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# Explainers' Development of Science-Learner Identities Through Participation in a Community of Practice

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**Explainers' development of science-learner identities**

**through participation in a community of practice**

**by**

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**Abstract**

The urgent environmental issues of today require science-literate adults to engage in business and political decisions to create solutions. Despite the need, few adults have the knowledge and skills of science literacy. This doctoral dissertation is an analytical case study examining the science-learner identity development of Exploratorium Field Trip Explainers. Located in San Francisco, CA, the Exploratorium is a museum of science, art, and human perception dedicated to nurturing curiosity and exploration. Data collected included semi-structured interviews with sixteen former Field Trip Explainers, participant observation of the current Field Trip Explainer Program, and review of relevant documentation. Data analysis employed constant comparative analysis, guided by the communities of practice theoretical framework (Wenger, 1998) and the National Research Council's (2009) Six Strands of Science Learning. Findings of this research indicate that Exploratorium Field Trip Explainers participate in a community of practice made up of a diverse group of people that values curiosity and openness to multiple ways of learning. Many participants entered the Field Trip Explainer Program with an understanding of science learning as a rigid process reserved for a select group of people; through participation in the Field Trip Explainer community of practice, participants developed an understanding of science learning as accessible and a part of everyday life. The findings of this case study have implications for research, theory, and practice in informal adult science learning, access of non-dominant groups to science learning, and adult workplace learning in communities of practice.

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## Preface

Explainer blog entry, October 30, 2007:

*I feel fortunate to have experienced one of [Senior Artist's] famous light walks this past September as part of our explainer training for the upcoming school year…For me, the experience was one of those moments where I couldn't wait to get home to tell other people about my day at work. I wanted to show them how when you cross your fingers and let the light shine through, you can see little circles, or how the sunlight travels through the branches of the trees, or how white light contains all the colors and information…it's just waiting to be separated out.*

*But more than anything it was one of those times where I felt genuinely lucky to be a part of such an amazing group of educators and scientists who can explain the secrets of the universe but would rather let you figure them out for yourselves.*

This excerpt describes one of the training sessions Field Trip Explainers take part in every morning before school groups arrive at the Exploratorium, and one of the many learning moments in which Explainers seem to be constantly engaged. It was written by an Explainer who studied literature, not science, before coming to the Exploratorium. He was a self-defined, "non-science person", and actually felt that it was unlikely that the Exploratorium would turn out to be the right fit for him professionally. Four years later, he is working in a permanent, full-time position at the Exploratorium, and says of himself, "I'm totally a science person now! I just didn't understand what science could be before" (former Explainer, personal communication, May, 2010). Similarly, I was in conversation with an Explainer finishing her second year in the program who said, "Being an Explainer has changed everything about the way I am in the world.

Now everything is a question that can be explored" (former Explainer, personal communication, June, 2010).

These types of statements of science becoming a part of one's identity are frequently heard in the Field Trip Explainer program, and so I began to wonder—what is going on here? Is it possible that through participation in the Field Trip Explainer Program, a person can develop an identity of a science learner? If so, this seems to me to be an exciting contribution to science education, to individual lives, and to a world that could use more science-literate citizens right now. And then I wondered, if this is happening, then what are the critical elements of the program that make this possible? I have been working in a leadership role in this program for eight years and have been engaging with and reflecting on these questions all the while. This dissertation is an opportunity for me to bring together the worlds of theory and practice to answer questions that are meaningful to me, that I hope will benefit the Field Trip Explainers and their visiting school groups, and that will contribute to a growing body of research in science-museum education.

*"Despite the fact that utilization of free-choice environmental education resources through visits to national parks, nature centers, natural history museums, zoos, and aquariums, and similar organizations are at all time highs, few within the environmental community are feeling sanguine. This is because the environmental challenges to the planet, not the least caused by worldwide climate change, seem to grow exponentially, while solutions to these problems lag seriously behind. The urgency to get "good" at what we do has never been greater"* (Falk, Heimlich, & Foutz, 2009, p. 3).

