecological garden was, and after being there the first time, I even got more anxious as I feared I was going to get lost and everything (!). After working with H' and all the others in the group, I gradually moved into thinking about how good I'm going to be. We visited the EG a few more times on our own, so I wasn't afraid about being there alone. The activities I planned helped me to be more structured, and the talks with the (school) teacher helped a lot in getting prepared. I remember that my activities were not so great when I first presented them to the course. I remember that Tali and Orly (the instructors) suggested having more fun activities on the expense of teaching more scientific ideas. Eventually, I think I had a good mix of both …. More than anything else, I believe this experience showed me how I will behave when I'll take my students on a field trip. I know that I do not have to know everything. It's enough that I enjoy the environment and help my students enjoy it too. I'm sure that learning will occur if I feel at ease. I came to like the idea of having field trips, and I have a good idea on how I'm going to handle them. (Participant-facilitator R', portfolio)

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AFFILIATIONS

Tali Tal
Department of Education in Technology and Science
Technion, Israel Institute of Technology
rtal@technion.ac.il

LEAH MELBER

PUTTING THEORY INTO PRACTICE

TALI TAL'S ACTION RESEARCH AS A MEANS TO LEARN TO TEACH IN OUT-OF-SCHOOL SETTINGS

Tal's work will likely strike a chord with both classroom teachers and informal educators alike, highlighting the importance of identifying processes to better connect classroom teachers and museum professionals while respecting the key tenets of each community of practice. Theories abound on how to better connect informal and formal educators. Tal takes a step back from how to determine the most effective educator professional development program format, and instead asks us to think about the very role we afford teachers in the process.

Most of us dislike simply being told what we need to do. As professionals, we prefer it when our opinions are solicited and decisions are made that take into account our past experience together with the reality of the situational need. Tal reminds us that by creating the opportunity for teachers to serve as action researchers, including the allocation of time necessary for thoughtful self-reflection, we create stronger opportunities for true collaborations between these communities of practice. Thus, we move away from professional development models that didactically address the importance of museums, and instead ask teachers to co-create the most meaningful opportunities for bi-directional support between our institutions.

My own experience with action research was in exhibition development. Most will agree this process often comes with challenges and I was personally experiencing significant frustration with the tensions in our exhibit design team. With an upcoming conference call for proposals staring at me from my desk, I had the idea to combine my need for a small-scale research presentation with the opportunity to critically reflect on the exhibition project in a positive manner. And though it would be inaccurate to say that several interviews and a document analysis later I embraced the difficulties of the project with a smile, it did provide a positive avenue for my frustration and helped me identify solutions and alternative approaches for further action. Action research forced me to step back and conduct some critical self-reflection rather than staying rooted in my own personal views and struggles. Of course when presenting the work at that conference in the following year, it was also empowering to hear—surprise!—these struggles were not unique. As a colleague complimented me for trying to look at the process through a research lens, albeit an overly simplified one, the critical role action research can play in personal and professional growth became even clearer.

D. Ash et al. (eds.), Putting Theory into Practice, 95–96.

So while my example is museum rather than classroom-based, the key tenets remain the same. Action research is a way to engage individuals as participants in new initiatives or the process of change in a manner that is empowering and inclusive. Tal guides us through how to forge these connections with classroom teachers with the final goal of establishing stronger ties between museum and classroom.

DISCUSSION QUESTIONS:

1. Review Tal's treatment of three theoretical dimensions of action research: Technical Action Research, Practical-Collaborative Action Research, and Critical-Emancipatory Action Research. Can you think of a sample situation that would best be served by each?
2. Identify a current professional challenge you are facing. Would embarking on an action research project be a way to address this challenge? Why or why not? And if so, what would it look like?
3. Do findings from action research need to be presented or published to have merit? And if so, presented to whom? Provide support for your opinion.

THAO MAI AND DORIS ASH

6. TRACING OUR METHODOLOGICAL STEPS

Making Meaning of Diverse Families' Hybrid "Figuring Out" Practices at Science Museum Exhibits

INTRODUCTION

The process of interpreting how collaborative groups make sense of science in informal learning and teaching contexts such as museums has been actively studied for the past few decades. Studies often focus on the science content that is learned or the ways in which content is taught. Such studies also largely focus on the typical European-American public that predominantly populate museums and other informal places of learning. The research we describe in this chapter disrupts these patterns; our research has actively explored scientific sense making from the point of view of the learners, who, in our study, were all ethnically diverse families with children in a nearby school serving culturally and linguistically diverse students. As in the other chapters in this volume, we focus here on the twists and changes of methods with time that made our research possible. We start with a short vignette, in order to introduce some of the themes we will advance.

Vignette 6.1 "What are we supposed to be doing?"

This question "What are we supposed to be doing?," was posed by "Leticia," an African American teenager (13 years old), to her family as they approached the DINO-Saurus exhibit. DINO-Saurus included a structurally large (3ft x 5ft) dinosaur head with an open mouth and detachable plastic teeth, surrounded by two tables displaying samples of meat-eating and plant-eating animals' teeth.

When Leticia and her family first came to the dinosaur head, they questioned each other about what was expected. Then, collaboratively and with much discussion and laughter, they put in the plastic teeth. Leticia said very little as she directed her younger brother, "Pedro" (6 years old), giving him some plastic teeth to place in the spot toward the back of the dinosaur's mouth. At that point Pedro turned to his mother, who stood next to him and was also placing teeth in the dinosaur's mouth, and told her that the teeth she was holding were molars.

Mother: How do you know those are the molars?
Pedro: Cause I know.
Mother: Did your teacher tell you?
Pedro: [laughing] Yes.

D. Ash et al. (eds.), Putting Theory into Practice, 97–117.

Soon after that exchange, the youngest brother, "Norman" (5 years old), jokingly punched the dinosaur with his older brother "Karl" (12 years old). He was directed by his mother to stop and join the others in the teeth placement activity. Norman joined Pedro and started to put the teeth in while Karl watched them from behind.

Pedro: No, look, lookit, lookit, look what I'm, what I'm doing! You twist it in.

Pedro was telling and guiding Norman to put the teeth in a certain way so they wouldn't easily fall out. But as he watched Pedro, Norman objected:

Norman: No! The sharp teeth ain't supposed to go up there!

Pedro disagreed by saying, "No, up!" and the two struggled to place the teeth. At this point, the mother said,

Mother: You can put them in any way you want. Let's look at these right here.

She got up and walked over to the other area of display and the boys followed.

("Aarons" family at DINO-Saurus)

This vignette provides a short summary of a digital video-captured segment (1:37 minute) of a longer visit at an interactive science exhibit at an urban museum of science and industry in south central Florida. Similar to many other families in our data set, the "Aarons" family collaborated in guiding each other to "figure out" how to "do" the exhibit.

The Aarons family (four children and a mother) initiated their visit with a question concerning how the family might navigate the exhibit. Such instances illustrate how families at such exhibits try to guess the intentions of the exhibit designers and, then, try to follow them. Leticia's question externalized what may have been on the minds of all family members. Such scenes have taught us a lot about how families make sense of exhibits in their own way. We use such vignettes, called "scaffolding scenes" in this chapter and in our research in general to illustrate aspects of how family members scaffold each other's understanding and actions.

In this chapter we argue that such scaffolding activities form the essential foundation for families' social practices of, first, determining how "to do" the exhibit, and, subsequently, approaching what they perceive to be the science (or other) content, typically interpreting that content in their own way. In this family, it was Leticia, the oldest daughter, who asked, "What are we supposed to be doing?" Her question indexed how *they,* as a family, would or could approach this exhibit. Leticia's question was followed by several instances of scaffolding. We originally viewed scaffolding more traditionally, as episodes where learner ability is assessed, guidance is given, and support eventually fades as the learner becomes more competent. Eventually we came to a more nuanced view of scaffolding. In this short segment, for example, we saw that Leticia guided Pedro by showing him;

then Pedro showed and taught Norman; then Norman and Pedro negotiated with one another, based on their distributed knowledge, while Karl watched. Like other families in our data set, we found that part of scaffolding and understanding the exhibit together included laughter and jokes as well as instances of shifting roles. In this scene, we also noticed that Pedro positioned himself as an authority by showing his mother and his younger brother, Norman, how and where to place the teeth. Others also took authority at times. Such complexity of activity requires detailed examination.

Once we had arrived at this rudimentary understanding of the complex amalgam of activity and talk that comprised what our research families *actually* did at such exhibits, we labelled this early activity "figuring out." Our next research step was to delve more deeply into the nuances of how social groups like these families actually make sense of museum exhibits and how, if at all, these activities related to the science content behind the exhibits, or to the goals of the exhibit designers. To accomplish this, we collected many (hundreds) scaffolding scenes across ten diverse families, representing a variety of cultures, educational backgrounds, financial circumstances, and interests. As we analyzed these segments, at four diverse exhibits, definite patterns began to emerge. We noticed that, like the Aarons family, most families had interactions that involved two or more learners continuously engaged with one another in scaffolded sense making. The sense-making activities, moreover, which before might have seemed somewhat idiosyncratic, now fit into more discrete categories with particular characteristics and functions.

We noticed, too, that many of these interactions included intense social activity such as playing, teasing, joking around, laughing, typically mixing science and non-science talk together seamlessly. Taking note of this mixing, or hybridizing of both social and scientific aspects by these families was an essential step in coming to understand the family activity of "figuring out." It became less important to locate the exact intended scientific content of the exhibit designers in family activity. We noted, instead, what family members actually did with the material presented to them, how or if they used their own available resources in negotiating meaning, and we watched intently for the outcomes of such intermixing or hybridizing of goals, and the ways family members used tools such as the exhibits, language and gesture. We understood that such 'figuring out activity' helped families to acculturate to this new setting. It appeared to make them more comfortable, and allowed them to use their existing social skills in the service of sense-making. We have written this chapter around this basic premise.

This chapter, then, closely traces the steps we took in developing this analysis and gradually coming to understand the full range of family participation in sense making practices in museums. Our "journey" of methods, like others in this book, is a practical look at the not-so-straightforward nature of doing research. We include turning point moments. Our intent is to clarify the complex and sometimes unexpected steps such 'messy' research engenders.

One such turning point in clarifying our analysis was our realization that, in order to understand families' sense-making activities, we needed to look at the

entirety of what families actually did at exhibits in its full complexity rather than focusing exclusively on science content. Using this holistic approach challenged us to work in new ways. We had to expand our views of what counted as science when coding scientific talk and action. We had to design new ways of segmenting, coding, and analysing all the data, as well as find new ways to represent our thinking about family interactivity. We also needed to include an analysis of the social function of humour in family interactions of scientific sense making.

Another turning point came as we recognized the need to expand our vision of how to identify a reliable unit of analysis in order to include the activity and talk of all five participants involved in entering into, guiding, talking with, and scaffolding each others' understandings. The origins of, and rubrics for, identifying this new kind of social unit of analysis, which we have called "scaffolding scenes," is described below in the methods section.

We also explored how to code families' laughter and joking around, as in the above vignette. We wondered what joking might have to do with scaffolding, science learning, or doing science, if anything at all. All these and other questions led us to explore different theoretical and methodological pathways, allowing us to re-examine the concept of scaffolding, meaning making and family social practices in science museums

Before we describe the methods as they evolved and our own problem solving, we want to clarify our theoretical framework. Then we discuss the methodological tools we created and our reasoning in designing and choosing them. We then present our preliminary findings and end with a discussion of implications for future research.

THEORETICAL UNDERPINNINGS

Early on, we determined to use the concept of scaffolding in informal settings in our research and thus place our research findings firmly within this theoretical domain. Scaffolding research has become quite common in classrooms (Cazden, 2001); although this is not true in out-of-school settings. In our research we were particularly interested in scaffolding interactions in informal settings, because we believe that museums and other informal settings have the potential for offering rich learning contexts where we might see naturalistic scaffolding as it occurs with families and educators. This is particularly true when compared with what is often perceived as the more hierarchical or formulaic modes we expect to see in classroom settings.

Moreover, the theory and practice of scaffolding fits naturally within sociocultural views of learning, especially Vygotsky's (1978) notion of the "zone of proximal development" [ZPD]. Wells (1999), a cultural-historical activity theorist, viewed scaffolding as "working within the ZPD." Such "working in the ZPD" is one way to concretize scaffolding; the ZPD is defined as an area within which a learner can traverse from current to higher levels, with the scaffolding (or cognitive, developmentally-significant assistance) of a capable peer, book, video, adult, etc. (Brown et al., 1993).

A further motivation for our central emphasis on scaffolding was the lack of documentation about how adults, children and families from underserved communities (e.g., communities with high percentages of families from non-European-American backgrounds, high levels of cultural and linguistic diversity, and low socioeconomic status) participate in scaffolding activities, particularly in informal settings. We discovered that recent findings on scaffolding (Grannot, 2005), participation as joint activity (Lave & Wenger, 1991), as well as activity theory (Engeström, 1999) have helped us think more equitably, as well as more accurately, about learning in places like museums.

Historically, the concept of scaffolding has evolved tremendously since Wood, Bruner, and Ross (1976) first defined it as "a process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts" (p. 90). Since then, Granott (2005), Mascolo (2005) and others have proposed multiple ways in which scaffolding can be reconceived to reflect a less hierarchical and more mutual relationship between "scaffolder" and "scaffoldee." They have suggested that scaffolding can occur reciprocally (e.g., back and forth exchanges or negotiations between two or more) rather than only unidirectional (e.g., adult guiding a child).

In more socially-collaborative terms (beyond dyads, for example), scaffolding occurs in situations in which all family members, working together as an "ensemble," are responsible for instructional activity, such as planning, monitoring, and structuring (e.g., a mother directs her children, children follow mother's direction, and mother monitors the progress of their activity) (Granott, 2005). Granott, Fischer, and Parziale (2002), explained that "an ensemble includes the smallest group that co-constructs knowledge and the mediational tools and semiotic resources they use" (p. 123). Ensembles are "microcontexts of development that are embedded within and in a bi-directional relationship with the larger cultural context" (Stone & Gutiérrez, 2007, p. 45).

We ultimately developed a complex, multifaceted, and multi-directional lens of scaffolding. The characteristics that defined scaffolding in our study included: (a) several people engaging in joint activity; (b) one member typically asking for or receiving a question or explanation; (c) the exchange occurring between members who are cross-age or cross-generations (e.g., sibling to sibling or parent to child); and, (d) support fades as participant becomes more proficient.

In the research reported here we had come to view scaffolding as an on-going, recursive, and collective/collaborative activity in which learning goals or objectives are defined and redefined as part of the group's in situ activity (Stone & Gutiérrez, 2007). We found that certain components of scaffolding, such as "fading," which is the gradual extinguishing of guidance with mastery of a skill or concept (Pea, 2004), were embedded and sometimes distributed in scaffolding episodes. For example, a family might at one moment attempt to figure out where to place the dinosaur teeth, then switch to figuring out why the teeth have different shapes, and then, some time later, come back to figuring out the teeth placement. In our data set with family participants, we found, as did Stone and Gutiérrez (2007), that the goals of any learning activity were first defined, then sometimes aband-

oned, and oftentimes revisited. Our data suggest that learning activities in which the learning goals are distributed, abandoned and revisited are representative of and reflect the flow of meaning-making we saw in situ with these ten research families.

The idea of participation in joint activity, as suggested by Lave and Wenger, (1991) offered us a powerful expansion to our understanding of scaffolding. "Participation" or practice can account for the evolving identity of the person or people who are increasing their expertise/experience as well as changing their (category) membership(s) in a community; for example, people who know how to interact with museum exhibits versus those who do not. Participants such as Leticia, Pedro and Norman are expected to give and take from each other and also to continually (re)define their roles. By observing such activity we can see how identities shift, not only with increasing expertise with a task (e.g., competence), but also with shifting roles, such as from observer to leader or student to teacher. A case in point was when Pedro (6) moved from the position of a learner (e.g., follows his sister Leticia's guidance) to the position of teaching his mother about types of teeth (e.g., Pedro telling his mom about molars).

Such examples of participatory identity shift became important for our current research with non-traditional museum visitors, because part of knowing how to "do" (science) museum exhibits involves the extent to which one feels comfortable and familiar with being in museums. In working with participants who are non-traditional museum visitors (e.g., those who are non-European-American, culturally and linguistically diverse, and/or low socioeconomic status individuals), we wanted to address how participants situate themselves with respect to the exhibits, negotiate with one another and with museum "tools" in knowledge construction, and *become* participants of a science activity in a museum. We came to realize that mutual and reciprocal participation was an integral part of how family members scaffold with one another at museum exhibits, and which guides their *being* with each other while interacting with museum tools.

Activity theory (Engeström, 1999) was particularly applicable to our analysis because it encouraged us to think about learners working toward a collective goal or objective while using multiple meditational means (tools) such as language and the exhibits. Such a framework seemed singularly applicable to our museum visitor families. The "scaffolding scene," for example, was based on our examination of the movements and actions of participating families. Activity theory proposed that the productive and unique outcome of an activity comes from the agency of participating members (e.g., family members acting singly and collectively), and the mediating tools (e.g., museum exhibits, talk, gestures, signs, and videos) they choose to use. We found such analysis very appropriate to our data because it helped to explain the fluid movements and groupings in which our family participants engaged as they collaborated with one another in figuring out the exhibits.

Research in educational settings, such as classrooms, has also begun to give more attention to how students create hybrid spaces or alternative ways of making meaning of "official" academic content. Hybridity is understood as a theoretical "in-between-ness" or a liminal arena in which we apply, evaluate, and/or adjust our knowing, doing, and being to approaching different situations (Moje et al., 2004).

Calabrese Barton, Tan, and Rivet (2008), for example, described ways in which middle school girls participate in class and engage in science by merging their social world with the school science world. The authors argued that the girls took on authority by merging their social world with that of school science. Using our more fluid notion of scaffolding, our observation and analysis, as detailed below, revealed what Gutiérrez, Baquedano-Lopez, and Tejeda (1999) have described as engagement in "hybrid" activities.

Lastly, we came to understand that notions of hybridity should be applied to our observations of how families "figure out" science museum exhibits. In the scaffolding scene of the Aarons family reported above, for example, we noted that laughter, playing around, and arguing were some of the ways in which the family collaborated in figuring out the task at the exhibit. Joking was melded with science content seamlessly as the family's social world came into direct contact with the designed science content. Using the concept of hybridity in further analysis, we began to see that the families were merging their personal narrative and ways of doing things with the museum narrative, with scaffolding taking on a form of hybrid multi-textual talking and doing. We came to label this hybrid activity "figuring out," which we elaborate on below.

We found that by refocusing our analysis on the hybrid activities embedded in scaffolding scenes, such as the one above with the Aarons family, we were closely examining "families being families." We came to deeply appreciate the educational productivity of such activities, especially the unscripted interactions among family members. We began to place the families' agendas at the forefront of our research, and we looked to the families to instruct us about what they did with the museum exhibits. We found that beginning with the family, rather than focusing on the science, did not change the methodology overall, but shifted the viewing lens considerably and helpfully. Shifting methodological lenses has been crucial in guiding us to re-examine the concept of scaffolding and discern how meaning making is actually happening. This, finally, helps us inform museums about the collaboration practices of culturally diverse family visitors, which can, in turn, help them in their exhibit design.

A JOURNEY OF ANALYSIS AND FINDING

A Word about the Data and Context

Our research team uses sophisticated equipment and software to collect and analyze a large digital database of audio and video recordings of family museum visits. Data collection for this study was naturalistic (Moschovich & Brenner, 2000), and focused on four diverse hands-on exhibits.[i] The data included interviews with families before and after museum visits, as well as audio- and videotaped capture and transcription of visits and ethnographic notes. We routinely used at least two camera angles and up to four remote microphones to capture family dialogue. We currently have a completed sample size of 42 families visiting interactive exhibits at a large science museum in south Florida, with and without

mediation by a museum educator/docent. We focus in this chapter on the detailed activities of 10 diverse families visiting two exhibits without museum educator mediation:[ii] the DINO-Saurus exhibit described in the introductory vignette; and the Bed of Nails (BON) exhibit which included a table of 3000 nails with the sharp ends pointing upward. A visitor lies on the bed and pushes a button so that the nails then rose and created a "mattress" of nails under the visitor.

All of the families were invited to participate as part of an ongoing collaborative agreement with a Title 1[iii] school across the street from the museum site. Families with 2nd or 3rd grade students (preferably with an older child as well) were invited to attend a Family Science night at the museum; from this some families were recruited to participate further. The museum and school serve a typical U.S. urban city with a mixture of cultures, languages and ethnicities. We include the families' demographics in Table 6.1 (42 families) and Table 6.2 (subset of 10 families).

The Power of "Scaffolding Scenes" as a Methodological Tool

The research we report on here reached a depth of understanding and analysis that took our colleagues and us by surprise. It took months of trying everything we knew and following clues to fine-tune our methods and units of analysis to have the insights we finally achieved. Initially, we began with "traditional" qualitative methods to familiarize ourselves with the families. We observed video clips and read transcripts; we took notes of events that stood out to us as potential patterns, trends or themes that related to how participants learned or guided one another; and then we categorized these events. Such an iterative search for patterns and trends is typical of modern qualitative research (Strauss & Corbin, 1998).

Table 6.1. Demographic Information of All Family Participants

Race/Ethnicity of family		Language of family		Educational level of parents	
Caucasian	15 (35.7%)	Monolingual English	27 (64%)	Less than high school	1 (2%)
Latino	13 (30.9%)	Monolingual Spanish	3 (7%)	Attended high school	2 (4%)
African American	9 (21.4%)	English/ Spanish	10 (24%)	Completed high school	22 (40%)
Asian	1 (2.3%)	Other	2 (5%)	Attended college/no degree	13 (23%)
Middle Eastern	1 (2.3%)	Total families	42		
Multi-Race/Ethnic	3 (7.1%)			BA/BSc Degree	10 (18%)
Total families	42			MA/MSc/MBA Degree	7 (13%)
				Total parents*	55

*The total number of parents reflects dual and single parent households.