## I. Introduction

The knowledge and skills of science literacy prepare people to evaluate the credibility of scientific information and to engage in political, personal, and business decisions that impact their lives and the environment. A science literate person has knowledge and understanding of both natural phenomena and the inquiry process, as well as motivation for science learning and a science-learner identity (NRC, 1996, 2009; AAAS, 1993).

The National Science Board's review of science literacy surveys in the United States and other countries found that most adults do not have the knowledge and skills of science literacy (2006). While there has been considerable research into how K-12 students learn science, there has been comparatively little research into adults' science learning (Sachatello-Sawyer, Fellenz, Burton, Gittings-Carlson, Lewis-Mahony, & Woolbaugh, 2002). This case study examines the science-learner identity development, through a communities-of-practice lens, of emerging adults who participate in a one to three-year museum program in which they work as "Explainers" at the Exploratorium in San Francisco, CA.

### *A. Significance*

The urgency of environmental issues demands that adults, as well as children, are science literate (as defined above) so that they can participate in current decision-making that impacts the environment. For example, due to human activities, the Earth is now experiencing a rapid loss of biodiversity—the sixth of mass extinctions of species that have occurred in the past 500 million years (Wilson, 1992). Additionally, due to anthropogenic greenhouse gas emissions, global temperatures are significantly higher than any other period in the instrumental or ice core data, sea levels are rising, and snow coverage is decreasing (Pachauri & Reisinger, 2007). Changes in global climate have had, and will continue to have, impact on human life and will require considerable adaptations in water systems, agriculture, infrastructure along coastal areas, and public health (Pachauri & Reisinger, 2007).

Given this level of environmental crises, it is critical to create opportunities for adults, in addition to children, to become science literate citizens so that they may participate immediately in the urgent environmental issues that are impacting the globe today. This research focuses on emerging adults, which are a particularly important group of learners. Emerging adults are generally ages 18-30 years, at a developmental point when their identity and values are solidifying (Arnett, 2000). At this time, people are old enough to influence environmental issues through their voting and spending decisions.

Among other science-learning activities and venues, science museums play an important role in developing science literacy for visitors (Ballantyne & Packer, 2005; Storksdieck, Ellenbogen, & Heimlich, 2005; Falk, 2001; Rennie & Johnston, 1996; Hein 1998; Falk,

Dierking, & Foutz, 2007)[1]. The role of museums in teaching science is substantial, as approximately 36 million school-age students are served by science museums in the United States each year (IMLS, 2005). However, adults age 18-29 are underrepresented in the museum audience (Sachatello-Saweyer et al, 2002, p. 116), and little research has been done to determine the learning potential in museums for this age group.

The reason for the under representation of emerging adults in museums is likely that this group doesn't feel that they have time to visit free-choice settings for their own learning (Falk, Heimlich, & Foutz, 2009, p. 29). At the Exploratorium, a word-renowned science center (Cole, 2009) based in San Francisco, CA, a group of adults who do not necessarily have science backgrounds are paid to work as museum educators for a one to three-year period, eliminating the barrier of time for a museum visit. These educators, Field Trip Explainers, are not only museum staff, but are also extended learners in the museum. Their employment includes extensive training and learning through practice.

This research examines the Field Trip Explainer program from a social learning perspective, using the communities of practice framework (Wenger, 1998) as a lens to study the development of science-learning identities. This group is an important case to examine to determine the potential influence of an extended museum experience within a community of practice on the development of science-learning identities in emerging adults. There is no other research at this point that examines the development of science-learner identities in museum educators from the communities of practice perspective.

[1] *Science literacy* is related to, but distinct from *environmental literacy*, which includes the knowledge and skills of science literacy. Environmental literacy consists of "personal and civic responsibility, knowledge of environmental processes and systems, skills for understanding and addressing environmental issues, and questioning and analysis skills" (National Environmental Education Advisory Council, 2005, p. 11).

### *B. Statement of Purpose*

Research Question: Do Exploratorium Field Trip Explainers build identities as science learners, and if so, how?

Proposition: Exploratorium Field Trip Explainers build identities as science learners by working within a community of practice (Wenger, 1998).