Table 6.2. Demographic Information of Our Sample Subset of 10 Families

Race/Ethnicity of family		Language of family		Educational level of parents	
Caucasian	4 (40%)	Monolingual English	7 (70%)	Completed high school	7 (39%)
Latino	3 (30%)	Monolingual Spanish	1 (10%)	Attended college/no degree	8 (44%)
African American	2 (20%)	English/ Spanish	2 (20%)	BA/BSc degree	3 (17%)
Multi-Race/Ethnic	1 (10%)	Total families	10	Total parents*	18
Total families	10				

*The total number of parents reflects dual and single parent households.

We approached our data originally from a macro-level, eventually viewing the data from three levels—macro, intermediate and micro. Using the macro perspective first, we holistically watched and read transcripts of what families did and said in order to gain insights on how to think about the units of analysis and eventual coding schemes we would need to capture what was actually happening. We first looked for the words and ideas of science in participant dialogue, but that was not what we found. Rather, we discovered that many families seemed to be trying to make sense of what the exhibit itself wanted them to do, i.e., answering for themselves the question: "What are we supposed to be doing?" Only after the family felt they had answered that question were they able to appropriate the ideas and words of science embedded in the exhibit. This realization led us to refocus our observations away from a more standard search for science words and ideas and instead to deeply examine the actual family activity we saw.

This initial macro-analysis, then, led us to more actively examine how cultural-historical activity theory (Engeström, 1999) could inform our search for an appropriate unit of analysis for what these families actually did at the two exhibits. With this mindset, we next set out to cleanly define and select meaningful units of analysis that captured activity as it was happening. Toward this end, we used Studio Code, qualitative analysis software that has the capabilities to segment, code, and tabulate instances of video data. We segmented our video data into what we called "scaffolding scenes," which were episodes of family activity (families working together toward a common goal using the tools and meditational means available to them) with coherent beginnings and endings at museum exhibits. The scaffolding scenes represented the intermediate level of analysis.

The established criteria for coding scaffolding scenes included identifiable exchanges involving at least two people that include at least one turn or exchange, whereby an exchange was defined as an initiation of talk or gesture that solicits a response in the form of talk or gesture. In the museum context, we identified

moments in which someone was talking/gesturing to someone else at the exhibit. Specifically:

- Scaffolding scenes appear in two or more lines of the transcript.
- The initiation of a "scaffolding scene" was identified by the following:
  - Indicated by gesture and/or talk (e.g., topic),
  - Scene starts right before the first utterance or gesture of the new scene,
  - The presence of signifiers of transitions in dialogue (e.g. "Let's look at this display.") or movement (e.g., all participants come to display table and begin talking).
- The end of a "scaffolding scene" was identified by the following:
  - Indicated by gesture and/or talk (e.g., topic),
  - Scene ends right before the first utterance or gesture of a new scene,
  - The presence of signifiers of transitions in dialogue (e.g. "Let's move to the next exhibit.") or movement (e.g., all participants leave display table).

We also set a criterion that allowed analysts to disagree *within 2 to 4 lines* of the transcript. We had a total of three pairs of analysts. We practiced segmenting scaffolding scenes of one family visit, discussing and resolving our disagreements and then established reliability with two more family visits. We determined reliability by comparing where we started and ended our scenes, as marked on transcripts. We achieved 80% agreement between the three pairs of analysts.

The scaffolding scene intermediate level allowed us to organize our video data into smaller, exemplary, manageable and coherent chunks. At that point we were able to begin to look at the more nuanced details of family activities, especially in terms of how families organize themselves, use the tools and materials at the exhibit, and negotiate their participation.

The "scaffolding scene" was a methodological unit of analysis we created out of necessity, as we worked, and it was based on our examination of the movements and actions of our participating families. We appealed to Activity Theory (Engeström, 1999) for its theoretical grounding, as each scene contained a desired outcome stemming from participating members (e.g., family members) using mediating means (e.g., talk). We discussed in chapter 3 the other uses to which scaffolding scenes were put, specifically for professional development. Scaffolding scenes in the context discussed here allowed us to clearly and reliably identify a segment of activity; from *that* we were able to conduct a microanalysis of other dimensions within them, including science content and processes, such as questioning, as well as its perceived function.

Breaking down scaffolding scenes to examine science content was the first aspect of the micro-level analysis. Examples of science content coding included the following categories for the DINO-Saurus exhibit; Table 6.3 below has sample categories.

Table 6.3. Science Content Codes

Science Content Codes at DINO-Saurus	*Example of Occurrences in Family Dialogue*
Identification	Dad to daughter: " Which one is the shark's tooth? Well, you see the pictures. Which one is the shark tooth?"
(Connecting to) Our body	Grandma to child: "Well remember, like, these would be like your teeth, your back teeth probably. Okay. Think about that."
Tooth function	Dad to daughter: "Well see how his teeth are different? 'Cause they're plant eaters."
Tooth placement	Mom to son: "I don't think you just stick it anywhere because how do we know this one goes in the back?"
Tooth shape	Mom to son: "And the elephant has flat teeth."

After completing this coding round, we realized that coding for science content alone did not allow us to capture fully how families were approaching the exhibit and making meaning of it. If we had relied solely on these data, we would have missed most of what actually happened at the exhibits. Some families, in fact, did not engage in "science" talk at all; yet it was clear from the intermediate analysis of scaffolding scenes that scientific meaning was being made. We knew that the actual activity in which families engaged was relevant to the purpose of learning about the exhibit and/or the science behind the exhibit, because we had seen from the macro perspective where such activities eventuated.

Noting the lack of power of science content coding to capture the nuances of the social and science sensemaking we were witnessing, we decided next to segment more minute instances of scaffolding. In short, we broke down the existing units of analysis into even smaller segments, in order to see more details of family collaboration. We coded micro-episodes of teaching, directing, and collaborating interactions. We called these smaller and more detailed segments "figuring out" segments. These smaller instances gave evidence to support the nuanced productivity we were seeing in the larger "scaffolding scenes" but which were not reflected in the content codes.

These micro "figuring out" segments illustrated more forcefully the ways in which families worked together, scaffolded, and figured out the exhibit, whether or not they talked about science content. The instances were coded within each of the original scaffolding scenes,[4iv] so that they could be added together or taken separately as data. "Figuring out" instances were part of our micro-level analysis. Such instances include the categories in Table 6.4.

Table 6.4. "Figuring Out" Instances

Categories of Figuring Out Instances	*Example of Occurrences in Family Dialogue*
Questioning how exhibit works	Dad to family: "What are we supposed to do?"
Teaching how exhibit works	Dad to sons: "So it's to grind stuff down. He doesn't have sharp teeth like these that rip apart meat."
Explaining how to do exhibit	Boy to grandma: "One, two, and then this is the third one." (Boy counting teeth spot away from center of his front teeth to indicate where canine tooth goes). Grandma, "Is there a number (on the tooth) or how do you know (where it goes)? Oh-" Boy says, "'Cause I count my teeth." Grandma says, "oh" (laughs).
Reading signs about exhibit	(Reading instructions or captions of displays)
Directing about how exhibit works	Dad to sons: "Put the teeth there."
Showing/demonstrating how exhibit works	Boy to his brother: "Look how I'm doing it."
"Teamwork"/collaborating with others	Mom says to her sons as she begins to put teeth in, "You might need a little help. You got it?"
"Figuring out" through observation	(No dialogue; engaged observation of exhibit or someone doing exhibit)

We subsequently came to realize that even though micro "figuring out" instances did not necessarily overlap with talk about science content, talking about how the exhibit worked did facilitate talk about the science behind the exhibit. This important finding changed how we looked at what the families were doing. Because "figuring out" behaviors did, in fact, smooth the way for talking about and understanding science content, they became key activities to track and understand.

An example of how talking about how the exhibit works facilitated talk about the science behind the exhibit was the visit of the Nedder (Caucasian) family at the DINO-Saurus exhibit. A son (8 years old) and daughter (13 years old) argued about how they were supposed to start working on the same dinosaur mentioned at the beginning of this chapter. The daughter said that the teeth should be taken out, while the son said they should be left inside the mouth. During this initial dialogue, as the siblings talked about correct procedures for how to do the exhibit, they never talked about science content explicitly. Their argument was, however, a prelude to some real talk about the proper placement of teeth in the dinosaur's mouth, which was the focal science content at this exhibit. This example was echoed throughout

the data. Because figuring out the exhibit and the science behind the exhibit appeared so interconnected in so many family interactions, we later did not distinguish between these two processes in coding "figuring out" instances within any scaffolding scenes. We see the total number of figuring out instances for all 10 families at both exhibits in Table 6.5 below.

Table 6.5. "Figuring Out" Segments Category Detail

Categories of Figuring out Instances	Bed of Nails Exhibit	DINO-Saurus Exhibit
Questioning how exhibit works	15	14
Teaching how exhibit works	6	27
Explaining how to do exhibit	3	9
Reading signs about exhibit	3	18
Directing about how exhibit works	45	41
Showing/demonstrating how exhibit works	2	13
"Teamwork"/Collaborating with others	0	12
"Figuring out" through observation	7	1

The collected coding data (10 families) indicate clearly that families "figure out" the exhibits overwhelmingly by directing and teaching one another. This was the case across both exhibits we examined. Family members predominantly taught each other about how to use the exhibit in a variety of ways; this is welcome news as there was limited signage and no museum educator present for these interactions. As with many hands-on museums, these exhibits were designed for use by families with children.

This is an important finding as these seemingly simple data represent thousands of micro activity units tracked, marked and coded for diverse families of 3-6 members by three coding teams including multiple reliability checks and many terabytes of hard drive storage. The beauty of Studio Code, however, is that we can re-capture the coding as well as the digital sample of all these micro, intermediate or macro units. We have coded the data so that we can track each family, each individual and/or collections of them (see Ash & Lombana, chapter 3, for a sample of video code data).

Still, although very useful and rich due to the number of events they represent, the data represented in Table 6.5 still do not entirely reflect how families interacted. Family members taught each other and constantly interacted in a variety of nuanced ways and with many diverse outcomes. Just as capturing content was not sufficient, merely naming the kinds of interaction (directing, questioning, etc) was also insufficient. We therefore also coded for the function of these micro units. Table 6.6 lists the functions of the micro units. When we compare Table 6.4 with Table 6.6, for instance, we can see that important social aspects such as humor play a large part in the function of an activity. We perceived humor to play an important role in shifting authority, empowering, and building confidence of individuals or the entire family. As the two vignettes and data summarized in Tables 6.4-6.6 suggest, families spent a great deal of time laughing and creating a sense of "fun" when doing the exhibits, when collaborating in knowledge construction (working together to "solve" problem presented to them at exhibit), and interestingly, when

making meta-comments, for example, talking about the exhibit functioning, including evaluation of the actual task of the exhibit, the experience of doing the exhibit; and/or expressing feelings about the exhibit.

There were differences between the two exhibits, as well. The DINO-Saurus exhibit elicited more demonstration and collaborative work than the Bed of Nails, where the family group simply stood and observed as one member after the other tried out the exhibit. The DINO-Saurus exhibit, on the other hand, included a larger space with multiple structures for manipulation. We believe that this larger, more diverse structure allowed greater potential for visiting families to make meaning of the exhibit as well as to consider the science together (See the PISEC study for family friendly exhibit structures, Borun et al., 1998).

Table 6.6. Functions of "Figuring Out" Segments

Meta-Comment: Family talk about exhibit functioning.

Function of Family Talk/Activity	*Example/Description*
Evaluation of the actual task of exhibit or experience of doing exhibit; expressing feelings about exhibit.	"It feels weird." [Referring to BON]; "this is hard to do"; "I thought I couldn't do this but now I can"; "This is fun."

Humor/Play: Family creating sense of "fun" in doing exhibit.

Function of Family Talk/Activity	*Example/Description*
Shifting authority, empowering, and building confidence	"I hope they don't stick in you." [referring to nails in BON] "No, no hammers, just nails." [Responding to Dad's joke at BON] "He was too scared to get on last time."

Collaborating in Knowledge Construction: Family working together to "solve" problem presented to them at exhibit and how to "do" exhibit. Scientific explanation about exhibit.

Function of Family Talk/Activity	*Example/Description*
Collaboration in disciplinary science knowledge.	"But if you do any variation, it'll … you'll feel a pinch. It's something about where your body is aligned … Why doesn't it hurt?" [Comment made about BON]
Collaboration in manipulating or talking about manipulating exhibit.	"It tickles." "It's relaxing." [Comment made about BON]

Our data indicate that much of the family talk, which was organized around directing or teaching/telling one another what to do, concerned coordinating with each other about figuring out how the exhibit works and, in turn, discovering the science message behind it. We saw families acting quite naturally and bringing to the exhibit "repertoires of practices," or "people's usual ways of doing things"

based on their history of participation in their varied communities, including ethnic, national, academic or religious communities (Gutiérrez & Rogoff, 2003). We consider these merged social and museum-directed practices as examples of hybrid ways of doing museums. In light of the data just presented, we can now re-visit the introductory scaffolding scene of the Aarons family, which showed how the family worked as an "ensemble" (Granott, 2005) to make sense of DINO-saurus. That scaffolding scene showed how members of the family participated in the collaborative figuring out of the exhibit by co-constructing their own hybrid understanding of the exhibit.

To recapitulate briefly, we saw Leticia, directing Pedro silently (gesture) about where to place a certain plastic tooth in the dinosaur's mouth. Pedro then turned to his mother to tell her (explain) that the teeth the mother was holding were molars. Pedro, in essence, re-positioned himself as an authority and tried out a narrative about "molars" as he understood it. The mother asked Pedro how he knew and whether his teacher had told him that information (domain expertise). The mother legitimized Pedro's knowledge and furthered his ideas about molars. When Norman joined him, Pedro had another opportunity to assert his authority by showing (directing) Norman how to place the tooth in the dinosaur's mouth so that it did not fall out. Norman challenged (authority) him and they, then, briefly worked collaboratively. The mother decided (authority) when to move on. They joked, bid for authority, shared expertise, changed teaching roles, illustrated a full range of social skills and scaffolded each other constantly. The Aarons family made sense of this exhibit through the co-construction and appropriation of multiple storylines (e.g., Leticia guided Pedro, Pedro showed Mom and Norman).

While one could suggest that very little explicit science occurred, we would argue that this family (new to museums) seamlessly merged their social agenda with that of the exhibit and museum. DINO-saurus was a hands-on exhibit; they experimented quite a bit with their hands, actions and talk. They intermixed words like molar with jokes and directions to each other. They played out family dynamics; the mother seemed to favor Pedro, for example, and Leticia often was a little "mother." The intermediate level scaffolding scene was comprised of many micro figuring out scenes that sometimes contained formal science content, often contained humour as well as commands, jokes and meta recognitions, but typically merged social and museum science. In short we can understand the Aarons family activity better by having analyzed their (and nine other families) activity in a series of ever more discrete slices.

Other families in our data set, like the Racelli family below, (as well as all of those included in the figuring out segments in Tables 6.4 & 6.6), were similarly engaged in hybrid interactivity. We present here another scaffolding scene vignette (3:03 minutes) with the Racelli family at the Bed of Nails exhibit:

Vignette 6.2 "Push the button eh Mom, push the button"

Present at this exhibit were the mother (mid-40s) and her three children, "Susan" (15 years old), "Fidel" (12 years old), and "Diego" (7 years old).

> The family code-switched between Colombian Spanish and English, although the mother spoke mostly Spanish in this particular scene. First the children went on the bed of nails and, last, the mother. All three children observed attentively as the mother positioned herself onto the bed of nails.
>
> Diego: Now it's Mom's turn!"
>
> Mother: Yo teng chancletas. Yo si voy a sentirlo mas [I have sandals/flip-flops. I'm going to feel it the most].
>
> As the mother got onto the bed, Fidel directed her in a soft, almost teacher-like voice, "Push the button eh Mom, push the button." Then the three children carefully and quietly observed as the mother pushed the button and worked the exhibit. Once the nails rose on the bed, the mother held the button for a few seconds, and then Diego broke the silence.
>
> Diego: Hey Mom can do it! … OK Mom, let go!
>
> Fidel: Mom, let go.
>
> Mother: You see?
>
> The mother's last comment may have been meant to reassure the children that it is OK to get on the Bed of Nails. It also may have covered her own fear of going on the nails in her simple shoes. In either case, the children lead the event. ("Racelli" family at BON)

This scene may be painfully "unscientific" to those designing exhibits and for those educators wishing for a rich discussion of the distribution of weight across the many nails. We have collaborated now with many diverse families at Bed of Nails and we can claim that the science of weight distribution underlying the exhibit arises far less often than family bonding times, which the Racelli family demonstrates. As both social and natural scientists, we have asked ourselves, often, how we are to treat such data? Do we discount it because we do not "see the science" or do we find new ways to "see the data?" We have chosen the latter. We have seen many episodes like the Racelli family at the seemingly content rich but in practice science content barren bed of nails. Such a disconnect between design and reality is the dilemma of all science museums. Rather than viewing such data as a failure of effort, we have chosen to interpret them as opportunities and occasions for social bonding, use of humor, and for the children to be on an equal playing field with the adults. In short, they are opportunities to acculturate to the museum setting. We can see, for example, in the above scene that the Racelli mother shifted her role from being the oldest person, adult, and leader to being just another participant in the exhibit, allowing her children to guide her as she worked the button. Toward the end her comment "You see?" seemed to indicate her

switching back to her leadership role to teach her children to not be afraid of the Bed of Nails.

Like other families in our sample, the Racelli family had little discussion about the physics behind the exhibit, but their museum practice arguably points to other "lessons" that the exhibit offered them. By allowing the children to take on leadership positions, the mother was teaching or scaffolding the children to be a part of a collaborative effort to problem-solve an exhibit like the Bed of Nails, in which there is the prospect of danger in lying on nails. The Racelli family above demonstrates how families often merge (or even override) the museums' way to "do" the exhibit with their own ways of doing.

Methodologically, as we juxtaposed the figuring out instances (micro-level analysis) within a scaffolding scene (intermediary analysis), we discovered that the Aarons and Racelli families, like most other families in our data set, were merging or hybridizing "being in a family" with "doing museum." Essentially, the family participants created their own learning space in the merging or hybridizing of multi-layered "story-lines" and ways of doing.

Identifying the families' nuanced figuring out practices, such as shifting authority roles and creating alternative "lessons," gave us insight into the families' "cultural practices." A word of caution is important here. Our goal in referring to cultural practices is not to essentialize by suggesting that certain ways of talking and doing museum can be labelled as belonging to certain cultural groups. Rather, we refer to individuals' "engagement in shared and dynamic practices of different communities" (Gutiérrez & Rogoff, 2003, p. 21) as cultural practices that are based on their history of participation in their own varied communities. Culture, in this perspective, is embedded in the ways we are, do, and think that are derived from our participation and membership(s) in community(ies) and that are enacted *in situ* (Rogoff et al., 2003). In our study, for example, we found that parents participated differentially, ranging from acting as full participants/manipulators of the exhibit, to taking on "teacher" roles, or to standing back observing the children manipulate the exhibit. These practices may be rooted in parents' personal and/or cultural beliefs or ethno-theories about how children learn (e.g., by being directly taught or by observing) and the purpose of visiting museums (e.g., to acquire knowledge or to entertain) (Puchner, Rapoport, & Gaskins, 2001).

Ways of being, doing and thinking are not, however, tangible items that we can easily label. Instead, they continually shift as experiences accumulate. Analytic complexity is intensified as well when we cross community practices and contexts, such as speaking Spanish at home and speaking English in a science museum. For this reason, the concept of "hybridity" or "hybrid spaces" (Gutiérrez et al., 1999; Moje et al., 2001) is useful to capture the fluidity and "messiness" that is inherent in the crossing or blending of ways of doing, knowing and being. In our study, we found that "hybridity" reflected well the manner in which multilayered narratives indexed the merging or blending of "being a family" and merging the family social agenda with the museum science.

We end this discussion with an extended quote from Calabrese Barton et al. (2008), focusing on urban girls and school science. The sentiments and the argument work equally well with our diverse families and urban museum settings.

> In our own work, we are interested in hybridity because we have observed time and time again youth taking up knowledges, resources, and identities in novel ways that often go unsanctioned by school science …. This allows them to build their social identities while they build and gain epistemic authority. (p. 71)

The short vignettes offered here only begins to tell the story. The collective and detailed data of ten families confirm these ideas, and the triangulation across coding schemes, ethnographic notes and detailed interviews give us reason to strongly suggest that we need to look at diverse families "doing exhibits" in new ways. In Calabrese Barton et al.'s terminology, these families often take up unsanctioned topics and ways of doing, using them in ways novel to them and, in doing so, build their own authority and identity as museum goers and knowledgeable of science.

CONCLUSION AND IMPLICATIONS

Knowing how families, particularly those of traditionally marginalized backgrounds, "do" museum exhibits is an important step in making informal learning spaces more effective and accessible. Our research is undertaken in agreement with those who are working toward "reinventing the museum" (Mesa-Bains, 2007). As we traced our methodology for this chapter, we could see clearly what a critical turning point it was for us to focus on understanding what families are actually saying and doing. By doing this, we legitimized families' ways of being, or, as Moje et al. (2004) proposed, we asserted the value of the knowledge and discourses that have traditionally been marginalized. Understanding the families' hybrid activities has become important for three important reasons.