This case study research is guided by the National Research Council's (NRC) Six Strands of Science Learning (2009) and the communities of practice theoretical framework (Lave & Wenger, 1991; Wenger, 1998). Science literacy was identified as a priority in the United States in 1983, at which point the American Association for the Advancement of Science (AAAS) began to develop science literacy standards for K-12 students to reach by adulthood (AAAS 1989; 1993). More recently, the NRC (2009) developed a set of learning standards addressing how students should learn science in informal environments. I use these learning standards as an analytical tool to understand the science learning behaviors and identities of the Exploratorium Field Trip Explainers.

Initially coined by Lave and Wenger (1991), the communities of practice theoretical framework was further developed by Etienne Wenger in 1998 as a tool for describing and understanding how people learn in naturally-occurring functional groups. Grounded in theories of social learning, this framework explores learning and identity development as a relationship between individuals and their communities. I use the communities of practice framework as an analytical tool for understanding the learning and identity development of Field Trip Explainers.

The purpose of this study is to create a rich description of the experiences of people who participate in the Exploratorium Field Trip Explainer program during the emerging-adult years of

their lives. The focus of the study is on the ways in which the program reflects the communities of practice model (Wenger, 1998), particularly how the experience influences the Explainers' development of science-learning identities. The findings will provide an example of how museums can impact science learning for adults, generate further questions for research, and could influence the development of museum programming for this audience.

### *C. Definitions of Terms*

In this section, I provide operands for the terms in the research question, as well as definitions of other, related terms. These operands and definitions will be used to guide the data collection and analysis.

*Identity* is a concept about which there is a great deal of research (e.g., Dweck, 2000; Gupta, 2009; Clayton & Meyers, 2009; Falk, 2009). For the purpose of this dissertation, I am referring to identity as defined by Wenger (1998, p. 151) as a set of experiences and their social interpretation.

*Science-Learning* is also a well-researched concept with many definitions (see NRC, 2009). For the purpose of this dissertation, I am using the NRC (2009) definition, which includes the six strands of learning detailed in the Science Literacy section of the Literature Review Chapter.

*Science museums* are natural history museums, science centers, zoos, aquariums, botanical gardens, arboretums, and nature centers (Falk, 2005, p. 267) whose mission it is to support public engagement with science, thus contributing to the development of a more scientifically literate public (Bevan & Semper, 1996).

*Science-museum educators* are variously referred to as docents, guides, facilitators, or explainers. They may be paid staff or unpaid volunteers, and may have a wide variety of responsibilities including teaching, marketing, and program coordination (Tran & King, 2007; Bailey, 2006; Grenier & Sheckley, 2008). This study examines the museum educators in the Exploratorium Field Trip Explainer program. Their work includes performing demonstrations, interacting with visitors at exhibits, and orienting school groups. I refer to them as Explainers in this dissertation.

*Emerging Adulthood* is a term coined by Arnett (2000) defining a developmental level that exists among affluent groups in developed countries. Emerging adulthood is defined by its lack of normative characteristics in terms of work, educational, and marital status. This is a transitional period in which people test out multiple life paths in order to determine what they want to do, and this is generally resolved by around the age of 30 years (Arnett, 2000).

### *D. Chapter Summary*

This dissertation is a case study of participants in the Exploratorium Field Trip Explainer program. I examine whether the Field Trip Explainers work in a community of practice, whether and how participants developed identities as science learners, and the relationship between working in a community of practice and the development of science-learner identities. The significance of this case lies in the urgent need to create effective opportunities for emerging adults to become science-literate citizens so that they may participate in current issues that impact their lives and environment.

The following chapter covers the theoretical underpinnings of the case. I describe how learning in museum environments can be understood through theories of social learning, the

connection between science literacy and learning in museums, understanding identity development in the museum context, and the communities of practice framework. The research methods, described in the third chapter, include interviews, participant observation, and document review. Sixteen former Exploratorium Field Trip Explainers participated in this case through semi-structured, 1-2 hour interviews. Observations of the program in action and extensive review of documentation provide rich description of the case and triangulation of the interview data. The research findings are presented in a series of five chapters, organized by case study sub-questions that guided the case. Finally, the dissertation concludes with a discussion of the findings, theoretical and practical implications, and questions for future research.

## II. Literature Review

There are four key themes in the literature associated with the main research question of this dissertation: 1) research that has sought to understand museum learning; specifically through social learning theories; 2) science literacy; 3) research on identity development; and 4) the theoretical framework for this dissertation, communities of practice (Lave & Wenger, 1991; Wenger, 1998). I review each of these four themes in the sections below to contextualize this doctoral research and discuss additional contributions to the scholarly literature.

This review begins with the literature on social learning theories and learning in museums to provide a context within which the concepts of science literacy and identity are situated. Finally, I close this chapter with a review of the theoretical framework, communities of practice, the literature that is most specific to this dissertation.

### *A. Understanding Museum Learning through Social Learning Theories*

The learning examined in this study occurs primarily within a museum context. Although the Explainers leave the museum at the end of each day and may continue to engage in related learning practices in social, family, or other work settings, it is the activities that occur in the museum that are the central focus of this research. Museums are unique learning environments that have their own characteristics and body of research. Most of the research that has been done is about the learning of museum visitors, rather than the learning of museum educators. This literature review describes what is known about museum visitor learning, as well as differences between the learning of museum visitors and educators where relevant.

Research on learning, including learning in museums, has been informed by many theories, including social and cognitive constructivism, social cognitivism, humanism, and

behaviorism (Merriam, Caffarella & Baumgartner, 2007; NRC, 2000). The theoretical framework guiding this study is the communities of practice framework (Lave & Wenger, 1991; Wenger, 1998), which is a social theory of learning. What follows is a description of the historical relevance of social learning theories to museum-based learning research, and a brief overview of what is known about what visitors learn in museums.

*Theoretical Context: How are museum visitors learning, and how do we know?*

Historically, educational psychology, including research on learning in museums, was dominated by behaviorist theories of learning. Behaviorism (Thorndike, 2008 [1903]) places emphasis on stimulus-response behavior and the transmission-absorption model of teaching and learning. Early museum-based research focused on behavioral outcomes of visitors and visitors' responses to pre- and post-tests (Falk & Dierking, 2000; Hein, 1998; Melton, Feldman, & Mason, 1936; Storksdieck, 2006, NRC, 2000). Research in museum settings that seeks to understand behavior change, particularly relating to conservation behaviors, employs behavior-change models such as the Theory of Reasoned Action or the Theory of Planned Behavior (Heimlich & Ardoin, 2008).

Cognitivist learning theory built on behaviorism, differing in that learning is examined in terms of patterns, rather than discreet events (Merriam et al., 2007). Cognitivists emphasize the importance of learners making sense out of new experiences through their prior knowledge and experiences (Piaget & Inhelder, 1969), rather than on stimulation alone. Social theories of learning (e.g., Rogoff, 2003) build on cognitivism but focus on the importance of learning as a social, rather than individual, activity. The work of Bandura (1986) served as a bridge between cognitive and social learning theories—his view of learning acknowledges both individual

thought processes and the social nature of thought and action, connecting the learner with his/her environment and social interactions.

Over the past two decades, museum learning researchers have shifted their approach from behaviorism to embrace the complexity of learning in museum settings by emphasizing theories of social learning. In particular, researchers emphasize elements of learning theory that focus on choice, motivation, timing, physical context, and social interactions (Hein, 1998; Falk & Dierking, 2000; Falk, Dierking, & Foutz, 2007). While there are many theories that describe how people learn, theories of social learning, particularly constructivism and sociocultural theory, have dominated the recent thinking on learning in museums (Hein, 1998; Falk, Dierking, & Foutz, 2007; Rennie & Johnston, 2007). The foundational theorists, John Dewey (1910; 1938), Jean Piaget (1954; 1959; 1981), Lev Vygostky (1978), and Jerome Bruner (1960; 1996) strongly influenced constructivist and sociocultural learning theories, and are frequently cited in the museum learning literature. While the writings of Dewey and Piaget have been criticized (e.g., Carey, 1985; Cohen, 1998; NRC, 2007), they have nevertheless been influential.