1. Locating Scaffolding

One of the important lessons we gathered from our research process was the need to organize and make sense of the complexity of video data so that we could both locate scaffolding as well as find meaning in the families' activities. We found that we needed to create a dialogue, or multiple back and forward shifts, between the three levels of analysis in order to find the underlying coherence in the progress and continuity of families' figuring out activities as well as to discern the context in which learning is taking place for them.

2. Implications for Education and Museum Research

Focusing or "noticing" what families do, as Ash and Lombana pointed out in chapter 3 of this book, has important implications for the teaching practices of museum educators/researchers as well as for museums as they consider exhibit designs. Part of what families do is based on how they interpret the purpose of the

exhibit, instructional signs, museum objects, etc. The scaffolding scenes we cited, for instance, revealed that family members were learning social lessons (e.g., how to take on leadership roles, how to be in a family, how exhibits work, etc.). In addition, understanding families' collaboration and participation practice is important and a way into understanding how families construct the agenda/lesson/goals of their visit as they see it. By noticing what families actually do, museum educators (e.g., docents and explainers) can coordinate family agenda(s) with the museum's agenda(s) for each exhibit. A museum educator can, for example, make museum exhibits more engaging for families by making space in the exhibit design for families to first or simultaneously generate topics of discussion of interest to the family before engaging in the exhibit's activity(ies). This might have changed the design of the Bed of Nails and allowed the Racelli family's concern about why one should not fear lying on a bed of 3000 nails to become more explicit. If families unaccustomed to museums or to an exhibit's particular format refrain from engaging with it, designers, educators and administrators need to recognize that and work to mitigate such fears. We have found that such fears, humor, and discussion, first addresses concerns so that learners can then segue into the science lessons that the museum exhibit originally intended to convey. We are now in the process of implementing a professional development program for museum educators based on our findings in this research (see Ash & Lombana, chapter 3).

3. Legitimizing Hybrid Doing

Because museums serve the public and are invested in equitable access by members of all communities, understanding what families actually do at exhibits powerfully legitimizes their families' practices. We argue that families' nuanced ways of talking and "doing" science museum exhibits are expressions of agency. That is, by doing what they do, families are asserting how and what they take from science museums. This does not necessarily follow the expectations of science museum exhibit designers; recognizing the effects of hybridizing activities can change that for science museums.

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NOTES

[i] Tug of War, Bed of Nails, Dino-Saurus, Museum Magnified.

[ii] We chose for our sub-sample of families in this particular study a representative cross-section of the racial/ethnic diversity in the south central Florida community, which is, as well, a representative cross-section of our total sample of 42 families.

[iii] Title 1 schools—Improving The Academic Achievement Of The Disadvantaged. The purpose of this title is to ensure that all children have a fair, equal, and significant opportunity to obtain a high-

quality education and reach, at a minimum, proficiency on challenging State academic achievement standards and state academic assessments.

[iv] Studio Code allows sub division of existing segments.

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AFFILIATIONS

Thao Mai
Department of Education
University of California Santa Cruz
thao707@gmail.com

Doris B. Ash
Department of Education
University of California Santa Cruz
dash5@ucsc.edu

LEAH MELBER

PUTTING THEORY INTO PRACTICE

MAI AND ASH'S TRACING OUR METHODOLOGICAL STEPS

The nature of a museum visit is a complex one. How we as researcher and practitioners categorize the behaviors we observe and the conversations we overhear provides the lens through which we form opinions about the visitor experience. In looking specifically at how families scaffold a museum experience for each other, Mai and Ash explore the importance of a multi-faceted and multi-directional approach to how we research this interplay.

For my dissertation, which centered on how mothers spoke to young children in a mammal diorama hall with regards to zoological concepts or perceived imagery, I incorporated video and transcript analysis. My method implied the coding of each phrase or sentence as conceptual or perceptual using established codes from the literature—a micro perspective if you will. One young subject would enthusiastically declare either "I like those!!" or "Oh mommy, I DON'T like those" as he moved from animal to animal. It wasn't until I looked at the video later and conceptualized all of his comments as a whole that I realized the little guy had an affinity for herbivorous prey animals and categorically did not like anything resembling a predator. The full meaning of the repeated *like* and *dislike* comments did not become clear when looked upon in their totality, viewing the data at an intermediate level. Unfortunately, as it was not part of my core research question beyond simply coding them as "conceptual," I did not unpack any patterns of maternal response to this key issue of like and dislike, and thus missed the opportunity to explore at a macro level of complexity how as a family they were addressing potential fear of predatory animals.

The necessity of exploring at micro, intermediate and macro level in order to better understand the "figuring out" process of families would seem a natural requirement. However, as we strive to align informal learning research with what has gone before us within the formal sector, the reduction of data to discrete units in order to cleanly code and quantitatively analyze can occur and potentially impact our ability to fully understand the family museum experience. Mai and Ash reinforce the importance of a multi-faceted approach to unpacking the family experience within a museum, the critical role this plays in particular when working with diverse families, and provide a sound method for moving forward in this philosophy.

D. Ash et al. (eds.), Putting Theory into Practice, 119–120.

DISCUSSION QUESTIONS

1. Can you recall an observation you made where your initial interpretation of the experience changed after additional opportunity to observe, study or explore?
2. Why would a multi-dimensional approach to unpacking family conversation be even more critical in effectively understanding the visitor experience for diverse families?
3. Reflect back on a recent study at your institution or within the literature focused on family interaction with exhibits. Can you identify how data was explored and/or viewed at the micro, intermediate, and/or macro level?

JRÈNE RAHM

7. MULTI-SITED ETHNOGRAPHY

A Tool for Studying Time/Space Dimensions of Learning and Identity Work

INTRODUCTION

Studies of science learning and identity development in out-of-school settings (OST) grounded in sociocultural historical theory attest to its important contribution to the development of science literacy in children and adolescents. Learning science takes many forms in quality OST settings and is typically initiated and directed by the youth themselves. Through interaction with authentic, rich environments, such as gardens or science laboratories, learning in OST settings is about connecting scientific knowledge with scientific practice. OST settings also offer opportunities to engage in scientific reasoning by observing, manipulating and questioning the surroundings. Engagement in science in OST settings also support new ways of understanding and relating to science. Youth may come to see themselves as knowledgeable of science through their engagement with it and through the opportunities that emerge that make agency possible (i.e., putting science to use). Youth may, for the first time, come to see themselves as capable of doing science and, therefore, as potential insiders of science. It is this kind of identity work, which is closely tied to learning, that I explore in this chapter, as I look at learning and becoming in OST settings (see also National Research Council, 2009; Rahm, 2010).

What is missing from the discussion of learning and identity work in OST settings as presented so far, however, is a stronger focus on horizontal learning "practices developed in the movement and flow as youth move across everyday settings and practices" (Gutiérrez & Lee, 2009, p. 219). What is also missing is an account of the way that engagement with science across settings and practices adds up to learning and identity work. To date, most studies are place-based (in a particular context such as an afterschool club), and rarely view learning as dynamically sensitive to context, which would necessitate following subjects or focusing on the making of science across space or time. Researchers have tended to think about science learning in fairly static terms, often referring to a museum, or home, or perhaps a classroom as the sole point of reference. As we will see from the data in this chapter, my goal is to free up our thinking by exploring learning over time and space in new ways.

I start with a vignette of Lya, a female student who we met for the first time when she was twelve years old and enrolled in an all girls afterschool science program in the spring of 2005. The following summer Lya and three other friends from that program gardened next to other youth of their age in the local botanical garden through a partnership that I mediated between the two programs that year (Rahm, 2010). Lya was born in Montreal; her parents emigrated from Laos. Lya

D. Ash et al. (eds.), Putting Theory into Practice, 121–139.

has two sisters (3 and 10 years old in 2005). By following Lya's engagements with science across diverse contexts (in the afterschool program and the garden, and by talking with her about other settings), I gained an understanding of the temporal and spatial scale that constituted her science literacy development. Her comments below provide insights into her views on science and how these views evolved over time and were influenced by her experiences in different spaces. I draw from data from two semi-structured interviews (at age 12 in the summer of 2005, and at age 14 in the summer of 2007), informal conversations, and field notes from the garden program study.

Vignette 7.1

When Lya, at age 12, and I talked about what science and scientists made her think about, she said:

> When I think of science, then I think of the laboratory, those are the ones in the laboratory with the white lab coats and the ones who try to find new medications or products that can help our environment or health …. Maybe it's because of my father, he works in a chemistry lab and I often visit him.

Later, Lya came in contact with science in *ScienceGirls*, an afterschool science program for girls in her community, and, during the following summer, in a University outreach program called *Folietechnique*. She spoke of this latter experience:

> I learned about chemistry, that one could mix things and it would make different colors each time and when one added more chemicals, it would lead to a different chemical reaction. And then we learned some new science terms, like CO_2, H_2O, but I knew that already from school.

The following summer, Lya participated in the gardening program, which she judged to be about "gardening and harvesting, but not science." When pushed, she noticed some links with ecology that she had studied in school, as she explains, "knowing how crop grows, knowing why some crop grows on top of trees while other crop grows underneath the soil, things like that." Later in the interview, Lya talked about her relation with school science as it evolved over time:

> I liked science a lot [in the past], I always liked science, I like doing experiments, last year [in high school] we dissected a frog, and we could see how similar the body of a frog and a human are, it was really an exercise of recognizing the parts of a human body. Then we also did an experiment to see how much air one can breathe in and another where we measured pH, the acidity of milk, juice and oil.

She added: "I do not like to write about science, I like to do it." When thinking about her future, Lya talked about her dreams of going to college, to

travel and to become educated: "My parents have high expectations that I go into medicine but then later, they said, they just want me to be happy and pursue something I like." She also dreamed about travelling and spending time in different countries and to discover the world.

These examples of Lya's ways of talking about her engagement in and with science over time and across space indicate that science literacy development is best viewed as stretched across many different practices in diverse contexts. This story also introduces the complexity of describing relationships among cultural practices. By cultural practices I mean the forms of scientific engagement and scientific identity work that each setting supported and defined. Lya's position in science was made up of a complex web of interconnections among these practices. Even though engagement in science took a unique form in each practice, Lya had no trouble seeing connections among them; such connections facilitated her travel across different spaces of science literacy practice.

There is also evidence that Lya was aware that, despite certain links she perceived among the practices (i.e., gardening and school), which made her knowledgeable in science and a potential insider to science, such ways of knowing and being were not enough to become educated. She talked about her parents wanting her to go on "all the way to university." She added, "they do not want me to play too much but to concentrate on my studies." Gardening was considered play. Later, Lya added, "it's easier to have fun than to study, but my parents have high expectations."

This suggests that not all of Lya's practices were equally desirable to her parents given the different kinds of contributions these made to her education within a system where schools are recognized as holding the most power and prestige. It led to a discussion about her parent's high aspirations for her, a common theme among immigrant families who have left their home country for the sake of their children's future. Lya's everyday life was marked by her cultural heritage, adding both richness and complexity. She spoke Lao at home; had visited her home country once since emigrating; had other relatives who had also left Laos and were now spread across the northern United States; she practiced Buddhism during occasional visits to the temple with her parents; and she was expected to take care of her siblings and know how to cook ethnic meals.

Lya's transnational identity contributed in important ways to the manner in which she engaged in science during school and in her community. She could engage in some activities during her free time, as long as they did not interfere with other duties and activities and as long as she took formal schooling serious enough. Her parents saw engagement in science in the programs mentioned above as valuable for her general education and for being successful one day within the local educational system. Initially, Lya's mother ensured that Lya had enough time to engage in the educational activities offered to her, while her father "worked all the time." Later, at the time of the follow-up interview, her mother worked while her father assumed the household duties, leaving much time for Lya and her father to talk together about science and their cultural heritage. At other times, Lya had to manage her time carefully, in order to complete both her domestic work and her

science activities. In the summer of the gardening program, for instance, she dropped her siblings off at a local day care center. This was difficult for her, but it made her participation in the garden program possible. Lya's parents supported her interest in the garden project. However, neither Lya nor her parents viewed such engagement with science outside of school as driven by an interest in a scientific career per se. Rather, Lya referred to these activities as "fun." Lya's story foregrounds the many dimensions, tensions and contradictions that engagement in science over time and across space entails, especially the factors that contribute to meaning and identity work in science for diverse urban youth.

Lya's story about engagement in science reminds us that place-based studies may be too limited to understand science literacy in the making. Such studies may limit our ability to truly understand the contributions of different kinds of informal educational settings to developing science literacy, and especially their role in making science accessible to youth like Lya. As noted by Dimitriadis (2008),

> [E]ducation is an increasingly emergent phenomenon, unfolding across numerous sites and settings with and between multiple texts. It is the "in-between" the moving back and forth between sites and texts that increasingly defines our children's lives and cultural landscapes and must, therefore, define our research agenda with urban youths. (p. 99)

Following this line of thinking, the study of learning and science literacy development needs to take into account the full range of repertoires of cultural practices that constitute the lives of youth today, including afterschool science programs, science leisure activities, museums, summer science camps, science activities in community youth programs, in their families, and in school, to name a few (Gutiérrez & Rogoff, 2003). The importance of each of these different practices is reflected well in Lya's life. She tried every educational opportunity that presented itself over a period of years. In turn, engagement in the practices contributed to her becoming involved in and going beyond particular science activities in important ways.

If we take seriously the fact that learning and becoming are constantly in motion, are not clocked in time or neatly packaged in space, but rather, as Clifford (1997) noted, continuously reconfigured in relation to "travelling cultures," then we must ask ourselves how we can travel across and within informal science settings in order to understand their local uniqueness and also their global contribution to learning. How does such engagement and travel add to, even constitute, the development of science literacy and how does engagement and travel play out in terms of insider positions to science? And, perhaps most importantly, how can we go about studying the rich complexity of such travel and adding-up?

My discussion so far argues for a new way of conceptualizing and studying science literacy development that is "life-long, life-wide, and life-deep," meaning it is spread out over time, across space and is continuously in the making (National Research Council, 2009). It requires a method that can take this movement into account. Researchers working in the traditions of anthropology of education have

shown that engagement in multiple practices of enculturation contributes to the education of children, youth and adults today (Weis & Dimitriadis, 2008). At the same time, postmodernism and research on globalization have offered much needed critiques of the bounded notion of culture that has dominated the work of anthropologists for a long time, though without offering clear solutions in terms of methodologies that are able to capture the flows and intersections among cultures (Eisenhart, 2001).

In this chapter, I offer some insights into multi-sited ethnography, a qualitative research method little talked about in science education yet actively pursued in anthropological studies of youth's learning and becoming in a global world. Given its versatility with regard to movement and interspatiality (learning across sites), I make the case for its usefulness in the study of informal learning through several examples. I focus on two issues in particular: (1) The manner in which a multi-sited ethnography may be configured, and (2) the relationship between the researcher and the informants. I conclude with a brief discussion of why such a method may be particularly promising for educators and researchers working in the field of informal learning.

THEORETICAL FOUNDATIONS OF MULTI-SITED ETHNOGRAPHY

My research is guided by writings on global ethnography, which question single space placed ethnographies and which locate ethnographers in networks and flows of meaning, at the borders of places, or within transnational social formations (Gille & O'Riain, 2002). Globalization, a phenomenon present in any large urban center, like Montreal, confirms the need for a spatial dimension in current research. Learning and becoming can no longer be understood by being studied only in one site or setting, or exclusively at the macro or micro level (e.g., Suarez-Orozco, 2001). As also suggested by some authors, ethnography is the kind of method suitable to account for movement and complexity, given its ability to deal with units of analysis that are in flux (Eisenhart, 2001).

Yet, less is known about the specifics that define such ethnographies. Some situate themselves in networks or flows while others focus on the borders of places where the action takes place (Gille & O'Riain, 2002). What they share is the recognition that ethnographies may take "… unexpected trajectories in tracing a cultural formation across and within multiple sites of activity" (Marcus, 1998, p. 80). Culture is understood from this vantage point in terms of "integrated constellations of community practices" (Rogoff & Angelillo, 2002, p. 212) and therefore demands the study of such constellations, making them the unit of analysis (see also Eisenhart, 2001).

To offer some precision to mobile research endeavors and flux notions of culture, Marcus (1998) proposed multi-sited ethnography as a method of choice and posture. A multi-sited ethnography, or multi-sited research imaginary, is best understood as a sort of ethnography that "reconfigures and complexifies the spatial plane on which ethnography has conceptually operated" (Marcus, 1998, p. 63). The term "imaginary" captures the manner in which the object of the study (i.e., what it

means to engage in science) is a co-construction by the researcher and the researched. It is no longer a construction by the researcher alone, once she or he has become a native of the landscape, a point I turn to in the second section of the paper. To continue, multi-sited ethnographies are

> designed around chains, paths, threads, conjunctions, or juxtapositions of locations in which the ethnographer establishes some form of literal, physical presence, with an explicit, posited logic of association or connection among sites that in fact defines the argument of the ethnography. (Marcus, 1995, p. 105)

In this quote Marcus makes the case for some unifying logic that holds a multi-sited ethnographic research project together across cultures, places or spaces. Returning to Lya's case, the logic that held the study together and became "a chain" or "thread" was its focus on Lya's engagement with science, with a goal of understanding the development of her science literacy as distributed among and facilitated by these spaces. Applied to studies of learning in museums, a thread could entail a study of how museums, along with schools and family activities, contribute to science literacy development. Another thread could be a focus on the manner in which science is represented among science centers. By traveling across science centers with families or youth, an understanding could be gathered about how the visitors integrate the different messages and meanings of science that these spaces make available.

Marcus proposes four modes of construction or logic, which allow such studies to capture movement and trace "things." The most common construction is about *following people*; many anthropological accounts have already delineated this method. One example is Callanan and Jipson's (2001) study of families' engagement in science at home and the museum, with the unit of analysis being the people in the family. Another construction might be the study of a material object — *the thing* — across space, including the manner it circulates or is invoked. For instance, one might wonder how technology mediates science learning at home, in school, and the museum. The study of the circulation of signs, symbols or metaphors, in other words, *cultural productions*, across space is yet another construction. An example might be the study of what it means to be a successful science learner in a museum or at school, as well as how such success has been defined historically. The totality of these, if taken together, could offer rich insights into youth's participation in science today. Lastly, one might simply follow the *plot, story, or allegory,* and by doing so, travel naturally across space and time and come to understand the world system within which the individuals' narratives of learning and becoming emerge. While multi-sited ethnography is mostly about space, extensions in terms of time have also been forthcoming. Take for instance Gille and O'Riain's (2002) exploration of the production and transformation of sites with a simultaneous grounding in their history and political landscape.

In contrast to Marcus (1998), Burawoy (2000) suggests that studies linking up the local with the global exemplify the extended case method. He identified four dimensions that unify such studies. The first two dimensions entail an extension of

the observer into the world of the participant, which implies that in-depth ethnographies are actively pursued and that one is not simply becoming a traveling tourist, easily satisfied by a narrowly defined glimpse at the phenomena under study. Third, such studies tend to bridge out and away from micro processes into macro forces. Fourth, such studies offer extensions of theory, rather than opportunities for reinventions, and therefore, they build upon what is currently known about informal science learning.

Whether a multi-sited ethnography or an extended case method, all such studies share a strong commitment to the collection of detailed ethnographic data in conjunction with interview data, artefacts, visuals and other data. Such studies do not question the fact that ethnographic methods are still the best means by which we may learn about and understand others. What the two methods do challenge, however, is the location of the ethnographic work, a work that is continuously reconstituted in new ways in terms of its location, time and space. To continue with an illustration of my own journey of putting into place such a multi-sited ethnography, I return to Lya and show what the experience of following people entailed for me. In this next section, I focus on the making of science across time and space and thereby illustrate what following the "thing"—science in the making—might look like.

CASE 1. THE CASE OF LYA: CONNECTING SITES BY FOLLOWING PEOPLE

Lya's trajectory in and beyond science (summarized at the beginning) is a story constructed from different ethnographic data and artefacts collected over time. It started with a one-year video ethnography of science in the making in the afterschool program *ScienceGirls*, in which she participated and where I got to know her. I then followed her into an eight-week summer gardening program *Jardins-jeunes*, where I also conducted a video ethnography of youths' engagement in science as they gardened. That data was reduced to video logs, some exchanges of which were transcribed for detailed microanalysis of science talk, and in turn supplemented by semi-structured interviews in order to capture youths' ways of talking about their engagement with science, their relationship to science as they experienced it in and outside of school, their perception of science and scientists, along with their future aspirations in and beyond science. Artefacts were also collected. In this case, the study of engagement with science across space entailed two detailed video ethnographic case studies both of which I conducted (Rahm, 2010).

To capture Lya's learning trajectory over a longer time period, I pursued a detailed, semi-structured follow-up interview two years later (in 2007; Atkinson & Coffey, 2003). That data offered a glimpse into the ways Lya constructed herself at that time (i.e., as a happy and balanced transnational youth), and how she narrated her relation of self to and in science at that moment, and in moments before. I asked her again to reflect upon her engagement in science in the programs *ScienceGirls* and *Jardins-jeunes*. Across these data sources, I then identified the repertoires of practices that Lya articulated and engaged in at the time of the study

and the form and meaning that such engagement held for her. Analysis of these multiple data sources led to a story of Lya's participation and positioning in and beyond science, part of which was presented at the beginning of the chapter.