Constructivist learning theory is based on the principle that learning is a contextualized and constructive activity carried out by the learner (Fosnot, 2005). This theoretical approach fits well with learning that occurs in museum settings, where learners have a great deal of control over their learning. Central to constructivism is the notion that the learner constructs his/her own version of reality in a non-linear manner. Any new information must be integrated somehow with existing understandings held by the learner. It is the role of the teacher not to provide learners with knowledge, but to provide experiences through which learners may construct meaning for themselves (Fosnot, 2005; Resnick, et al, 1991).

Closely related to constructivism, sociocultural learning theory emphasizes the social and situated nature of learning. This school of thought includes theories of situated learning (Lave & Wenger, 1991), communities of practice (Wenger, 1998), and guided participation (Rogoff, 1995). Rather than the individual or the community driving the learning process, learning occurs as individuals and communities interact and people participate in culturally-relevant activities (Lave & Wenger, 1991; Rogoff, 1995). One way that science literacy can be described is becoming familiar and facile with the ways of knowing and being of the scientific community so that one can engage in or interface with that community if s/he so chooses. Science museums are an interactive interface between the scientific community and the public. Learners can be exposed to, practice, and learn these skills and knowledge through visits to museums.

The Contextual Model of Learning (CML) (Falk & Dierking, 2000) is a framework that is frequently referred to in research on learning in museums (e.g., Bamberger & Tal, 2008; Bamberger & Tal, 2006; Cox-Petersen, 2003; Gilbert & Priest, 1997; Tal & Morag, 2007; Vinson, 2006). This framework pulls together various aspects of social learning theories to describe the key factors that influence learning in museums. It was designed as a tool for researchers and museum educators to use in order to better understand, describe, and plan learning experiences in museums. According to the CML, learning in museums is influenced by the learners' personal, social, and physical contexts interacting over time. This includes the prior knowledge and experiences of visitors, the amount of control visitors have over their learning, the interactions they have with other visitors and museum staff, the layout and design of the exhibition space, and reinforcing experiences that occur after the museum visit (Falk & Dierking, 2000, p. 137).

Falk and Storksdieck (2005) tested the model and found that no single aspect of the CML is enough to account entirely for the learning of a visitor. As the model suggests, Falk and Storksdieck found that the three contexts of the CML do interact over time to create a unique learning experience for each visitor. Given that, they stress that research methods should be complex enough to account for the multiple factors that influence learning. The purpose of the CML is not to be a predictive model, but a framework that characterizes the learning environment. The CML describes factors that *influence* learning, but cannot predict or prescribe what visitors learn in museums, or how the learning happens. Even so, in their discussion of the model within the same book, *Learning from Museums* (Falk & Dierking, 2000), the authors do make recommendations about what and how visitors learn in museums. The distinctions between the model being predictive and descriptive are sometimes blurred by researchers in their use of the CML (e.g., Bamberger & Tal, 2006; Cox-Petersen, et al, 2003).

Despite its widespread use in museum learning research, the CML is not applicable to this dissertation. The CML was designed with a typical museum visit in mind, which usually occurs over the course of one day. The Field Trip Explainers spend an extended time—20 hours per week—in the museum, making communities of practice a more relevant choice.

The communities of practice framework (Wenger, 1998) is underpinned by situated learning theory (Lave & Wenger, 1991), which is not often applied to museum learning but does have relevance in the case of the Field Trip Explainers. Situated learning involves examination of activities that are dependent on context, social learning, and the production and reproduction of social order. This type of learning occurs over long periods of time, making this theory inadequate for understanding typical museum learning, as most visitors spend only one day per

year in a museum. However, this is not the case for Field Trip Explainers, who spend 20 hours per week at the Exploratorium, for a one to three-year period.