This led to a bricolage or bringing together of different pieces and stories that are illustrative of my ways of seeing and understanding links among the practices that Lya engaged in over time as she talked about them in interviews (Kincheloe & Berry, 2004). In fact, the term bricolage captures well the fact that multi-sited ethnography is neither a comparative study of sites nor a simple adding up of perspectives, but instead, "an emergent object of study" (Marcus, 1998, p. 86). The complete story emerged from my study of Lya's engagement in and with science over time and across space, and my exploration of what such engagement came to mean to her in terms of her positioning in and beyond science, as summarized in Figure 7.1. It is a story we constructed together, given our shared commitment to the research project and topic of study. As articulated well by Kincheloe and Berry (2004), "bricoleurs move from convergent to divergent forms of meaning making, abandoning the short-sightedness of pre-specified, correct patterns of analysis in favor of more holistic, inclusive and eclectic models" (p. 21). It is about formulating ways that capture complexity and contradictions as they are continuously in the making. Figure 7.1 depicts some of the networks and practices that constituted Lya's becoming in and beyond science. Note that ideally I would have followed Lya's trajectory into all these practices. As a researcher, I was an active participant only in *ScienceGirls* and *Jardins-jeunes*, whereas insights into the other practices were gained through interview data only, which is a shortcoming of my study.

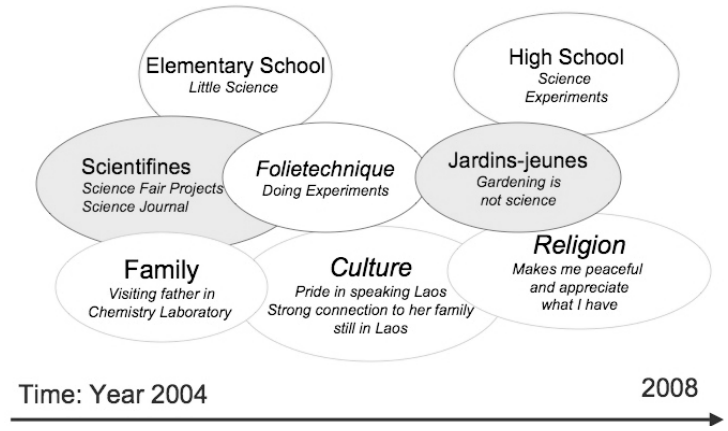

Figure 7.1. Lya's Repertoire of Practices

Clearly, Figure 7.1 does not capture the complexity of Lya's repertoires of practices that constituted her learning and becoming over time and the manner in which they added up. For instance, religion was an important means that Lya's

family used to support their integration into the local culture. Gatherings at the temple also helped them develop a social network with others who had histories similar to theirs. Yet, at times, religion also competed with Lya's participation in the science activities at *ScienceGirls* and *Jardins-jeunes*. Social events at the temple on Saturdays competed with seed planting events in the garden prior to the summer.

Such a tension underscores why we have to study the interconnections among different practices over time, along with everyday practices beyond science, in order to truly understand and appreciate diverse youths' engagement in science. In Lya's case, non participation in some science activities was due, in part, to lack of access (i.e., her family could not afford science summer camps) and at other times simply due to lack of time or conflict with engagement in other practices that her family valued, such as presence at the temple or domestic duties her parents needed her to perform because they were at work. Interestingly, during the summer that Lya gardened, she ended up missing a week of gardening because of her participation in a chemistry camp at the University, for which she had won a stipend through the program *ScienceGirls*. Both she and her parents perceived it as a special honor, which then justified missing gardening for a week. Lya's mother made herself available to travel to the University with Lya every day by metro, something that posed a serious constraint on her time, yet obviously was judged as important. Lya's mother also joined us twice in the garden, marking her interest in her daughter's well being, even though this entailed travel by metro with Lya's baby sister in a stroller. Clearly, parental engagement created, in important ways, the foundation for Lya's emergent repertoire of cultural practices, which subsequently marked her learning and becoming in and beyond science. Hence, Lya's travel across space and time has to be examined not solely in terms of her own positioning in that landscape, but also in terms of her family's work. This underscores emphatically the ways in which such research imaginaries can take us places we may not have anticipated a priori, and which may not be significant in other youths' travels. It underscores too, that only through dialogue over time with Lya did all these interconnections and dimensions surface and take on meaning for both of us. It was an imaginary that was constructed together, hinting at the fact that the pursuit of multi-sited ethnography also entails different positions for the researcher and the researched, an issue I return to later in the chapter.

CASE 2. SCIENCE IN THE MAKING ACROSS SETTINGS

The second illustration follows the thing "science in the making" across three settings: an afterschool science program, *ScienceGirls*, a summer gardening program, *Jardins-jeunes,* and a Math and Science Upward Bound Program known as *COSMOS* (Rahm, 2010). The goal of the study was to better understand what the making of science entails outside of school. The chosen sites shared some features, a theme that held the study together. All three sites offered hands-on science activities, were based on voluntary participation and were accessible to

diverse youth, while also offering the possibility for sustained participation over time. Table 7.1 offers a summary of the features of each site.

Table 7.1. Profile of the 3 Sites of the Multi-Sited Ethnography

	Afterschool Science Program for Girls only ScienceGirls	Summer Gardening Program Jardins-jeunes	Math and Science Upward Bound Program COSMOS
Location	Canada – French data	Canada – French data	United States – English
Duration of program	Academic school year (September – June)	8 weeks in the garden; some meetings prior and after	6 week residential program
Year of data collection	School Year 2003 - 2004 19 youth	May – September 2005 46 youth	June – August 2000 40 youth
Age	9-12 yrs	12-14 yrs	13-15 yrs
Gender	girls only	67% females 33% males	50% female/male
Ethnicity	72% born outside Canada	82% born in Canada	42% European-American; 40% Hispanic; 18% Hmong
Follow-Up 1	May 2005: Interviews of 7 youth	June 2007: Interviews of 3 youth	Spring 2004: Interviews of 10 youth
Follow-Up 2	June 2007: Interviews of 4 youth		Fall 2007: Interviews of 4 youth

A video ethnography of science in the making in each program was supplemented by questionnaire data of participants' attitudes toward and notions of science, and demographic data. Semi-structured interviews of a subset of the participating youth helped assess youths' talk about the making of science. Let me illustrate with some examples the form science in the making took across the three settings.

Story 1. Science in COSMOS: Ecology Work at the Elbows of Scientists

In COSMOS, I explored the making of science at the elbows of scientists. The following example comes from a partnership in the ecology laboratory, where two youth explored the effects of herbicide use on soil. The youth first extracted soil from the area of study, then filtered out mites from that soil under heating lamps in the laboratory, and identified the kinds of mites they had collected. This offered them important insights into the state of health of the soil. In the following exchange, Amanda, a graduate student in the laboratory, apprentices the youth into "learning to see" the mites in the soil when viewed under the microscope. She had just completed a lecture on the body parts of mites. The participants had pictures of

different kinds of mites, which they analyzed together before turning to the microscope:

Amanda	You're gonna see a lot of different mouth parts and a lot of the terms are gonna be redundant (mumbles on as she is trying to assemble a number of pictures to illustrate mouthparts for the youth; turning to Tina) What was your question?
Tina	That whole . . . that piece here. . . the thing is the chelicerae?
Amanda	Right, let me see, in your picture, (comes over to Tina to look at picture and points) so right here, this is one side and here's the other (she shows Tina the parts on a picture). And if you look at this top, actually there's this little skinny part and this other is underneath it. They're kind of like this (she uses her fingers to imitate the claws' movement; then takes one of the mite pictures in her hand) So this is actually a mesostig (slang for 'mesostigmata') or a prostig (slang for 'prostigmata') so the white body mites, when we take pictures, they come out really clear. (She holds up a picture of a white one. All four students raise their hands.) How many of you have the red ones? (All raise their hands). They have like a hard shell. Ok, they still have chelicerae, but it's only this little section (points to it on picture that she holds in hand so everybody can see). So the chelicerae are much reduced … in several mites. But it's still . . . the same kind of mouthpart.

Story 2. Science in ScienceGirls: The Making of Science Fair Projects

In *ScienceGirls*, the girls started their work with a topic in science they were curious about and subsequently transformed that interest into a science fair project. In doing so, they appropriated the science protocol of developing a research question and objective, and in turn, learned about the proposition of a hypothesis, which then guided their research. Meaning making of science entailed much guidance by the instructors, since most of the girls had never pursued a scientific investigation and project elsewhere:

Instructor	So what's your hypothesis?
Jackie	I don't know
Wanda	I don't know, we don't have a hypothesis
Instructor	That's what you were supposed to identify. At this point in time, you got tons of information but now you need to organize it and select some of it. To do so, you need a hypothesis, a question.
Wanda	Well, I tried, I asked a question, where do the

tornadoes come from, why do they exist, and when the tornadoes move, do they turn or do they just move and do not turn at all?

Story 3. Science in the Garden: The Making of Science by Listening in and Doing

Often the science of gardening was hidden under layers of gardening work. At other times, science became a means to ensure the growth of crops. Newcomers to the garden learned much about these facets of science through observation, intent participation, and guidance, as shown in Figure 7.2. Note the exchange below, taking place between Carol, one of the instructors, and two youths, Anna and Kamila. Four other youths who worked close-by stopped and listened to the exchange:

Carol	The cucumbers have a really hard time this summer
Anna	Mmh
Kamila	Lots
Carol	They told us (referring to horticulturist) because it was super hot and humid it (the disease) spread super easily. It's the chysomalidae that chews, eats away the Leaves and that gives a bacteria and then it was super hot and the bacteria was like, yeah! and it spread super easily
Kamila	I just had four cucumbers, me
Carol	Ah yes?
Kamila	Two that others gave me and two that came from my garden
Anna	Me too.
Carol	And two from your garden (looks at the cucumber plant again)
Carol	Mmh, today, you could almost harvest this one (points with foot to it), even if it is still a bit small, since otherwise, if you wait until next week, it risks to get too big, so you could maybe harvest it as it is
Lya	But even if it is big, that's not a problem, I already tasted it
Carol	Oh really, I like it better small than big, and you?
Lya	Either way is fine with me
Carol	I prefer small over big
Kamila	My mother prefers big.

Analysis across the Three Stories

As illustrated in Story 1, youth were apprenticed into ways of seeing that are particular to ecologists in COSMOS. They learned to see, think and do science like ecologists and, through mastery, became insiders to these science practices. Story 2, taking place in *ScienceGirls*, underlines the manner in which guidance and scaffolding by instructors mediated the girls' engagement with and appropriation

of the scientific method. In the garden, Story 3, science figured into the talk only marginally and was hidden under layers of doing gardening work, but in some

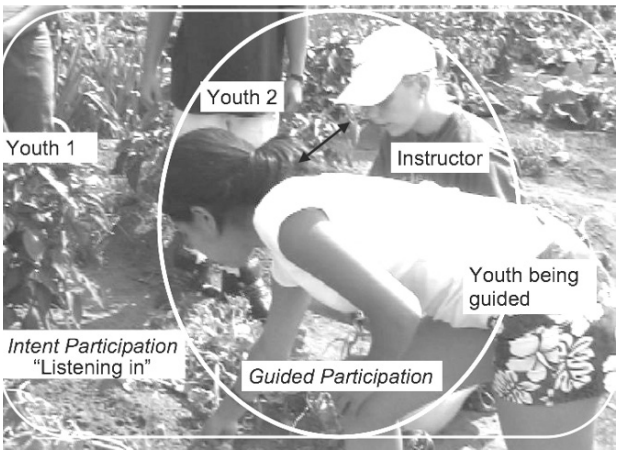

Figure 7.2. Learning through Intent Participation

instances, science explained why crop was not more abundant. Several youth joined the conversation between the instructor and a youth, and participated as silent observers. This is a form of learning known as intent participation, or participation driven by anticipation (Rogoff, Paradise, Mejia-Arauz, Correa-Chavez, & Angelillo, 2003; see Figure 7.2). The youth knew that such ways of knowing could possibly be useful to them one day and inform their own gardening practice, and hence, many joined the conversation as silent observers and listened in on the educational moment.

When examining science literacy development across settings in this manner, one becomes readily aware of just how complex the making of science is, the many forms it takes, the different ways that youth engage with science, participate in it, and contribute to its making. What unifies the settings is the underlying multimodality of science in the making. Youth had to appropriate scientific terms and the scientific genre of each practice; they had to learn to see and talk science, to put forth an argument and to put science to use through the right kinds of actions (e.g., harvesting at right moment). Youth had to learn to see the science in the soil samples, but also to read the garden for signs that action was needed. Youth had to learn to become systematic in their approach to answering questions of science and thereby developed more of a sense of how science is made. While much more could be said, the study of science in the making across sites illustrates its hybrid nature. It suggests, too, that youth who had opportunities to engage in such science practices outside of school were exposed to many different dimensions of science: in COSMOS, youth were exposed to scientists' science; in *ScienceGirls,* the girls had an opportunity to appropriate much science knowledge while also become

apprenticed into the scientific method; in *Jardins-jeunes*, youth put science to use as they interacted with and developed a relationship with nature. The programs supported youths' participation in practices in which science figured as a means to an end. Participation also made available opportunities to develop positive relationships with science.

As shown so far, the object of study in a multi-sited ethnography is stretched over time and across space and pushed beyond the traditional *mise-en-scène* of the single site. In fact, "ethnography becomes multi-sited when it comes to transcend and to move literally to other locations… and work inside the 'elsewhere' or 'third' that stimulates the collaboration of situated epistemic partners" (Marcus, 2007, p. 9). It also changes the position of the researcher and the researched in that the relationship itself becomes a research tool of sorts, another defining dimension of multi-sited ethnography. I turn to next.

SHIFTING POSITIONS OF RESEARCHER AND RESEARCHED IN MULTI-SITED RESEARCH

Multi-sited ethnography foregrounds and acknowledges the implications of social relations in ethnographic research. It calls for "a rethinking of the space and positioning of the anthropologist-informant relationship that is at the heart of the fieldwork" (Marcus, 1997, p. 87). It challenges the classic ethnographic authority of "being there," given the study of the "here and there" (p. 117) as no longer located nicely within a particular space but understood as spread and stretched beyond that space. It also challenges the traditional notion of "building rapport," and reformulates the dialectic process as one in which both the researcher and the informant are trying to figure out each other's position and stakes and, through dialogue and *complicity*, try to create some common ground that then constitutes the research imaginary.

> [Complicity] inevitably pushes the entire research program of the single ethnographic project into the challenges and promises of a multi-sited space and trajectory—a trajectory that encourages the ethnographer literally to move to other sites that are powerfully registered in the local knowledge of an originating locus of fieldwork. (Marcus, 1998, p. 120)

It follows that the construction of what science in the making may entail is literally a collaborative endeavor, and it is this collaboration that emerges from complicity among researcher and researched. Hence, "collaboration becomes … a modality of method" (Marcus, 2007, p. 8). It is from the relationship and dialectic between the researcher and researched that the story emerges and unfolds about what science learning entails outside of school. No longer is the story the creation solely of the researcher who built some kind of rapport with others, and made him or her an insider to their practices. Instead, the researcher builds the study with the researched. In essence, journeys with informants across space and over time are marked by "outsidedness" (p. 118). Yet, that position makes the imaginary that much more complex and interesting. The data emerges from that "outsidedness," as

well as from the relation with the researched, who themselves construct stories for the researcher about what may be happening. It is the coming together of these two voices that constitutes the data. For instance, I gained insights into Lya's engagement in and with science over time through her dialogue with me, and the manner in which she engaged in the practices that I observed. But this was influenced in important ways by the way I noticed her engagement in science, and by what I counted as engagement in science, in light of my own subjectivity in the research endeavor. It was also influenced by Lya's performance for me and what she was willing to share with me. Hence, the following kinds of questions may need to be asked and may guide the research imaginary with regard to the notion of complicity:

> How did the ethnographer and subjects interact day to day within the field? What did they talk about? How did these relations affect the ways in which the research evolved? What representational choices did the researcher make because of this complicity? How did all of these relational dynamics move the researcher to other sites? (Gustavson & Cytrynbaum, 2003, p. 252)

These questions suggest that as a researcher, I needed to develop a "keen awareness of being within the landscape," while, simultaneously, my own "identity" as ethnographer "required" continuous "renegotiation" as I traveled across sites at the elbows of Lya (Marcus, 1998, p. 97). In essence, the study itself built upon an evolving relational space (Gustavson & Cytrynbaum, 2003). During informal conversations with Lya in the car on the way to the garden program, I gained some insights into her complex life as a transnational youth who contributed in significant ways to her family; this was something that was expected of her, too, since she was the oldest girl of three siblings. Over time, I also came to appreciate her positive outlook on life, which guided her engagement in garden science and her interest in learning exemplified by her active questioning. It helped me see her engagement in science in different ways, through the learning opportunities she valued and enjoyed. As I traveled with her over time into her high school science classroom, I got to know a youth who was engaged in the enriched science class and fascinated by science, yet I also learned about her interest in travelling. It led me understand, as well, that many of the girls who participate in *ScienceGirls* and *Jardins-jeunes* are eager to become somebody, to become educated, and that this was an interest that was already there prior to participation in these programs. It left me wondering about the girls who did not participate. Who were they? Did they refrain from participation for reasons other than struggles with accessibility?

DISCUSSION: MULTI-SITED ETHNOGRAPHY AND INFORMAL SCIENCE, NEXT STEPS

Most informal science education studies have been place-based. Recent studies of learning in community-based organizations have purposefully tried to move away from traditional schools in order to enjoy the richness of learning and identity work

that other informal sites can support (Heath & McLaughlin, 1993). Yet there is also "a danger of reifying these sites as objects for study" (Weis & Dimitriadis, 2008, p. 2309). Critical studies of informal learning are sorely needed. I have tried to make the case in this chapter for the need to situate studies of informal learning in the relationship among sites, including schools. While globalization has led researchers to struggle with youth vibrancy and movement, we still know very little about how youth work across sites and cultural practices, how they manage that movement or fail to manage it, how that movement adds up and constitutes learning and identity work, and how cultural practices connect or disconnect. We, as researchers, seem to be struggling to move beyond the dichotomy of formal and informal learning, which has provided justification for single place-based studies for a long time. Work by Marcus (1998) and others who have written about and pursued multi-sited ethnographies challenge our research imaginary and call for reflexivity in terms of the sites and objects of study and ways we may delimit the study of informal science, and on what may count as learning in informal settings. You might wonder about what a multi-sited ethnography of science centers and its science would look like. Would it entail a study solely of visitors' engagement in science, or would the imaginary have to move beyond that space and examine the ways in which the museum relates to other spaces of science? Would it have to examine engagement over time in the museum or also outside of it? What would a study of science in the making across sites (home, museum, school) and space (as studied across the country) bring to the foreground about the accessibility of science and what it means to become an insider? What could such a study tell us about the science literacy infrastructure defining youths' lives today, to what extent it includes them or excludes them? What could such a collaborative project tell us about the kind of methodology needed to capture the becoming and being in and beyond science in our global world?

Qualitative case studies of family science practices have been part of the informal science literature for a while (e.g., Callanan & Jipson, 2001). Qualitative case studies of different science practices have also been put together purposefully in books and articles in an attempt to shed light on what engagement in science entails more globally (e.g., Eisenhart & Finkel, 1998). While such studies have made possible, to some degree, the "tracing and describing [of] connections and relationships among sites previously thought incommensurate" (Marcus, 1998, p. 14), I have advocated in this paper for rich multi-sited ethnographic case studies, conducted by the same researcher, or by a team of researchers, which share certain features about site selection: ways of relating and traveling across space and time, and ways complexity defines the data collection, write-up, and authoring of such ethnographic work. An example of such a multi-sited ethnography is Heath's and McLaughlin's (1993) study of community-based organizations across the country (US) that was conducted over five years. It presented a complex vision of the key features that made those settings successful, and the manner in which they were emergent and unpredictable in terms of the kinds of learning opportunities and forms of engagement they offered youth in ways that support life-long learning. It also provided an understanding about the ways in which science can filter into

some of the community programs studied. Much work remains to be done, however. In addition to accounts of their engagement in meaningful learning at home, in school, and in other contexts, it is crucial to know more about how youths' participation in quality community programs adds up over time.

I have laid out the beginning of what such an endeavor may entail for the study of informal science. I claim that the study of informal science can only be fully understood when situated in relation to a vast network of formal and informal practices. My account is incomplete, however, and more work needs to be done. Perhaps we need to move beyond the dichotomy of formal and informal science and talk about repertoires of science practices that constitute all discovery, exploration and inquiry, and find a conceptual framework that has the ability to capture today's movement of youth across sites and the manner in which engagement in a vast network of practices contributes to their learning and becoming.

As some researchers remind us, we need to not merely explore time as a factor constitutive of science literacy; rather, we must consider the multiple dimensions of time simultaneously. Then we may discover how engagement in science through brief face-to-face interactions plays out, compare it to how such engagement constitutes the becoming in science across a childhood, and find the broader historical dimensions that further color that process (Lee, 2002). Similar issues could be raised about how we treat space. In essence, such research imaginaries imply "self-reflexivity about how particular ethnographic sites are imagined [and] how objects are delimited" (Dimitriadis, 2008, p. 87). Each science practice is understood in relation to its background and system, but also in terms of how it contributes to cultural life and the actors within and beyond it.

CONCLUSION

I began the chapter with the argument that youth today come in contact with science in many different places, and that through engagement in many diverse cultural practices across space and over time, they develop their science literacy and come to see themselves in certain ways, in and beyond science. I have shown in what ways a multi-sited ethnography can capture such a process of meaning making of science across space and time and offer insights into youths' navigation among diverse science practices. Youth also play a new role in such research imaginaries and contribute to its making rather than simply being its object.

Simultaneously, our stance as researchers is no longer locally grounded but emergent from travel across sites and space, constituted by time, and also the evolving relationship between the researched and the researcher.

I think back to my own relations with youth: they changed over time in significant ways, and were also experienced differently across space as I participated in science with them, observing their learning and becoming. These changes themselves became the richest resources for understanding what engagement of and with science can entail. They helped me understand just how interested children and youth are in science, yet how difficult it is for most of them

to become insiders to the science our system has created for them. Through engagement in science in marginal spaces, however, they get to play with science in ways that are meaningful to them and that constitute their life-long learning and becoming.