Situated learning happens through engaging in the practice of a community. Over time, newcomers learn the walk and talk of full participants, and gain their own identity as masters. This is what Lave and Wenger (1991) call "legitimate peripheral participation." It implies that a newcomer is engaged in some level of meaningful practice while interacting with full participants from whom newcomers may gain new skills or knowledge. Situated learning has been used to help understand adult learning in informal situations such as adapting to a new culture, training in the medical profession, and workplace learning (e.g., Andersson & Andersson, 2005; Browne-Ferrigno & Muth, 2006; Cope, Cuthbertson, & Stoddart, 2000; Fuller & Unwin, 2003). While a useful framework for understanding how learning occurs in social contexts, researchers have also pointed out that reliance on situated learning as a primary form of training or knowledge sharing can be incomplete and flawed in some instances (Fuller & Unwin, 2005; Hogan, 2002).

Field Trip Explainers engage in daily practice within a group of their peers over extended periods of time, and so I use the lens of situated learning in communities of practice to better understand how and to what extent they build science-learner identities. I describe learning in communities of practice in much greater detail in the Theoretical Framework section later in this chapter. The following section discusses what museum visitors learn, particularly in relation to science literacy and interconnections with this research.

*Practical Context: What are museum visitors learning?*

It is widely accepted that visitors to science museums are learning something (NRC, 2009). So what do people learn in museums? There have been numerous labels applied to the

types of learning that occurs in museums, but museum learning can be broken generally into three overarching categories: 1) the development of interest or motivation in science learning; 2) the development of science process or inquiry skills; and 3) the development of understanding of natural phenomena. As I will describe in more detail in the section on science literacy, all of these types of learning can be a part of a science-learner identity. I describe what we know about these types of science learning in museums in this section in order to set the stage for understanding the science-learner identities (or lack thereof) of the Field Trip Explainers.

Harkening back to the progressive educational values set forth by John Dewey (1938), some researchers have argued that the development of curiosity, interest, and motivation for learning about science could be the most important role of science museums (Pace & Tesi, 2004; Perry, 1994; Rennie, 1994; Tran, 2006). The development of the desire, or motivation, to learn is categorized as part of the domain of "affective" learning, which encompasses changes in emotions and attitudes.

The division of learning into the affective and cognitive domains of Bloom's Taxonomy (1956) is common in the museum-learning literature (e.g., Eshach, 2007), and a substantial portion of recent research on museum learning has measured affective learning outcomes (e.g., Anderson et al., 2002; Ballantyne & Packer, 2005; Bamberger & Tal, 2008, 2006; Cox-Petersen, et al., 2003; Falk & Balling, 1982; Pace & Tesi, 2004; Rennie, 1994). These studies focus on particular dimensions of affect that relate to visitors' perceptions of museum experiences, their reports of interest in or curiosity about the experiences, their motivation to engage with museum exhibits, or the development of interest or motivation to continue learning about science.

The research interest in the affective domain of learning in museums stems from discussions of the value of museums, in which they are frequently contrasted with schools for

their potential to spark curiosity, interest, and motivation for learning in students (e.g., Ramey-Gassert, et al., 1994; Wellington, 1990). Indeed, museum visitors have shown an increase in interest and motivation for learning science (e.g., Bamberger & Tal, 2008; Falk & Balling, 1982; Orion & Hofstein, 1994; Wilde & Urhahne, 2008) and persistent memories of museum visits tend to be related to affective gains such as happiness or curiosity (Medved & Oatley, 2000; Rennie, 1994; Wolins et al., 1992).

Researchers have used many methods of assessing this type of outcome, including self-reports, analysis of facial expressions, discourse analysis, and observation of engagement in behaviors that indicate an interest (NRC, 2009, p. 3-6). For example, motivation is sometimes measured based on dwell time or on-task behavior (e.g., Bamberger & Tal, 2008), a proxy indicator that Falk (1984) evaluated as an effective indicator of learning *if* it is examined in the context of other factors. A more detailed approach was taken by Rennie (1994), who identified three types of outcomes relating to intrinsic motivation: learners' perceptions that they have been successful in what they tried to do, enjoyed what they did do, and thought it was helpful to their learning. More recently, Wilde & Urhahne (2008) employed the Intrinsic Motivation Inventory (Deci & Ryan, 2003), a more formalized scale for measuring indicators similar to those identified by Rennie (1994).