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AFFILIATIONS

Jrène Rahm
Department of Educational Psychology
Université de Montréal
jrene.rahm@umontreal.ca

LEAH MELBER

PUTTING THEORY INTO PRACTICE

JRÈNE RAHM'S MULTI-SITED ETHNOGRAPHY: A TOOL FOR STUDYING TIME/SPACE DIMENSIONS OF LEARNING AND IDENTITY WORK IN SCIENCE

Rahm's chapter highlights the importance of recognizing the vast array of experiences that shape an individual's science literacy. Addressing both the continuums of time and space, her advocacy for appreciating the broader context in which one learns science is timely and necessary.

I think of a former student of mine and how her understanding of, and affinity for, science learning and museums has changed over time and across several different sites or settings. Megumi was a third grade student of mine when I was working in a traditional classroom a number of years ago. She excelled at all the traditional measures of science learning and even then eagerly embraced the opportunity to explore and investigate. Our paths crossed again when she and her family tracked me down at a natural history museum where I was a science education specialist. Looking for summer growth opportunities, she was eager to take on the opportunity to volunteer for our museum summer camp. It was quite an experience to see her leading children the same age as I last saw her through explorations of science and cultural topics, especially when she referred back to anything from our classroom time together. She continued on working with the program for a couple of years more, experiencing continued success. She then parlayed this early museum experience into a position with the on-campus art museum once enrolled at university where she grew as a young professional, with a much richer and deeper understanding of science and museum education than I can take credit for instilling in her during the brief moments our paths crossed.

Many of us have these stories: the summer camp student who went on to earn a Ph.D. in biology and serve as senior vice president at the same museum he attended camp; an art-loving teacher that inspired us to volunteer at a local museum; a childhood bird-watching or camping that led to a career as a naturalist. We often use the term "anecdotal" in tandem with sharing these amazing stories, down-playing their impact with the justification they are just a single story. Working within the framework of multi-sited ethnography and extended case method, we are given permission to see these stories as meaningful data. And while yes, their impact may not come with statistics confirming its generalizability to the greater populations, if we remember to view learning and personal development as a deeply individualized process, these frameworks are what would seem to provide us with true insight.

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We also tend to highlight just the portion of these individual's stories—the one that pertains to our institution or organization. We're queried, "But are we sure it's the time they spent at the museum that resulted in their career choice?" If we cannot answer in the affirmative, we are led to believe our stories are somehow less impactful. With the view of multi-sited ethnography, the power is not in assigning credit to a single experience in a manner not likely accurate. Rather, it reminds us that indeed our institution played a role, as did many other experiences. Rahm's work reminds us we should no longer strive to function as a dichotomy—formal and informal—if we are to truly understand the complexities of learning. Moving past this dichotomy however requires an inclusive research framework that supports exploration of connections across sites of learning and spans of time. Providing both theoretical grounding and pragmatic application, Rahm sets the stage for practitioners to venture successfully along this path.

DISCUSSION QUESTIONS

1. How could a multi-sited ethnography or extended case study approach better support you in sharing programmatic successes with stakeholders?
2. Identify two logistical challenges or resource constraints that might make this approach to research/evaluation difficult at your institution. How might you overcome these challenges?
3. How might the time/space dimensions of science literacy development and the call for a movement beyond a dichotomy between formal and informal learning guide the development of your next exhibit or program? In what ways could these dimensions become resources for novel exhibit and program development?

SHAWN ROWE AND JENNIFER BACHMAN

8. MEDIATED ACTION AS A FRAMEWORK FOR EXPLORING LEARNING IN INFORMAL SETTINGS

INTRODUCTION

Research on learning in informal settings has made huge strides over the last 30 years with a rapid expansion of the number of methods and theoretical frameworks employed across the field. As Phipps (2010) demonstrates, a consistent shift can be seen from studies focusing mostly on observable, easily quantifiable behaviors to studies taking a constructivist approach to studies identifying with various sociocultural approaches. In this chapter we discuss a particular sociocultural approach: mediated action, an approach most often associated with the work of Wertsch (1998). Mediated action is a way of researching how people use all kinds of objects and tools, both physical and psychological to structure their interactions, communicate with each other, and think. Since it is not tied to a particular method of data collection or experimental design, a mediated action approach allows us to use a variety of methods that are hallmarks of research in informal learning. Furthermore, because it attempts to account for the individual, social, cultural and historical contexts within which learning occurs, a mediated action approach can help make connections among interdisciplinary studies of learning across life contexts. In this chapter we briefly discuss the theoretical background of a mediated action approach, and then we explore some of the ways it may be used in research on learning in informal settings, specifically in science museums and home learning settings. Finally, we turn to some of the practical and theoretical implications of adopting a mediated action approach.

WHAT IS MEDIATED ACTION?

Mediated action is not a theory of learning; it is not a method of data collection nor of analysis. Rather, it is a research approach that encompasses multiple methods of data collection and analysis and that embraces a view of learning as an individual and group *activity*. It is a way of focusing research on multiple aspects of learning, rather than on only one aspect at a time. Mediated action seeks to understand simultaneously the learner, the learning contexts, and the tools of learning, and how these interact in any given learning event. Mediated action is one type of what are variously called sociocultural or cultural-historical approaches that set as their

D. Ash et al. (eds.), Putting Theory into Practice, 143–162.

task the understanding of "human mental functioning in relation to cultural, institutional and historical contexts" (Cole, 1996; Wertsch, 1998). Most researchers who use a mediated action perspective define learning in terms of the appropriation or internalization of physical and psychological tools for both communication and thinking. They further analyze how this appropriation occurs, mostly through participation in collective and individually meaningful activities (Linell, 2001). This definition of learning is based on three theoretical claims:

1. All cultural and social development begins in interaction between people.
2. Sign use underlies all thinking.
3. Psychology must be an interdisciplinary science.

We explore these three claims, to show how the mediated action framework helps us understand learning in informal contexts, before we look at practical examples.

Individual Development Begins in Social Interaction

Vygotsky's work rests primarily on what he called the general genetic law of development. By genetic Vygotsky meant the study of the origins (genesis) and development of psychological phenomena. Vygotsky theorized that all higher order thinking originates in social interactions among people, which gradually become internalized and thus become part of an individual's psychological makeup, in the form of higher order mental processes like voluntary remembering, self-regulation, and planning. Vygotsky's often-cited formulation of the General Genetic Law of Development is really the cornerstone of a mediated action approach:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts, and the development of volition …. It goes without saying that internalization transforms the process itself and changes its structure and functions. Social relations or relations among people genetically underlie all higher functions and their relationships. (1981, p. 163)

In terms of research, to understand the development of particular higher order thought processes, such as making sense of a data table or employing scientific reasoning, one must understand the origins of such processes in social interactions and the paths those processes take from social tools of communication to individual tools of thinking. One must be able to capture and follow how such processes move from routines of communication and interaction among people to routines of thinking for an individual. Vygotsky was particularly interested in the development of psychological tools for remembering, organizing experience, self-regulation of behavior, planning, and problem solving. For this reason, his work is particularly relevant for researchers interested in science learning, or the

development of scientific thinking. The tools we associate with "thinking like a scientist," which include making arguments from evidence, deductive and inductive reasoning, and identifying and manipulating variables, first appear as part of communication between people in socially meaningful activity before "going underground" as it were, and becoming cognitive processes and productive dispositions, which then promote scientific thinking (Eberbach & Crowley, 2009). In order to document that development, the researcher needs to be able to work over different time scales to see how people take on and use, and then adapt communicative tools for cognitive purposes. Sometimes such processes may occur over several minutes, and sometimes they may take place over several years.

Signs and Symbols Mediate Development and Thinking

The second aspect of Vygotsky's work that shapes a mediated action approach is his claim that signs and sign systems (e.g., words, symbols and images), chief among them language, mediate individuals' development. Although various types of psychological tools such as mnemonic devices and number systems were investigated in his work, Vygotsky focused on language as the premier tool of psychological development. Language is ubiquitous to human activity, especially the kinds of group activities that interest informal learning researchers, and thus is often invisible as a mediator. Yet it is certainly not the only sign system at work in learning. From a sociocultural perspective we can speak of all sign systems, or modes of communication, which function as tools in the development of interpersonal communication and individual thinking. Other sign systems may include gesture, body language, drawings, mathematics, or any other objects that have symbolic meaning. A mediated action perspective often focuses attention on how these other modes are integrated into language for communicating and thinking (Norris, 2004). Language and other symbol systems mediate our communicating and thinking, just as pencil and paper (or a keyboard and monitor) mediate the act of writing. However, we rarely pay attention to these tools unless they quit working, thereby failing to mediate our actions. For this reason sociocultural psychologists refer to these tools as "mediational means." They may also be called cultural tools, in order to emphasize their origins in activities that are socially, culturally and historically situated (Wertsch, 1998). Objects in museums and other informal settings can also be approached as meaningful symbols that become part of communicating or thinking, mediating group interaction (Rowe, 2002).

All Action is Culturally, Socially, and Historically Situated

This third claim is closely related to the second. To understand human thinking and communicating, one must also understand the cultural, institutional, organizational, historical and evolutionary contexts within which communication and thinking take place, as well as how they develop across an individual's life. This emphasis on social, cultural and historical contexts is reflected in the names sociocultural and

cultural historical. Vygotsky claimed that in order to understand an individual's development, the researcher must understand the historical and social development of the appropriated cultural tools. More recent, researchers have focused on the development of cultural tools as part of cultural, institutional and even organizational contexts (Hutchins, 1995). Most researchers working within a mediated action framework pay close attention to the social contexts of learning (such as the family group or the museum), and the cultural meanings those contexts have for different learners. This aspect is particularly important to learning researchers, since it calls for a look beyond narrow definitions of learning and claims about learners towards the larger social, cultural, and historical contexts within which the learning occurs.

A mediated action framework strives to connect these three claims about learning—that learning originates in social interaction, that learning is mediated by language and other symbol systems, and that learning is always tied to a social, cultural and historical context. Studying learning means studying someone (an agent or multiple agents) involved in some type of activity using particular cultural tools toward particular ends within particular contexts (social, historical, and cultural). This "pentad" — agent(s), actions, tools, goals, and contexts—is well recognized in various fields interested in human action and interaction (Burke, 1966; Norris & Jones, 2005). Researchers employing a mediated action approach strive not to give primacy to any of these five things when studying learning. They try to treat as many parts of the pentad as is practical at once. However, in practice it is often possible to deal with only two to three of these at any one moment. As a result, most researchers who use a mediated action approach focus on only three of its five elements, namely *agents* using *tools* in *contexts*. To illustrate how this works and what it means for doing research in informal science learning and teaching settings, we present two examples, one from a museum setting and one from a home schooling setting.

PRACTICAL EXAMPLES OF MEDIATED ACTION

The following two vignettes introduce some of the issues a mediated action approach allows us to tackle. They also highlight some of the challenges that arise, such as identifying and working with different scales of time and space and moving between paying attention to the whole of the experience and each of its significant parts. The vignettes reveal many of the methodological decisions and issues that researchers studying family learning in such sites struggle with daily. We must decide on where to focus data collection: on the dyads and triads, the whole family, each of the individuals, the objects, or the space. We must make decisions about how to collect high quality data in noisy, crowded environments. We must make decisions about when and how it is appropriate to intrude on a family's free time together. We need to decide how to recognize when the intended or perceived science content we are interested in is evident, especially if we are consciously trying to use participants' own definitions of science.

Vignette 8.1 Learning at Touch Tanks

The family in this photo was spending some time visiting a free, small science center and aquarium on the Northwestern coast of the United States. They agreed to be videotaped at these touch tanks and to answer some interview questions about this part of their visit. The interaction is part of a larger study of families' interactions with and at touch tanks carried out by Rowe. The touch tanks are similar to those in most public aquariums, and hence, filled with marine invertebrates and fish of the intertidal zone of the North-Eastern Pacific Ocean. Here's a short transcript of the family's conversation and action at the beginning of their visit of the touch tank:

Figure 8.1. Family at Touch Tanks

Mom: What do you think that is, guys?
Boy1: [Boy2], touch this thing! It feels really □
Boy2: Cool...□
Girl: What's that, mom?
Boy2: Whoa, this is cool.
Girl1: What's that?
Mom: Those are sea anemones, I think.
Boy2: ooh, that feels weird.
Girl2: The water's kinda cold.
Mom: They look like sea anemones
Girl1: It looks really weird. Mom, no, Mom, touch it. It feels so weird.
Girl2: Isn't the water cold?
Boy1: Yeah, touch the sea anemone.
Mom: Is that a sea anemone or a sea cucumber? A sea anemone I think.
Girl: Whenever I touch it, it goes inside like that.
Girl2: Ooh, that's pokey.

Boy: Touch that one. It's really weird.
Girl: What's pokey?
Boy: Stick your finger inside.
Girl: No, it's ok.
Boy: None of them are poisonous.
Girl2: Ah!
Mom: What does it feel like?
Girl2: It's sticky!
Girl: I know they're sticky!
Girl2: It feels weird!
Boy: They're sticky. They grab onto you.
Mom: It is? This one's not.
Girl: What is this?
Boy2: No, stick your finger in its mouth. It's cool.
Boy: It's alive.
Mom: I don't think I want to-
Girl: I know!
Mom: Take my, take my finger.
Boy: Yuu guys, this is a sea slug thing.
Girl: That's so cool.
Boy: It has a shell. It's alive.
Boy2: Cool.
Mom: Oh yeah, I didn't even notice that!
Boy: It was moving until I touched it.
Girl2: I like touching the fish over here.
Boy2: Wow, the fish is cool.
Mom: Carefully, what does it feel like?
Girl: Whoa!
Mom: Hahah
Girl: It's really weird. It's protecting - see how it did that?
Boy2: Whoa! That scared me.

In this family dialogue and interaction with the tank, the family discovered that the water was cold, advanced several identifications of animals (some correct and some incorrect), made connections to their prior experiences and knowledge, negotiated access and expertise, and advanced at least one hypothesis. They did it all in a highly engaged, improvisatory and fluid way, distributing their attention, talk and actions among the whole group. None of them experienced the same thing exactly, but they experienced it together and co-constructed each others' talk and actions at the exhibit, making for a comprehensive story.

Vignette 8.2 Learning Science at Home

The family described below was part of a larger ethnographic study of how Pacific Northwest home-educating families study science and mathematics, carried out by Bachman. The family was doing a high school level chemistry 'lab' about molecular structures. The lesson designed by the mother was intended for the 18-year-old daughter Sue, although the 14-year-old son Jay was welcome to participate. With respect to the son, this lesson could be considered both free-choice and informal learning, since he was free to choose both the duration and

manner of participation. The home learning environment was relaxed and the children were free to come and go (i.e. the timing was flexible). It is important to note that the son had an interest in science, and that there were no predetermined learning outcomes for the son. The following vignette took place at the dining room table during their regular morning home-school hours. The mother had set out the following items: lesson pages from a science teacher's website, a book on molecular structures, a list of "Chemicals On Hand" with chemical formulae, two organic molecule building kits, a laminated periodic table, and a small whiteboard. Other resources they used included the Internet and a chemistry DVD series, which the daughter had watched prior to the lesson.

Figure 8.2. Molecule Kit for Home Learning

The activity began when the siblings sat down and began to play with the molecule kit pieces. They each built water, then they each built carbon dioxide, oxygen (molecular), ammonia, and nitric acid. During this exercise, Jay followed along with Sue's lesson by making the molecules in parallel with her. While the mother and Sue discussed the concepts of the chemistry lesson, Jay interacted with his mother and sister mostly by asking questions and making comments. For instance, he held up a molecule and joked, "Little horns"; he memorized the atom kit colors: "Blue isn't oxygen. I thought red was oxygen"; and he checked that his molecule was correctly built. At one point he turned to the metal springs in the kits and built an alien creature. His interactions with his sister became playful. Next, the mother looked for another molecule to build. Sue asked to build sucrose, a molecule she had learned about from viewing their chemistry DVD. The following is an edited transcript of the next 48 minutes, with some skipped segments due to space constraints. The mother, son, and daughter are sitting at the dining table. The mother is looking at the book while Jay and Sue use pegs and balls of the molecule kit to build molecules:

Mother: There's some cool things we can do.
Sue: No I think we should make sucrose! Can we make sucrose?
Mother: Yeah it's back in the sugars (searching in the book).
Sue: We were doing lots of stuff with sucrose in the DVD. I guess its because its easily obtainable.
Jay: Sucrose acid (banging his molecule on the table).
Mother&Sue No, there is no such thing.
Jay: I know.
Mother: Okay, (mother finds it in the book) Oh man I don't know whether you're gonna be able to.
Sue: No, no, write it down! Write it down. We might have to combine our forces.
Mother: No, I know. But I don't know whether you'll have to really read… look at this to see how it goes, see what's the center of it. (The mother writes the formula on the whiteboard)
Jay: C-12-H-22-O-11 Okay (reading the board).
Sue: It has a really, really high molar mass.
Jay: Let's get all our oxygen together (pulls apart previous model he built, collects red balls). (Mother turns the book to show them the image on the page; Jay continues to collect red, yellow, and black balls. Then Sue and Jay are looking at the image in the book together)
Mother: You're going to have to look sort of… cause see it isn't…
Sue: It looks like the carbon is in the middle. Then it has all the sticky stuff. (They look closer at the book and Sue begins to put balls and pegs together)
Mother: you might… you… you can probably see it better…
Jay: We need to combine our reds.
Sue: I don't know, we might be able to.
Mother: (Mother goes to the kitchen, from there she says) I was going to go for somewhat simpler molecules!
Sue: Now where is the fun in that!
Jay: Black.
Sue: Then another black and another black and another black.
Skip 12 turns
Mother: Is it a ring? (all three look closely at the image in the book)
Sue: Yeah looks like it, I mean its so hard to tell from this angle but see its up here and then it goes there, there, there, there, and there (pointing at points in the book image)
Mother: I don't know if that's a ring or not.
Sue: Well then what is it?

Mother: I don't know.
Sue: I think it's a ring. It all looks like connected to each other.
Jay: Hey I'm going to run out of resources pretty soon. Red.
Skip 34 turns
Mother: We're going to move on here I think. (Mother is talking to Sue and explains the next part of the project in which she wants Sue to measure and calculate moles. About 10 minutes later, Sue is getting started on measuring moles of table salt).
Jay: Wait if I do this I have one that's long enough. I think I'm done. Yes no?
Mother: Is this it?
Sue: I think this is it! I think that this is...what was it again?
Mother: Sucrose
Jay: Sucrose!
Researcher: Wow, you've got the two rings with the bendy bonds?
Jay: Yes here is one ring… this is one ring and here is the other ring. (Then he picks up the ring in front of the computer and moves it over to the table)
Jay: It looks very messy. (Sigh) Wow! I'm happy.

Figure 8.3. Jay and Sue Building Sucrose

The segment of video that covers the sucrose model building is approximately 48 minutes long. During this time the family discovered that sucrose has a double ring structure. Jay and Sue also negotiated the use of the kit resources, and Jay accomplished a self-imposed goal of finishing the sucrose model he started. Similar to the touch tank transcript, all the family members were engaged in the process. They engaged in improvisation while their attention/talk/actions were

distributed among them as a group and the resources available. They also pursued different goals in their activity.

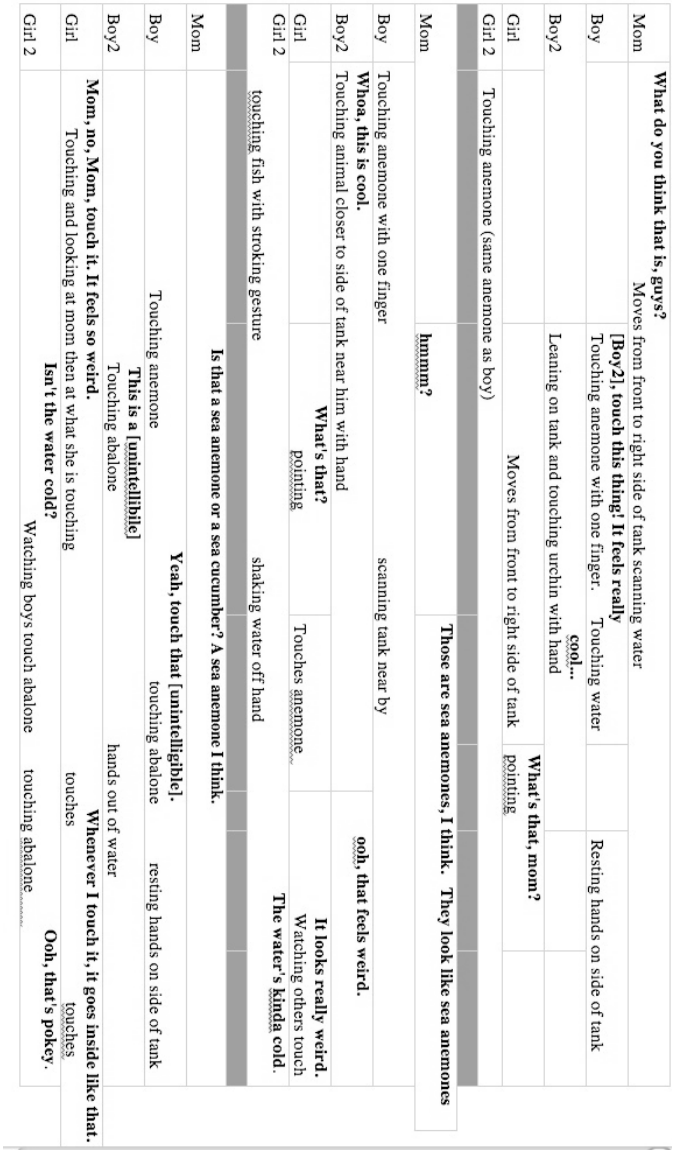
ANALYTIC SYNTHESIS ACROSS EXAMPLES

We noted earlier how a sociocultural approach encourages us to view the kind of learning in the vignettes of the touch tank and the sucrose molecule as resulting from interactions among people and between people, objects, and environments. Learning is further mediated by psychological tools which serve both communicative and cognitive functions. We learn to use those tools by being involved in socially meaningful interactions. Our transcriptions, therefore, have focused not only on who said what, but also on how what is said is tied to the context, the ongoing activity, and the use of tools. An alternative version of the first 21 seconds of the first transcript of the family at the touch tanks could look, for instance, like Table 8.1. We could also have provided a similar analysis for a portion of the home school sucrose transcript.

Interactions (Agents Using Tools Toward Goals)

A focus on interactions, as in Table 8.1, is essentially a focus on agents using tools toward some goal or goals. Often this means an analysis that focuses on people doing things with language and other symbol systems for particular purposes within particular contexts. In our research we tend to take a micro-genetic approach, analyzing interaction moment by moment. Such an approach is common in museum research and informal learning environment research. The primary tools are observations and coding of behavior and talk captured through video and audio recording or sometimes through ethnographic field notes. Each type of data collection has tradeoffs: video creates a huge amount of data that can be analyzed multiple times at varying levels of specificity and detail. It is highly intrusive. Direct observations (data collected via field notes) allow for studying many interactions, but may limit the types of analysis that may be done since some discourse may be missed.

No matter how the data is collected, the primary difficulty is the simultaneous capture of both talk and action, which is crucial to the analysis. The two contextualize each other—the meaning of what is said is dependent in part on what is being done at that moment, the context within which it is said, the immediately preceding talk, and the history of all participants. For instance, a transcript that captures a person saying "Look at that!" without some simultaneous way of indicating what the speakers are pointing or gesturing toward, literally misses most of the action. Beyond the obvious importance of pointing as a gesture for drawing another's attention, it clarifies the referential meaning of words like *that* and *it*, which in the touch-tank transcript stand for a sea anemone or a sea urchin or a sea slug, three very different animals (one of which is not in the tank). Likewise, in the learning at home example *that* and *it* might refer to



Mom	**What do you think that is, guys?**				
		Moves from front to right side of tank scanning water			
Boy		**[Boy2], touch this thing! It feels really**			
		Touching anemone with one finger.	Touching water		Resting hands on side of tank
Boy2		Leaning on tank and touching urchin with hand	**cool…**		
				What's that, mom?	
Girl		Moves from front to right side of tank		pointing	
Girl 2	Touching anemone (same anemone as boy)				
Mom		**hmmm?**	**Those are sea anemones, I think. They look like sea anemones**		
Boy	Touching anemone with one finger	scanning tank near by			
Boy2	**Whoa, this is cool.**			**ooh, that feels weird.**	
	Touching animal closer to side of tank near him with hand				
Girl	**What's that?**				**It looks really weird.**
Girl 2	pointing	Touches anemone		Watching others touch	**The water's kinda cold**.
	touching fish with stroking gesture	shaking water off hand			
Mom	**Is that a sea anemone or a sea cucumber? A sea anemone I think.**				
Boy	Touching anemone	**Yeah, touch that [unintelligible].**			
		touching abalone	resting hands on side of tank		
Boy2	**This is a [unintelligible]**				
	Touching abalone	hands out of water			
	Mom, no, Mom, touch it. It feels so weird.			**Whenever I touch it, it goes inside like that.**	
Girl	Touching and looking at mom then at what she is touching		touches	touches	
	Isn't the water cold?				**Ooh, that's pokey**.
Girl 2	Watching boys touch abalone	touching abalone			

Table 8.1. Talk and Action at the Touch Tank

the book image, the screen image, a physical molecule, or a particular atom (ball). Pointing also makes evident who is talking to whom, who is paying attention, or who is responding to whom.

Participant Goals

Once we have gathered useful, simultaneously occurring data, a good starting point for the analysis is focussing on participant goals. Goals actually shape how interactions develop, whether they are made explicit or not. As often as not, there may be multiple, competing goals within a group during an interaction. The mother at the touch tank certainly promoted learning as she promoted identifying animals, enjoying the aesthetic dimensions of the experience, and hazarding a guess. She attended to each of the members of the group while at the same time was a member and actor in the actual experience. How do we know that? We can "see" it in the discourse where the mother asks questions of the other participants, while simultaneously pursuing her own investigation of the sea anemone. It is also apparent in her answers to the interview and survey questions and her talk about the motivations and purpose that led to the family visit to the science center and touch tank activity. In this particular example, the mother talked about the museum as a great place to spend time learning about the environment. Her vision of the exhibit space as a place for learning shaped what she saw as appropriate behavior to model and suggest for the rest of the group. Other members of the family appeared to have different goals, such as getting someone else to do something (touch it in the mouth; touch the 'weird one') or even making sense of the touching experience using prior knowledge (as in the discussion of how the anemone protects itself).

In the home learning example, a prior interview revealed the mother's planned activity goals for her daughter; there were none for her son since the lesson was not designed for him. However, Jay's goals can be discerned by the way he participates. Sometimes it is necessary for the researcher to infer the goals based on the transcripts and observations; if it is a critical goal, it might be necessary to confirm the researcher's inference with the participant. For example, when Bachman viewed the transcript she used her prior knowledge of the history, motivations, and culture of the family in order to best understand the transcript. Bachman interpreted Jay's actions as driven by the goals of wanting to have fun, wanting to be involved, wanting to challenge himself, and perhaps competing with his sister. Participant checking indicated that her inferences of these goals were accurate. Participant checking also indicated the degree to which the mother's philosophy and style of learning at home influenced her actions during the activity; how her high standard for academics influenced the resources available and lesson plan; and how her flexible style influenced the course of the lesson.

Communication and Thinking Tools

Another way to analyze interactions is to examine how each family member uses cultural tools for communication and thinking. In both examples the family members used a variety of cultural tools, some coming from contexts of doing science and some from more everyday contexts. Pointing as a way of drawing attention, for instance, is a relatively simple, but crucial tool of communication. Every individual member of the family at the touch tank pointed to draw someone else's attention to a particular animal or feature of the tank, even in this brief transcript. Other more complex cultural tools included everything from the models used by the family in the home learning example, to simple question and answer routines, to making basic observations (e.g., "It was moving until I touched it"), to using prior knowledge to reason about a current phenomenon (how one organism protects itself by blending in). Note that these cultural tools run the gamut from basic gestures to interaction routines that are used in a wide variety of settings to share information (communicate) or to make sense of experience (think). It is also worth noting that while the family members could have conceivably used any number and type of cultural tools at the touch tank, they seem to have used only very few, and those were not very different from those other families mobilised. The exhibit itself appears, therefore, to promote the use of certain tools over others, particularly pointing, making exclamations, making affective statements to show others that you are engaged, asking questions and prompting others to touch. The museum context may similarly promote the use of certain tools over others—certainly no one picked up the animals, which they might do at a "real" tide pool near the beach. Similarly, no one splashed water in a playful way. Lastly, the goals of the interaction may have promoted the use of certain tools over others, especially tools associated with "learning" or "doing science," such as asking and answering questions, trying to name animals, or scientific reasoning.

Agency (Agents and Tools Using Each Other)

A fourth analytic lens of a mediated action approach is agency. This is the lens closest to the traditions of Western psychology, focusing on individual action or, more precisely, on how individuals come to be agents of their own thinking and communicating. To do this they must appropriate the use of new cultural tools, and use them in particular contexts and activities that are driven by goals over which they may have varying levels of choice and control. People come to learning experiences with varying background knowledge and experiences, personal identities, collective identities, assigned and ascribed status, and varying cultural models for learning in the environments within which learning occurs. Those environments may consciously or unconsciously privilege some identities, cultural tools and models of learning and interaction over others in ways that advantage some learners over others. Studies of agency in education and learning have increasingly sought to understand the ways in which access to cultural tools and the

privileging of certain cultural tools supports or denies agency to individual learners.

One way to examine how agency is exercised is to look carefully at how different cultural tools get used to enact agency. For example, in the transcript of the touch tank, the two girls engage in a series of identification questions with her mother. Far from being passive receivers of their mother's answers, the girls actually push their mother to put her hands in the water and touch the animal. The girls exercises agency not only in terms of their own choices of which animals to touch and which part of the tank to pay attention to, but in terms of their mother's interaction with the tank by directing what the mother should be doing. In a similar way, at these touch tanks, adults often try to exercise their own agency over children by monitoring and controlling time spent observing particular animals or interacting with the tank at all. Adults enact their agency in drawing attention from one part of the tank to another in such a way that children physically move from one part to another in a timely fashion. Note that such "moving along" may actually disrupt deep observations of animals in which children are engaged in, thus curtailing their own agency. The mechanism in each case is to use a regular cultural tool at the tank (drawing someone's attention by pointing or directing activity verbally) toward a goal that has less to do with observation and learning and more to do with controlling the group members' interactions.

In the learning at home example, change of agency is often indicated by a change in direction, or focus, which changes the goals of the activity. For instance, if Sue and Jay would have pursued the lesson as intended by their mother from start to finish, then we would have seen very little change in direction, with the mother in charge of the action. However, what we actually see is that the lesson changes direction as the various actors share agency. Each actor is influencing the outcome and goals of the activity via cultural tools (pointing, interrupting, directing, asking, drawing attention, etc). For instance, Sue and Jay changed the direction of the lesson towards making a sucrose molecule (even though the mother was initially resistant to the idea). One way in which Jay shows agency at the beginning is by choosing to participate in Sue's lesson. Sue's agency can be seen in her redirection of the lesson to include sucrose, pushing her mother to "Write it down!"

Affordances and Constraints of Learning Environments (Contexts, Tools, and Agency)

One of the most important ideas in a mediated action approach is that tools and contexts come with built in affordances and constraints. Certain kinds of uses and interactions are promoted and supported, while others are not. For example, in the learning at home vignette the organic model kits constrain the discussion to chemical and molecular concepts, how the size of the kit limits molecule complexity, while also encouraging cooperation and sharing among its users (since the kits have to be combined). At the same time, the kits and the lesson plan together afford a deeper level of complexity in interactions and molecule building,

negotiation, and presumably learning than would have been achieved without these particular tools and contexts. Jay would likely have never considered building a sucrose molecule if he wasn't allowed and encouraged (context) to participate by using the kits (tool) as he saw fit (context).

The homes of home educating families are often designed with particular learning arrangements and interests in mind. Some families arrange for specified learning areas while others make every room in the home a learning friendly place. Similarly, institutional informal learning environments, like museums, are carefully constructed and mirror the organizational commitments and interests of the social institutions and groups they represent. As a result, both environments are designed to promote or afford certain interactions while constraining others. By analysing the affordances and constraints of the cultural tools valued and marginalized in various learning environments we can gain a glimpse into an organization's interests and how they shape interaction. This is essentially an analysis of how tools and contexts get to be the way they are and how they afford or constrain what can be done in and with them.

In the photo of the family at the touch tank, for example, the physical nature of the space affords the kind of distributed, yet focused attention that makes the kinds of things discussed in the section on interaction above possible. The mother (not to mention the researcher) can see what all members of the group are doing at once without having to disengage from the actions of touching and looking at the organisms in the tank. That visitors can interact with the touch tank exhibit in this manner is not accidental. Designers purposefully set the height, size, and depth of the exhibit to allow multiple people to use it at once; the many sides to the touch tank also allow staff to see and talk to any given visitor while keeping an eye on the actions of all visitors, so as to protect the animals. While the developers probably did not have in mind the fact that this structure would allow adults to be engaged while monitoring group members, it certainly does afford that. A mediated action approach highlights this kind of unintended consequence by focusing simultaneously on all the ways cultural tools are deployed toward particular goals within the constraints of the context.

RESEARCH IMPLICATIONS OF A MEDIATED ACTION APPROACH

When we take a mediated action perspective, our focus shifts from substances to processes—from nouns to verbs. *Knowing* becomes doing things with cultural tools for particular purposes in particular contexts. A change in knowing (that is, learning) is a change in the ways of doing things with cultural tools or even a change of goals. A mediated action approach is therefore not about studying changes in knowledge or attitudes or beliefs by *measuring* them at time *a* versus time *b*, but about seeing changes to a system and documenting those changes over time. A change in any of the five elements of agent(s), actions, tools, goals, and contexts can be interpreted as learning, and this kind of learning may only become visible to either the knower or researcher by focusing on the mediated action.

The short interactions analyzed above are illustrative of many of the interactions observed on a daily basis by those of us who work in and do research in museums and other informal science education institutions. We know that these kinds of experiences are an important aspect of learning science, especially in terms of developing motivations and identities related to science (Natinonal Research Council, 2009). As the chapters in this volume suggest, the larger field is beginning to have a sense of how to document and describe such learning in its rich complexity. Unfortunately, just as the place of such learning and such sites for learning are coming to be recognized (National Research Council, 2009), the range of valued tools for documenting and describing that learning is shrinking. Researchers, evaluators, and curriculum and exhibit designers are facing calls for higher standards of accountability, couched in the rhetoric of increasing rigor and narrower definitions of success. Old-fashioned, large-scale medical study models are being called for as the most valuable proof of the effectiveness of informal science education.

There are undeniable pluses to large-scale model research. Large scale, randomized control treatment studies give a sense of surety in generalizing to large, heterogeneous populations; they can account for observer and contextual effects; they can promote rapid advances, as one study builds on the last. However, there are grave limitations to such research as well. First and foremost such research studies seriously limit the kinds of questions that can be asked and answered in a field. They focus on questions of cause and effect and yes/no questions or on model building and testing. These approaches do not lend themselves to answering "how" and "in what way" questions. Additionally, by their very nature, such studies tend to focus on large populations sampled at discrete times so that the rich experiences of smaller subgroups may be erased or silenced. Moreover, the process of learning often becomes secondary to claims about the quantity of learning. Researchers run the risk of being able to answer only questions that are of interest to government funding agencies and not to the very people who participate in our research. We run the risk of putting funders' needs ahead of learners' needs. This is not to say that such research is unwarranted. We need it as much as we need other more exploratory and documentary kinds of research. It is to say that randomized control treatment studies should always be juxtaposed with other techniques that more adequately address questions of interest to practitioners and learners themselves.

A result of an overreliance on the medical model of research, and the concomitant use of marketing and evaluation goals in designing research, is the tendency of our epistemologies of practice and research to loose the dynamic focus on process and become stuck in the stasis of nouns again. Research answers, in such large-scale models, assume that the content and meaning of a learning context or the learning that occurs there must somehow be in the learner or in the structure of an exhibit rather than *emergent* from the interactional activity that learners are engaged in. A mediated action approach encourages us to avoid such reductionisms by bringing a variety of research methods to bear in asking and answering questions about learning activity of groups in informal settings. A mediated action

approach seeks to document and understand learning as a dynamic process with multiple, often unanticipated outcomes. It does not insist on a particular method. Instead, it stands as a general pragmatic approach that draws on various particular methods of data collection and analysis, as appropriate, depending on the concrete questions one is trying to answer and the analytic level one is working through at the moment.

With this mediated action approach we must also rethink what it means to know and learn in informal contexts. A mediated action perspective shifts the focus away from the mind as a feature of individual brains to mind as a distributed (and perhaps emergent) feature of a system of brains, tools, purposes, and contexts. As the examples above illustrate, we are looking at individual brains (or groups of them) putting particular psychological and physical tools to work for particular purposes at a particular time and place. Similarly, from this perspective learning is seen as the distributed and social mastery and appropriation of cultural tools as part of interaction within some context that may either support learning or constrain it.

Understanding what's going on in the two vignettes requires knowing something about many factors, including the families' goals, the organizations' goals, the physical characteristics of the setting, the kinds of prior knowledge and experience each of the family members brings and how they deploy them during the interaction, what they each think they are doing and learning while there, how they talk about their experience or reconstruct it later, and perhaps what they think about being videotaped. We would expect that anyone who claimed to be familiar with this event would be able to tell us something about each of those. Why should we expect less of ourselves as researchers of such events?

Does this mean that all research always must take into account everything about agents, tools, contexts, goals, and actions? Certainly not. First of all, it would render short term, highly applicable research almost impossible. Second, it would require a huge amount of time and be more or less intrusive on learning itself. The three different analytic levels or perspectives we discussed above—interactions, agency, and affordances and constraints—can help researchers design ways to understand learning in its complexity and richness, without specious demands of inclusivity and generality.

CONCLUSIONS: AFFORDANCES AND CONSTRAINTS OF A MEDIATED ACTION APPROACH

We have argued that informal education research should continue to develop interdisciplinary, mixed method approaches to working with learners and that a mediated action perspective is one that is able to support this kind of work. A mediated action approach is necessarily interdisciplinary, drawing on techniques, theories, and methods from psychology, education, sociology, anthropology, textual analysis, history and cultural studies. As a result, a mediated action perspective makes our research able to be more responsive to diverse contexts and learners. It also allows us to line up research at different time scales (microgenetic, ontogenetic, historical), in order to understand how learning happens for

individuals and groups over time, and to develop accounts of learning that begin to document the real long-term impacts of learning in informal contexts. We have also argued that research focused on medical models of randomized treatment do not capture the rich interactive, socially distributed, emergent nature of active learning in informal settings. A mediated action perspective allows us to examine learning interactions holistically as social interactions with regard to individual change by utilizing research methods that respect both individual and social characteristics of learning, while not limiting research to one type of method or design. Vygotsky himself used experimental, quasi-experimental and descriptive methods. Lastly, we have argued that research primarily focused on learning as a change of knowledge or attitude or beliefs blinds researchers to the multiple elements of learning science in informal settings as outlined by the National Research Council report. By encouraging the researcher to focus on learning as an appropriation of cultural tools for communicative and cognitive purposes, a mediated action approach shifts the focus to processes and practices.

We have further indicated how a mediated action perspective can shed light on three levels of analysis: interactions, agency, and affordances and constraints of contexts and tools. A focus on interactions allows us to address a perennial issue facing researchers who study learning in situ, working outside of laboratories in schools, workplaces, and museums: what is the appropriate unit of analysis? On the one hand, we want to be able to make claims about individual learners and their learning in these settings. On the other hand, we recognize that learning is always a distributed, emergent phenomenon, particularly in settings like museums where most people interact with objects and ideas as part of a group (Dierking, 2002; National Research Council, 2009). By shifting the unit of analysis for research away from the individual learner to mediated action, mediated action approaches allow us to understand learning as both an individual and group process (Rowe, 2004, 2005). A focus on agency allows us to address issues of access, cultural representativeness and what ways of knowing and being in the world are being explicitly or implicitly privileged in the learning contexts we study. A focus on affordances and constraints allows us to address questions of access and purposes/goals of informal education settings and how they align or not with the purposes of diverse groups of learners.

At the same time mediated action approaches in museums have suffered from the same thing as the field in general: a lack of longer-term work with individuals and groups about their learning. Rowe's work, which often focuses on those all too fleeting visitor interactions with exhibits, suffers from this lack. Addressing this lack requires developing long-term relationships with research participants who in a sense become co-researchers on their own learning over time. It also means that the museum or university has to be a competent and valued community partner in order to develop working relationships with communities rather than working on communities. Bachman's home school family example attempted to follow families, understand their values, and share experiences over time. Families in her study co-interpreted the activities and were an integral part of her analysis via member checking. However, developing such connections with families and

participants is not easy. As Bachman's research suggests learning may be a more intimate act then we realize from school based research. Gaining "insider status" with families, even the ones the researcher knows well, may be difficult, as well as costly. A mediated action perspective does not hold the answers to questions of scale, access, and financing.

Even the careful attention to mediated action still illuminates only half the story of learning in museums and other informal settings. The tools we advocate here need to be paired with tools that describe and eventually explain how social interactions become or develop into individual intra-mental functioning. Vygotsky (1981) originally argued on behalf of this dual focus, in order to develop truly inclusive, powerful, and relevant accounts of learning. With a mediated action approach we are almost halfway there.

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AFFILIATIONS

Shawn Rowe
Oregon Sea Grant, Department of Science and Math Education
Oregon State University
shawn.rowe@oregonstate.edu

Jennifer Bachman
Department of Science and Math Education
Oregon State University
bachmjen@onid.orst.edu

LEAH MELBER

PUTTING THEORY INTO PRACTICE

ROWE & BACHMAN'S MEDIATED ACTION AS A FRAMEWORK FOR EXPLORING LEARNING IN INFORMAL SETTINGS

Rowe and Bachman immediately capture the attention of the museum professional with a vignette of a family learning together at a touch tank and then a family learning at home. They keep our attention as they discuss the critical role a framework of mediated action plays in effectively deconstructing this two common scenes to better understand the overall experiences of the learners. Using a pentad of factors—from actions to context—they inspires us to understand the experience as it is occurring, not alter the experience itself to fit an established methodological approach.

Though it occurred almost 30 years ago, I remember quite clearly my sixth grade field trip to the Museum of Science and Industry in Los Angeles (now, California Science Center). We were for the first time allowed to roam in groups of our choice and I was thrilled to be able to explore the space with my best friend Jenny and my other friend, her 'boyfriend' David. (At ten, I had not yet learned the concept of 'third wheel.') Our first stop was an exhibit with two sets of headphones through which a visitor could listen to a compilation of percussion instruments. I watched awkwardly as they listened to the music, and wanting to be involved, pushed the lone button on the console. "You started it over," David calmly stated in a clearly disappointed tone. He and Jenny abruptly replaced the headphones and turned away. Off we went to the next exhibit where I tried very hard not to touch the wrong thing again.

Reflecting on the pentad as outlined by Rowe and Bachman, I think we can see there were certainly a number of factors at work shaping my experience that day, much of which were social in nature. My goal was to explore the space with my friends. However, Jenny and David may have had goals more focused on exploring with each other than with me. While simple tracking and timing studies would have shown my group and I moving together from exhibit to exhibit and all "engaging" at the exhibit together, that would not have truly captured my experience. Our social interactions were shaping how as individuals we were exploring the exhibit space. The sign system in this case was not just language, but the abrupt replacement of head phones that indicated my action had ended the experience for them. With regards to the cultural and historical context of that experience, an analysis of pre-adolescent social structures would require a whole separate chapter. However, I think we'll agree had I chosen a different 'social grouping' for the day, I may not have had the perfect vignette for this chapter. And for the record, Jenny does not remember the situation in quite the same light—

D. Ash et al. (eds.), Putting Theory into Practice, 163–164.

perhaps another reminder that that the cognitive experience of the visit is both individual and social in nature.

We as museum professionals know that people visit our locations in groups. They interact in ways that can be difficult to capture, they don't move in a single line, they have discussions that have nothing to do with the exhibit, and we rarely can tell just by looking who is related to whom. Rowe and Bachman's work reminds us that this is not the 'messy outlier' that needs to be streamlined and simplified in order to have a quantitative and linear measure of the experience. Rather, this is the authentic experience at its most pure and that a framework of mediated action is one way we can seek to better understand the visitor experience while preserving the experience itself rather than seeking to reduce it to a more manageable data point.

DISCUSSION QUESTIONS

1. Think back to a recent visit you took with friends or family to a museum. How did the pentad of agent(s), actions, tools, goals, and contexts impact your reflection of the experience?
2. How would you go about making a case for a mediated action framework when stakeholder expectations may be centered on large sample sizes and pre-post measures of content gains?
3. If we reflect on learning as a process, rather than an end goal, the importance of longitudinal research is clear. What are some ways you can explore longitudinal studies at your institution given the reality of practical and resource constraints?
4. Take on the role of researcher and view the science center example with regards to the three levels described by Rowe and Bachman. Discuss the interplay of interactions, agency, and affordances/constraints of context and tools on the experience of the learners?

STEVEN R. GUBERMAN

9. EPILOGUE

Learning in the Usual Places[i]

In the introduction to this volume, the editors have set ambitious goals for themselves and the other contributors. They write, "the chapters that follow offer unique insights into how theory and methodology constitute one another and how a focus on their interplay strengthens our understanding of the role informal settings play in learning for life." Their main goal, they continue, is "to promote attention to the full complexity and richness" that the study of learning for life in informal settings entails (p. 1). Although they also hope to achieve other goals—bringing forward methods that can uncover and incorporate the resources of people typically underrepresented in such research (e.g., less educated, lower socioeconomic status, or culturally and linguistically diverse), and avoiding the trap of a simple formal-informal dichotomy—this main goal is both welcome and challenging. As a young and rapidly growing field, research on learning in informal settings can certainly benefit from a toolbox of theoretically-grounded, well-tested methods to promote the synthesis and progressive accumulation of research findings across a variety of fields, settings, and approaches. On the other hand, is there something about learning science in informal—often synonymous with out-of-school—settings that requires research methods[ii] that are distinct from those used in other settings? And how can research in informal settings inform our understanding of learning in general?

A LITTLE HISTORY

Learning is complex, whatever the setting, including the supposedly controlled environment of a psychology laboratory (Newman, Griffin, & Cole, 1984). Allen et al.'s (2007) suggestions for reducing or embracing complexity when conducting research in informal settings are helpful for anyone conducting research on learning in all settings. Historically, researchers have attempted to describe specific characteristics that distinguish learning in formal and informal settings. For instance, in an early contribution to the study of learning outside of formal schooling, Greenfield and Lave (1982) wrote:

> Apprenticeship to learn a craft or become a navigator is part of education. Learning to play pool by hanging around the pool room and practicing is part of education. Learning to sew, to play games, and even to master basic self-management skills in early childhood are informal educational experiences. (p. 182)

D. Ash et al. (eds.), Putting Theory into Practice, 165–180.

Just as informal settings vary, Greenfield and Lave noted that formal schooling can take a variety of forms, including bush schools and schools devoted entirely to memorizing religious texts (e.g., Scribner & Cole, 1981). Drawing on research primarily conducted in non-Western, less industrialized societies, Greenfield and Lave argued that "'formal education' and 'informal education,' considered as two poles in a typology, have opposite characteristics" (1982, p. 183), which are summarized in Table 9.1. Because of problems that are discussed below, it is this kind of dichotomy between informal and formal learning that this *Theory into Practice* text resists.

Table 9.1. Some Idealized Characteristics of Informal and Formal Education

INFORMAL EDUCATION	FORMAL EDUCATION
1. Embedded in daily life activity.	1. Set apart from the context of everyday life.
2. Learner is responsible for obtaining knowledge and skill.	2. Teacher is responsible for imparting knowledge and skill.
3. Personal; relatives are appropriate teachers.	3. Impersonal; teachers should not be relatives.
4. Little or no explicit pedagogy or curriculum.	4 Explicit pedagogy and curriculum.
5. Maintenance of continuity and tradition are valued.	5. Change and discontinuity are valued.
6 Learning by observation and imitation.	6. Learning by verbal interchange, questioning.
7. Teaching by demonstration.	7 Teaching by verbal presentation of general principles.
8. Motivated by social contribution of novices and their participation in adult sphere.	8. Less strong social motivation.

Note. Adapted from Greenfield and Lave, 1982 (p. 183).

Greenfield and Lave (1982) admitted that their characterizations of both informal and formal learning are idealized, and that cultures contain both informal and formal teaching-learning formats. Research in the U.S., for instance, has analyzed the mathematics learned and used in installing floor coverings (Masingila, 1994), children's engagement in commercial transactions (Guberman, 2004), parent-child everyday activities (Saxe, Guberman, & Gearhart, 1987), and game play (Guberman, Rahm, & Menk, 1998).

Although helpful for understanding teaching and learning in well-specified cultural practices, dichotomous descriptions such as those summarized above are problematic for research into the types of learning of interest to the authors of this

volume. Anderson and Ellenbogen (2012) contend that such "dichotomized views are frequently oversimplifications of the characteristics of informal learning. The nature of learning in informal environments is, however, much more complex." This statement both returns to the issue of complexity and overlooks the likelihood that these dichotomies also oversimplify the characteristics of formal learning environments.

Objections can be raised about how well Greenfield and Lave's (1982) characterization of formal education applies to contemporary classrooms, in which relationships between teachers and students are increasingly seen as important to student learning, and teachers are encouraged to instruct less by verbal presentation of general principles and more by engaging students in hands-on, project-based activities. In addition, learning is no longer the sole responsibility of the teacher but viewed as a responsibility shared by teachers and students actively constructing their own understandings (Hedegaard, 2001).

Equally true, many of the characteristics of informal education described by Greenfield and Lave (1982) do not apply to contemporary studies of informal learning. Rather than being embedded in the activities of daily life, visits to museums and working in urban gardens—informal educational settings described in this volume—are usually special occasions with distinct notions for visitors about what to expect and how to behave; they are often social occasions for families and friends, making it likely that teaching and learning will be personalized experiences. Perhaps most importantly, the educational philosophy of many museums and informal educational programs has moved away from didactic displays and demonstrations to learning by exploration (Hein, 1998). Rather than maintaining continuity and tradition, informal education often takes as its goal to challenge traditional beliefs and encourage new ways of thinking. For these and other reasons, Martin (2007) concluded that museums may actually "straddle" the informal-formal divide, drawing on aspects of both. In the introduction to this volume, Ash and Rahm take another approach, noting that one of their aims for the volume is "to step outside the traditional boundaries of the typical formal/informal dichotomy" (p. 6). Whatever one's position on the accuracy and utility of the informal-formal divide, characteristics of the two settings offer little guidance for understanding the full complexity of learning. Instead, as expressed by Ash and Rahm, studying learning demands a move "beyond case based studies of the informal" to explorating "belief systems and ideologies of other places that the participants bring with them" and that "constitute their participation and activity" (p. 6).

CONCEPTUAL FRAMEWORKS

In a recent review of studies of science learning in informal settings, Phipps (2010) noted that until recently many studies of learning in informal settings had lacked a conceptual framework, a situation that, she found, has greatly improved over the years of her review, 1997-2007. Of the 85 studies she reviewed, all but three included a guiding conceptual framework, and 93% of the others could be

classified as including at least one of four frameworks: behaviorist, constructivist, experiential, and sociocultural. Anderson and Ellenbogen (2012) described three research paradigms that have guided most research on science learning in informal contexts: positivist-decontextual, typically employing experimental designs with control groups and quantitative comparisons; relativist-contextualist, typically employing qualitative, interpretivist designs; and critical-theory, in which multiple, interacting systems influence outcomes, leading to questions about the meaning of learning itself.

The chapters in this volume do a splendid job of meeting the editors' aim to present methods that are "theoretically well grounded and methodologically rich" (p. 1). Reflecting the increasing trend in studies of informal learning to use a sociocultural conceptual framework (Phipps, 2010), all but one author (Anderson) explicitly draws from sociocultural or cultural-historical activity theory (CHAT), both rooted in Vygotsky's work. In accord with this perspective, each chapter provides detailed descriptions of the contexts in which teaching and learning take place. Context includes not just the physical setting but also the actors in them, with their varied backgrounds, motivations, and styles of interaction (e.g., Mai & Ash, Rahm). Context also includes broader socio-political forces, such as different demands for learning outcomes that exist between informal and formal learning environments, especially because the latter are increasingly influenced by mandated standardized, high-stakes testing (e.g., Kisiel, Tal).

In accordance with the foundations of sociocultural perspectives, most of the analysis presented here move away from seeing individuals as the only possible unit of analysis for studying learning, to focus more on group processes and group learning (e.g., Ash & Lombana, Mai & Ash, Rowe & Bachman). That is not to say that the individual is forgotten; chapters by Tal, Mai and Ash, Rahm, and Rowe and Bachman, in particular, illustrate the complex reciprocity of individuals learning within social groups engaged in activities that are, at least somewhat, organized and defined by others. For instance, Tal focuses on praxis—"the basic ways teachers learn their practice and on how they may improve their practice based on lived experiences, design and critical reflection in and of field trips" (p. 83)—and her analysis of group processes is primarily limited to how teacher-mentors and other members of the cohort provide information and support for individual learning. Following the dual emphasis on the individual and the group, and comparing how this interaction plays out in various studies, comprise one of the great pleasures of reading the chapters in this volume.

In describing a repetitive, dialectic, hermeneutic approach, Anderson encourages rounds of data collection, interspersed with hermeneutic analysis of emerging results. Throughout data collection, the researchers attempt to understand their data from the perspective of the people they study in a way that leads to the modification of methods for subsequent rounds of data collection. Rather than a fixed set of methods—the hallmark of traditional research approaches—methods change as the researchers' understanding of the phenomena under study grows. This thoughtful, reflective approach to conducting research is compatible with many conceptual frameworks, including sociocultural approaches.

Although some readers may wish the volume contained a greater variety of conceptual frameworks, the near universal focus on sociocultural theories provides an opportunity to see the diverse ways in which the authors use it in their work. Tal, for instance, uses CHAT to explain that thinking and learning are social and cultural processes and will, therefore, look different and require different competencies in school and out-of-school settings; the transfer of skills from one setting to another cannot be assumed and requires effort.

Ash and Lombana and Kisiel use the notion of "community of practice" in their work, but they do so in different ways. Ash and Lombana, referring to the collective and collaborative nature of the learning experiences they provided for their floor staff, describe them as emerging into "an ongoing community of practice with shared language, practices and identities" (p. 33). In contrast, Kisiel is concerned with the conflicts that may arise when two communities of practice—urban school teachers and aquarium educators—have their own priorities, goals, constraints, and routines, which may not be congruent. Conflicting views and values about educational procedures and outcomes are likely to be common whenever formal and informal educational institutions work together. Kisiel shows how small but significant modifications in each community of practice, brokered by key participants, eventually led to a successful collaboration. Tal's study complements Kisiel's analysis; although she does not explicitly refer to communities of practice, one could interpret the difficulty classroom teachers have on field trips as an example of a community of practice (classroom teachers) asked to engage with students in a setting outside their typical practice, such as outdoor or museum settings. We should not assume that teachers' practices can easily transfer from one setting to another. It is likely that other readers will make their own connections and comparisons across the chapters in this volume.

Rahm uses a sociocultural historical framework, including issues of identity development, to understand how youth's participation in practices occurring in various settings and times can eventuate in youth's learning and science identity. Rahm argues that settings or communities of practice vary, and although each can hamper and facilitate learning, both are essential components of learning and identity development. Researching the multiple settings in which learning takes place,, and the links between them, is not an easy task. In their seminal study of a small (population=721) Midwestern town in 1951-1952, Barker and Wright (1954) identified 2030 independent behavior settings. Compatible with Rahm's approach, White and Siegel (1984) noted:

> American children do not have one privileged, natural, and valid scene of action. Each child has many. Is an experimental room less natural to a child than piano lessons, or a session in Sunday School? Children live in many situations. A statement about a child may not travel across any pair of them. A naturalistic developmental psychology can be achieved only through the creation and use of a theory of situations. (p. 240)

Rahm's multi-sited ethnographic method is a promising approach for developing a theory of situations. More generally, the various uses of a sociocultural perspective

in this volume make clear the complexity and wide application of the approach (i.e., it is not just about one form of social interaction or just the zone of proximal development) and suggest the many ways it can inform our understanding of teaching and learning in out-of-school settings.

Links between Conceptual Frameworks and Methods

In her review of research on informal science education, Phipps (2010) found that the studies she reviewed tended to employ four categories of data collection—observations, interviews, surveys, and written artifacts. The chapters in this volume illustrate each of these methods and, in accord with the general trend in science education research toward more sociocultural approaches and interpretivist research practices, most of the research methods employed by the authors are qualitative in nature. It is important to remember, though, that although conceptual frameworks, methodologies, and methods must be compatible with each other, the studies reported in this volume show that the degree to which they are linked can vary. Rowe and Bachman, for instance, are clear that the mediated action framework they employ does not dictate a particular set of methods: "Since it is not tied to a particular method of data collection or experimental design, a mediated action approach allows us to use a variety of methods" (p. 143). Similarly, Tal notes that action research is "a family of approaches, used in a variety of fields" (p. 83) and, consequently, does not prescribe a fixed set of methods. As a result, there are a variety of methods described in these chapters, and many methods are shared among them.

In these chapters, interviews are the most common method of data collection. They range from standardized to open-ended, although most are semi-structured, and participants are often interviewed across varying time gaps (e.g., Anderson, Ash & Lombanna, Rahm). Some interviews are conducted with individuals (e.g., Kisiel, Tal, and Rahm) and some with groups of people (e.g., Anderson, Ash & Lombana). Interviews are conducted with the participants whose learning is being studied (e.g., Anderson, Tal and Rahm), and also with the staff members of communities attempting to create educational programs (e.g., Ash & Lombana, Kisiel). On occasion, researchers (e.g., Ash & Lombana, Kisiel) have engaged participants in *stimulated interviews* by asking them to reflect on critical events, which may have been chosen by the participants, the researchers, or both.

Observing participants while they are engaged in learning activities, and recording the interactions for subsequent transcription and analysis, is another data collection method employed in several of the studies reported here. The focus and use of observational methods vary: Several authors (e.g., Anderson, Mai & Ash, Rowe & Bachman) use observations and recordings to better understand their participants' learning in museums, aquariums, and homes. In some cases, the videos themselves are then used with museum educators (Ash & Lombana) and teachers (Kisiel, Tal) to promote reflection on their own and others' behaviors, similar to the use of stimulated interviews.

Other methods from the qualitative researcher's toolkit are also employed by these authors, including questionnaires (e.g., Kisiel, Rahm), member checks (Kisiel), and detailed field notes (most chapters). Discussions and reflection by individuals and groups (e.g., Ash & Lombana, Kisiel, Tal) are also prominent methods used both to encourage learning and to facilitate data collection.

Although these chapters illustrate that a conceptual framework does not dictate the use of particular methods, they clearly show how conceptual frameworks help to guide decisions about the methods and analytic approach to be used. Describing the link between guiding frameworks and methods is a highlight of each of these chapters. For example, semi-structured interviews are used in several studies, although the authors' theoretical commitments lead to small differences in their use: Using a repetitive, dialectic, hermeneutic approach, Anderson emphasizes that his interviews changed over the course of data collection as a result of the researchers' reflecting on and learning from their interim results. In the midst of data collection Anderson altered his use of stimulated recall to better focus on incidents that are significant to the people being studied rather than to just the researchers. Similarly, Ash and Lombana refer to their work as "design-based research," indicating that the results of earlier phases of study have been used to inform subsequent research activities.

Tal's commitment that teacher professional development should include "engaging the teachers in asking meaningful questions about their own practice, discussing these questions based on their practice, challenging and redesigning their teaching, and reflecting upon their experience individually as well as in a group of practitioners" (p. 83), is directly connected to her choice of action research that engages participants in observing, reflecting on, and discussing their own professional experiences. In their chapter on mediated action, Rowe and Bachman discuss the tie between their conceptual framework and choice of methods and analysis:

> We noted earlier how a sociocultural approach encourages us to view the kind of learning in the vignettes of the touch tank and the sucrose molecule as resulting from interactions among people and between people, objects, and environments. Learning is further mediated by psychological tools which serve both communicative and cognitive functions. We learn to use those tools by being involved in socially meaningful interactions. Our transcriptions, therefore, have focused not only on who said what, but also on how what is said is tied to the context, the ongoing activity, and the use of tools. (pp. 152-15)

In their chapter, Mai and Ash provide a detailed account of how employing a sociocultural framework has directed their attention to aspects of learning not typically included in learning research (e.g., laughter and joking) and has helped them make critical decisions about their methods and analysis.

Most chapters illustrate the use of a mix of methods. Surely, a mix of methods is appropriate for this, and other, research fields. As Loomis (2000, p. 19) explained, "the field of visitor studies has had its share of methodological 'paradigm'

advocates," and the methods we promote tend to be the ones we feel most comfortable with and have used before. But, he pointed out, "methods should always be in the service of ideas." The chapters in this volume are very much in the service of ideas, as they describe a variety of research methods, show how they have been shaped by conceptual commitments, and often have led, after a long and difficult process, to new questions about learning in a variety of settings.

None of the methods described here are new or unique to the study of learning in informal settings. Rather, many explicitly draw from research conducted in more formal settings, especially classrooms and teacher education. Ash and Lombana (this volume) note that they draw methods from those used in formal teacher professional development programs, and Tal (this volume) draws from the extensive work on teacher action research. But a distinct contribution of this volume is the way these methods have been adapted and extended in the studies reported here. Rahm, for instance, does not question the use of standard ethnographic methods as the best means to learn about and understand others, but argues that a full picture of science learning requires their use in multiple settings, across time and space. Ash and Lombana adapt procedures developed by Sherin (Sherin & Van Es, 2005) for teachers in classrooms, and use them with the staff of museums working with their visitors. In making these adaptations, the researchers extend the methods to address new questions in novel settings and also refine the techniques in ways that should increase their utility in any setting.

A discussion of the methods presented in this volume is important not because formal and informal settings may or may not differ in particular ways, but because the authors of this book articulate a conception of the learning process that extends beyond the learning settings themselves.

What's Really Different about Studying Learning in Informal Environments?

To gain a sense of how the view of learning presented in this volume differs from traditional views, consider two uses of the notion of scaffolding: one by Shepard (2005), an expert on educational assessment, and the other by Ash and Lombana (this volume; see, also, Mai & Ash, this volume). In both cases, the authors build on Wood, Bruner, and Ross's (1976) seminal work on tutoring and connect it with how a tutor (usually an adult) may assist a tutee (usually a child) to new levels of understanding within the range of potential learning that Vygotsky (1978) referred to as the zone of proximal development. Talking about formative assessment and scaffolding, Shepard (2005) wrote:

> When you consider the terms in light of sociocultural learning theory and Vygotsky's (1978) zone of proximal development, they're essentially the same thing. Occurring in the midst of instruction, formative assessment is a dynamic process in which supportive adults or classmates help learners move from what they already know to what they are able to do next, using their zone of proximal development. (p. 66)

Shepard went on to note that "learning in the zone of proximal development is a joint activity in which the adult simultaneously keeps an eye on the goal of fully proficient performance and on what the learner, with assistance, is currently able to do" (p. 66). Most sociocultural theorists would find little to object to in these statements. The problem, though, is in trying to equate scaffolding with formative assessment. Shepard explained that, in order to engage in formative assessment, students must accomplish three things: (a) hold a concept of quality similar to that of the teacher's, (b) be able to compare his or her current level of performance with the desired standard, and (c) be able to take action between the current level of performance and the desired outcome. In other words, "to be successful, the learner must also come to understand and take ownership of the goal" (p. 67). Horgan and Pressley (1997) made a similar claim when they identified "establishing a shared goal" as an essential aspect of scaffolding. Although teachers usually select goals based on curriculum (according to Shepard and Horgan and Pressley), students must understand and buy into these goals as a precondition of learning.

Similar to Shepard, Ash and Lombana (and Mai & Ash, this volume) describe scaffolding as a form of interaction among members of a social group, such as a teacher and student or museum educator and visitors, which enables the less capable participants to perform at levels beyond their independent ability. Also similar to Shepard, Ash and Lombana emphasize that the tutor needs to be tuned in to the tutees' current level of understanding and be flexible in building on the learners' prior knowledge. It is how the goal or the expected outcome of scaffolding is conceived that distinguishes the two approaches. For Shepard, goals are predetermined by teachers (and the curricula they must follow), and students must understand the goals to engage in the learning process, to be able to compare their current level of performance with the desired standard, and to take action to bring the two into accord. In contrast, there are no preconceived learning outcomes in Ash and Lombana's description of successful scaffolding on the museum floor. Indeed, they have found it necessary for their museum educators to give up the beliefs that there is a "correct" way for visitors to use the exhibits, a way that focuses entirely on content and, supposedly, that reflects the intentions of the exhibits' designers. These beliefs often conflict with the visiting family's "goal of wanting to create its own learning experience" (p. 37). Only by expanding what is considered to be a successful learning interaction have the museum educators been able to understand museum visitors' behaviors and become effective guides for them. Similarly, Mai and Ash note that visitors' learning goals and objectives are defined and redefined throughout the course of activity.

It is, perhaps, unfair to compare the open-ended goals of families visiting a museum with the curriculum and assessment demands of a classroom teacher. But I believe the difference reflects distinct views of the learning process itself. Ash and Lombana's view of scaffolding in the zone of proximal development is consistent with Vygotsky's (1986) insistence that the first time a child demonstrates having appropriated something new—such as a word—is not the end but merely the beginning of the developmental process through which the child comes to full understanding of its significance. Unlike most examples of learning, scaffolding in

the zone of proximal development produces performance *before* comprehension. Tracing changes in the relationship between adult speech and children's behavior across the zone of proximal development, Wertsch (1979) noted:

> For the child in the zone of proximal development … the coherence between speech and action must be created rather than assumed. One of the major ways that it is created for the child is by carrying out the behaviors specified by the adult and then building a coherent account of the relationship among speech, definition of the situation and behavior. This means that it is not the case that the child first carries out the task because she/he shares the adult's definition of the situation. It is precisely the reverse: she/he comes to share the adult's definition of [the] situation because she/he carries out the task (through other-regulation). (p. 20)

In other words, "holding a concept of quality similar to that of the teachers" may be the *first step* in an instance of formative assessment, but understanding an activity—a shared task definition between adult and child—is the *outcome* of scaffolding in the zone of proximal development. Rather than merely learning the procedures required for achieving the goals a teacher has for students, the gradual, effortful transition from other to self-regulation described by Vygotsky and, later, by Wertsch, provides opportunities for creativity, multiple outcomes, and cultural change, because the social interaction that takes place in the zone of proximal development not only assists movement to the next level but at least partially determines what that level will be. This makes it possible for learning (and development) to take a variety of pathways depending on social, cultural, and historical circumstances (Guberman & Saxe, 2000).

Conceptions of Learning in Informal Environments

As many researchers have pointed out, learning in informal settings differs from school learning in that the former is free-choice: visitors to museums, zoos, and other informal science institutions, typically decide for themselves the exhibits they visit, how long to remain there, whether or not to read informational labels, and so forth (Falk & Dierking, 2002). Indeed, learning may not even be a motive of many visitors to a free-choice educational setting (Falk, 2006). In reality, though, students in school may also choose to pay attention or not, to complete their assignments or not, to learn or not. In both settings, the freedom to choose what and when to learn is more about determining what is learned and less informative about the nature of learning processes.

In the Introduction to this volume, Ash and Rahm note that new views of learning (primarily sociocultural) have led to "the daunting challenge of capturing and analyzing learning in detail, as it occurs, interruptedly and discontinuously over time, within and beyond specific moments and settings" (p. 4). What does this new view of learning look like, whether sociocultural or otherwise, as represented by the authors of the chapters in this volume?

In accord with the sociocultural perspectives presented here, learning is a social process, based in activities or practices that are shaped by personal, social, cultural, and historical circumstances. The unit of analysis is contested, sometimes explicitly (e.g., Anderson, Kisiel, Mai & Ash, Rowe & Bachman); ultimately though, most authors choose a coordination that includes both individuals and groups. Learning occurs in family groups (Mai & Ash, Rowe & Bachman), institutionally-organized activities (Anderson, Kisiel, Rahm, Tal), and communities of practice that may include educators (Ash & Lombana, Kisiel, Tal) and the researchers themselves (Anderson). Learning occurs through active participation. Tal engages teachers in action research because "teachers learn their practice and on how they may improve their practice based on lived experiences, design and critical reflection in and of field trips" (p. 83); and Rowe and Bachman note that a mediated action approach to learning changes the focus from "substances to processes—from nouns to verbs. *Knowing* becomes doing things with cultural tools for particular purposes in particular contexts. A change in knowing (that is, learning) is a change in the ways of doing things with cultural tools or even a change of goals" (p. 159, emphasis in original). And because activities and practices are culturally and historically situated, they differ across individuals and families (Mai & Ash), communities of practice (Kisiel), and settings (Tal, Rahm, Rowe & Bachman) in ways that shape the learning that takes place in them.

As noted above, classroom-based learning research has also taken a turn toward sociocultural perspectives, and the views of learning described in this volume have also been applied to formal settings. So, again, is there something special about studying learning in informal settings? I propose that the chapters here point to learning as gradual, holistic, open-ended, and variable in ways rarely seen in the literature on school learning. Anderson provides a helpful description of what this type of learning is *not,* which he refers to as the linear approach

> … epistemologically linear and instantaneous in nature without consistent regard for the notion that learning is an ongoing dynamic phenomenon. Such linear views narrow the focus of visitor studies on the effects and impact on visitor learning of unitary events like using an exhibit, exploring a gallery, or visiting a whole museum. This isolated view of learning is reflected in the methodological approaches used, for example, exit interviews seeking to understand visitor experiences of the museum in the past few hours, or naturalistic observations that seek to understand the immediacy of visitors' behaviors in the gallery (pp. 16-17).

As illustrated in the chapters of this volume, learning is neither linear nor instantaneous; focusing on unitary events distorts the vision of both the learning process and its outcomes. Learning also is not only a cognitive process.

Learning is not linear. As in the example of formative assessment above, learning is often analyzed as a linear process in which incremental changes lead smoothly from one state of knowledge to another, more advanced state. In contrast, the conception of learning presented in this volume is an uneven, uncertain process in

which the direction and outcome of a potential learning episode are often variable. Rowe and Bachman explain that "a mediated action approach seeks to document and understand learning as a dynamic process with multiple, often unanticipated outcomes" (p. 159). Mai and Ash make a similar claim when, in describing families interacting at museum exhibits, they note that "learning goals or objectives are defined and redefined as part of the group's in situ activity" (p. 101). The museum educators, with whom Ash and Lombana have worked, had to give up their solitary focus on the science learning goals of the exhibit developers to also attend to the manner by which families "created their own learning space in the merging or hybridizing of multi-layered 'story-lines' and ways of doing" (p. 113). Sometimes, this entails an enlarged definition of the outcome of a successful learning episode. For instance, Mai and Ash note that few of the families they have observed using the Bed of Nails exhibit have engaged in conversations about the distribution of weight, the exhibit's presumed underlying science content. Instead, they write, "rather than viewing such data as a failure of effort, we have chosen to interpret them as opportunities and occasions for social bonding, use of humor, and for the children to be on an equal playing field with the adults" (p. 112). The implication is that these aspects and outcomes of learning are as essential to understanding the nature of learning as is science talk when it takes place.

Learning is not instantaneous. As any teacher struggling to keep pace with the demands of a full set of curricular unit and lesson plans is well aware, learning takes time. Within the sociocultural perspective, meaning is gradually appropriated, constructed, and reconstructed in the movement from other- to self-regulation during dynamic, social activity. Several chapters extend the learning timeframe beyond the usual descriptions of lessons, units, and cycles of classroom instruction and assessment. Rahm's research approach begins with the notion that science learning and the construction of an identity as one who can learn and do science are cumulative processes that build as children engage in multiple practices of scientific reasoning that occur across time and place. Similarly, Anderson asserts that "outcomes arising from a museum experience change over time, or longitudinally" (p. 17), such as when museum visitors' interests are piqued in ways that lead them to pursue related topics in conversations, the media, and the internet, and to make connections with other life experiences. This is the "lifelong, life-wide, and life-deep" learning described in the National Research Council's (2009) recent report, *Learning Science in Informal Environments*.

Learning is not a unitary event. Rahm's research goes beyond showing that science learners engage in a variety of science practices, each shaped by its local context, to argue that a full understanding of science learning entails looking at the relations between practices, both "their local uniqueness and also their global contribution to learning" (p. 124), and how some practices may support movement in a particular direction, while others may change or interfere with it. Similarly, Anderson argues that "no single learning experience is mutually exclusive of others, rather every life experience is interpreted in the light of who we are and our dynamically

developing socio-cultural identity(ies)" (p. 16). Whereas Rahm and Anderson both illustrate how individuals are engaged in learning opportunities, Kisiel switches the focus individuals to evaluating the success of educational programs, which requires "examining the entire learning infrastructure" (p. 55) and the conflicts within it. These researchers take learning not just out of the classroom, but situate it in the ever-expanding network that constitutes children's innumerable opportunities to do and learn science. These opportunities include multiple knowledge domains and, as Rowe and Bachman point out, what counts as science content is not fixed, if "we are consciously trying to use participants' own definitions of science" (p. 147).

Learning is not only a cognitive process. The contributors to this volume promote a view that extends far beyond the typical focus on cognition in learning research. Instead, they present a holisitic, multifaceted approach to learning. Just as the educators studied by Ash and Lombana, Tal, and Kisiel have broadened their learning goals to include more than traditional science content, Mai and Ash describe their own challenge when analyzing family learning to include more than science talk. A key turning point for Mai and Ash was the realization that they "needed to look at the entirety of what families actually did at exhibits in its full complexity" (p. 99), which include "playing, teasing, joking around, laughing, typically mixing science and non-science talk together seamlessly" (p. 99). They come to understand that, rather than being off-task behaviors that can be ignored in their analysis, these interactions are actually essential components of how learning takes place. As a result, Mai and Ash's attempt to understand family learning leads them to analyze the function of humor in family interactions. Anderson notes that definitions of learning often include multiple domains, "cognitive, affective, appreciative, aesthetic, social, moral, and identity, to name a few. These encompass a far broader range than the most dominant domain of investigation in research on learning: the cognitive domain" (p. 16). As Falk, Dierking, and Holland (1995) pointed out nearly two decades ago, better understanding how museums impact their audiences will require developing a set of possible learning outcomes, a step the National Science Foundation (Friedman, 2008) took recently by specifying five impact categories for the evaluation of informal science education projects: awareness, knowledge, or understanding; engagement or interest; attitude; behavior; and skills. The authors of this volume add to the list of potential impacts, and argue that understanding the connections among them is essential. How to accomplish this, by specifying a manageable set of outcomes, their interactions, and how to assess them, will require further development.

CONCLUSION

By acknowledging the complexity of the learning process itself, the authors of this volume distinguish their research from that conducted in schools and laboratories. This is in contrast to the argument that the complexity of the setting is the defining characteristic of learning research conducted in informal environments, Only after researchers strip away the unstated assumptions, common in studies based in

schools and laboratories, that learning is a linear, instantaneous process comprised of a series of unitary, cognitive events, will it be possible to attain a full picture of learning and acting in informal settings. It is a view of learning that is multidirectional and open-ended, dynamic and ongoing, spread over time and space, encompassing full learners with particular interests, prior knowledge, and emotions, engaged with others in distinct practices situated in specific cultural-historical settings. This view of learning is important because, as Falk and Dierking noted, "average Americans spend less than 5 percent of their life in classrooms, and an ever growing body of evidence demonstrates that most science is learned out of school" (2010, p. 486).

Falk and Dierking also argued that considerable research indicates that "much of what is learned in school actually relates more to learning for school, as opposed to learning for life" (p. 489; see also Lave, 1977). This points to a paradox. In general, it is the curious, rare, or special case that is marked in language. In keeping with this, when several seminal books about teaching, learning, and thinking in settings other than schools and research laboratories were published in the 1980s, many prominent titles used a kind of linguistic marker for them, such as *Everyday Cognition* (Rogoff & Lave, 1984), *Practical Intelligence* (Sternberg & Wagner, 1986), and *Contexts for Learning* (Forman, Minick, & Stone, 1993). These markers suggested that they were each special instances of cognition, intelligence, and learning, somehow different from their usual connotations and perhaps a little odd, valued mostly for what they could contribute to improving school instruction and students' test scores. In contrast, at the same time numerous books based on learning and thinking in the particular settings of classrooms and research laboratories were published using the general words *cognition*, *intelligence*, and *learning* in their titles, with no apparent need to specify that they were describing these concepts as they occur in only a few special circumstances, most often schools and psychological laboratories. Research on learning has not always been like this, Cole's *Cultural Psychology* (1996) is one example. Now informal learning is increasingly appreciated in its own right for what it reveals about learning in general.

This volume, with its subtitle *Tools for Research in Informal Settings,* continues the tradition of using markers by suggesting that the theoretically and methodologically well-grounded tools described here are essential for researching and understanding learning in informal settings. Yet, reading the chapters of this volume does not suggest in any way that those tools are unique to the study of learning outside of school. To the contrary, the argument is made throughout the book that complex tools are needed to fully grasp the richness and complexity of learning in all situations. Falk and Dierking (2010) suggested that many people consider the learning that takes place in out of school settings "a nicety rather than a necessity, an adjunct to the serious business of learning that takes place in classrooms" (p. 490). The view of learning in this volume and the research that supports it suggest the opposite. The variable, uncertain view of informal learning that occurs in the messy business of everyday life is the general case, something that research on learning in schools and laboratories can no longer afford to ignore.

NOTES

[i] The chapter title is borrowed from Singleton's (1998) delightful collection of essays about apprenticeship in Japan.

[ii] Similar to Anderson (this volume), I distinguish between methodologies and methods. Methodologies are broad frameworks usually tied to epistemological commitments that provide particular ways of seeing the world and how we can best understand it, such as ethnography and experimental designs. In contrast, methods are particular forms of collecting data that can be applied to a variety of methodologies; they include surveys, interviews, observations, and pre/post-tests. Because the methodologies presented in this book (e.g., ethnography, action research) are well-developed and applied in settings other than the ones that are the focus of this chapter, my concern here is with methods.

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AFFILIATIONS

Steven R. Guberman
Science Museum of Minnesota
sguberman@smm.org

ABOUT THE AUTHORS

Dr. David Anderson is a Professor and Director of the Master of Museum Education (MMEd) program in the Faculty of Education, University of British Columbia, Vancouver, Canada. His research interests include children's museum experiences, metacognition, educational reform, visitor memories, and the long-term impact of museum experiences. Dr. Anderson has made significant contributions to educational reforms by initiating and strengthening collaborations between museums and schools that make museums key sites for non-formal learning and cultural understanding. He is a *Japan Foundation*, *Ritsumeikan*, and *Unversitas 21* Research Fellow, and his contributions in the field of museum education span the Globe, but have had particular impact and relevance for the nations of Asia, including China, Malaysia, Thailand, India and Japan. He has worked on the leading edge of the trends in educational reforms in Asia, identifying the needs, working harmoniously within the changes, and bridging disconnected groups in ways that are yielding considerable benefits to education and revitalizing the extraordinary educational wealth of culture and history held in museums.

Dr. Doris Ash is an Associate Professor in the Education department at the University of California Santa Cruz. Dr. Ash's main research focus is on scientific sense-making in museums, classrooms and other out of school settings, specifically attempting to understand the resources, such as thematic science content as well as the social repertoire of skills, that families and students use in conversations about science topics. All her research centers on issues of equity and access to science for culturally and linguistically diverse students and their families. She was a collaborator with the NSF (National Science Foundation) CILS (Center for Informal Learning and Schools) and with the MLC (Museum Learning Collaborative) at the University of Pittsburgh. She is currently engaged in a collaboration with the Museum of Science and Industry in Tampa Florida, which seeks to advance existing research on learning in informal settings and to improve museum educator practice in mediating understanding with diverse families (the REFLECTS Model) in an urban museum. She worked for many years with Ann Brown and Joseph Campione in the Fostering a Community of Learners (FCL) classroom project.

Dr. Jennifer Bachman recently received her PhD in Free-Choice Learning and Science Education from Oregon State University. Her background in Earth and space sciences, college science teaching, and home-education has led to a research focus on sociocultural systems of learning and STEM learning activity. Specifically, how families choose, value, and experience STEM learning at home and in the community.

Dr. Steven R. Guberman is a Senior Associate in the Department of Evaluation and Research on Learning in the Science Museum of Minnesota. Prior to joining SMM, he was a member of the Educational Psychology faculty at the University of Colorado at Boulder. His background is in developmental psychology with a focus on social and cultural processes in children's cognitive development, especially how children's activities change in ways that both reflect and support their development. He has conducted research in the US and Brazil examining the emergence of mathematical problems and solution strategies in children's everyday activities, including games and household chores. At SMM, he has led studies of teacher professional development and exhibits about early childhood development and the mathematics of ratio and proportion. He is the current editor of *Visitor Studies*, the journal of the Visitor Studies Association.

Dr. James Kisiel is an Associate Professor in the Science Education Department at California State University, Long Beach. Although his initial studies were in the sciences (B.S. in Chemistry from Case Western Reserve University and M.S. in Organic Chemistry from the University of California, Los Angeles), he obtained his Ph.D. in Education (specifically Science Education) from the University of Southern California. Dr. Kisiel's prior experiences both as a high school science teacher and as an educator, program coordinator, and evaluator at the Natural History Museum of Los Angeles County have guided his research interests in how teachers make use of informal science institution resources. At CSU Long Beach, he continues to work with future teachers, as well as graduate students enrolled in the Science Education M.S., including museum educators enrolled in the Informal Science Education option.

Dr. Judith Lombana, Ed.D. received her doctorate from the University of South Florida in 1983 and is currently the Vice President of Research, Grants, Evaluation and Government Relations at the Museum of Science & Industry (MOSI) in Tampa. She has been the PI on a five year NSF grant to examine how underserved families learn in informal settings and how museum educators can assist them. She served as a Co-PI on several USDOE grants for marketing science teaching to future teachers whose degrees are in science and related fields and/or are retiring from industry and looking for a second career. Previously, she was the Grants and Research Operations Officer for the ninth largest school district in the nation and conducted hundreds of implementation evaluations, surveys and research. Dr. Lombana has presented her research at conferences, assisted school districts and non profits.

Dr. Thao Mai conducts research in the areas of identity and knowledge construction as it relates to a learning context. She focuses on identity in terms of one's race/ethnicity, immigration, gender, and socioeconomic status. Her work is mostly qualitative research in informal learning arenas such as museums, student organizations, and family interactions. She completed her Ph.D. in education, emphasizing in language, literacy, and culture, at University of California, Davis.

Her dissertation is a case study and discourse analysis of young Vietnamese American women and their families. She found that the women's negotiation of identity was a sorting out of the meanings of success and a reconfiguring of the model minority stereotype into their own lives.

Leah M. Melber, Ph.D. has 20 years experience within informal and formal science education. She holds a BA in Zoology, an MA in education, and a Ph.D. in educational psychology from the University of Southern California. She has published and presented extensively in her field of focus: authentic, mission-driven experiences within cultural institutions such as museums, zoos and aquariums, including two recent publications: "Informal Learning and Field Trips" (Corwin 2008) and "Teaching Science to Culturally and Linguistically Diverse Elementary Students (Pearson 2012). She was awarded the 2010 Promising Leadership Award through the Association of Midwest Museums and the 2001 Informal Educator Award through the California Science Teachers Association. She was recently accepted as a candidate on the Fulbright Specialist Roster and has contributed to the Institute of Museum and Library Services' blog on the importance of 21st Century Skills as they relate to informal learning programming. She is a former third grade teacher, university professor in science education, science education specialist at the Natural History Museum of Los Angeles County, and a consultant and presenter in the area of informal education for museums and other educational organizations around the nation. She joined the staff of Chicago's Lincoln Park Zoo as the Director of Student and Teacher Programs in December of 2008 and was recently granted adjunct status at Northwestern University.

Dr. Jrène Rahm is Associate Professor at the Université de Montréal. Through qualitative multi-sited ethnographies and discourse analysis guided by sociocultural historical theory, she has explored diverse youths' meaning-making and identity work as constituted by their histories and by who they are becoming in authentic activities in settings such as museums, afterschool and community science programs, as well as gardens. The way youth come to position themselves in relation to science and their future as science literate citizens is also of interest to her. She studies learning and identity work across time and space, which has left her with many questions about what learning is and what may count as learning. Her most recent work explores immigrant youth's and families' engagement in out-of-school settings and the kinds of issues it raises in terms of equity and accessibility. The potential of informal settings for teacher education has become another interest she is currently pursuing in the context of her teaching assignments both at the undergraduate and graduate level. Dr. Rahm is an associate editor of the Journal of Research in Science Teaching

Dr Shawn Rowe is an Assistant Professor at Oregon State University. Rowe's background is applied linguistics and developmental psychology in education, specifically the cultural historical activity theory of Vygotsky. Most of his work is with museums, both history museums and science museums looking at family

group interactions and at how exhibitions are structured to support or undermine certain kinds of learning. He emphasizes investigating how talk and activity work together to help people make sense of what they see in history and science museums His Sea Grant Extension position combines academic work on free-choice learning with practice-based research in the OSU Hatfield Marine Science Visitor Center. He works closely with graduate students in the Free-Choice Science Learning Ph.D. and M. S. programs as well as in the Environmental Sciences and Marine Resource Management programs at OSU.

Dr. Tali Tal is an associate professor of science education at the Technion, Israel, where she is the associate dean of undergraduate studies and the head of the environmental and informal science education group. Her research is focused on meaningful learning and teaching in diverse environments such as classrooms, museums and the outdoors, and in environmental education and teaching science for all. Dr. Tal is an associate editor of the Journal of Research in Science Teaching, and the chief editor of "Ecology and Environment," a peer review journal in Hebrew. Her public activities include being a board member of the Society for the Protection of Nature in Israel and the Israeli Society of Ecology and Environmental Sciences.

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