Several authors (e.g., Griffin, 1994; Koran, et al., 1983; McManus, 1993; Paris et al., 1998; Wellington, 1990) have suggested that the development of intrinsic motivation in learning science is a critical antecedent to learning science concepts. In fact, research has found that people who are interested in a topic or are intrinsically, versus extrinsically, motivated to learn are more likely to pose questions based on curiosity, to use systematic methods to find answers, to use effective learning methods, and to be persistent, invested, and productive in the learning

process (for reviews, see Kaplan & Maehr, 2006 and NRC, 2009). From this standpoint, affective learning objectives are an important precursor to learners achieving the objectives of using inquiry skills and understanding natural phenomena put forth by NSES for science literacy (NRC, 1996).

Learning in museums has also been described as both a process and a product, and some argue that the learning processes in museums are as important as the products (e.g., Dierking et al., 2003; Rennie et al., 2003). One reason for the focus on process is that learning takes time (NRC, 2007; 2009). Understanding a phenomenon may not occur within the timeframe of a museum visit, but an important part of the learning process may occur while interacting with a science exhibit. Further, science involves not only understanding phenomena, but the "habits of mind" (AAAS, 1993) that can be developed and practiced in science museums.

Learners who engage in the inquiry process have been shown to be capable of creating increasingly complex and accurate conceptual models of science concepts (White, 1993). Conducting research that measures whether museum visitors are engaging in the inquiry process is a relatively new and challenging undertaking. To meet this challenge, researchers are looking for the visitor behaviors that map onto the five elements of inquiry (NRC, 2000b): asking questions, obtaining evidence, explaining, evaluating the explanations (interpreting), and communicating these interpretations with others (Allen, 1997; Allen, 2002; Allen & Gutwill, 2009; Ash, 2003; Crowley & Galco, 2001; Gilbert & Priest, 1997; Gleason and Schauble, 2000; Ostrenko, 2002). To assess for this outcome, researchers often analyze video of participants engaging in learning activities to measure the sophistication and number of occurrences of behaviors such as asking questions, making predictions, or testing hypotheses (NRC, 2009, p. 3-11).

Finally, several authors have found that cognitive gains, or the development of understanding scientific phenemona, do occur for museum visitors (Bamberger & Tal, 2008; Falk & Storksdieck, 2005; Gottfried, 1980; Mortensen & Smart, 2007; Orion & Hofstein, 1994). However, others argue that change in conceptual understanding does not occur from one visit to a science museum; instead museum visits are more likely to reinforce prior understandings (e.g., Anderson, 1999; Roschelle, 1995). This discrepancy may be due to inconsistencies across studies in the way that cognitive leaning is measured. Falk and Dierking (2000) recommend testing whether visitors' understanding of science concepts is strengthened from a museum visit by measuring *change* in understanding before and after the visit, rather than comparing visitor self-reports to a predetermined hierarchy of responses. Falk and Storksdieck (2005) measured change in understanding of science concepts from before to after a museum visit, including measurement of various levels of cognitive gain (knowledge, application, synthesis), and comparing learning to multiple influences from the CML. They found that multiple factors do influence learning, and that visitors were able to make significant cognitive gains during their museum visits. One of the Six Strands of Science Learning (NRC, 2009) is that learners understand scientific concepts. Understanding scientific concepts was not measured in this study, however participants' reports or demonstrations of understanding are included as part of an overall measure of a science-learning identity.

*Section Summary*

Museums are unique learning environments in which learners exercise choice in their learning behaviors and engage in social interactions with museum educators and other visitors. Research that seeks to build understanding of the learning that occurs in museum settings now focuses on the social and situated nature of learning in these environments. The learning

outcomes for visits to science museums include increasing interest or motivation for science learning, practicing inquiry skills, and developing understanding of scientific concepts.

### *B. Science Literacy and Museum Learning*

In order to understand the development of Explainers' science-learner identities, I need to first be clear about what counts as science learning. This section describes the historical development of the concept of science literacy, and concludes with the current, most widely accepted framework for science learning in museums. This framework is used to guide my investigation of Explainers' science-learner identities.

The development of science literacy has been identified as a national (AAAS, 1993; NRC, 1996) and global (McEneaney, 2003) priority, and as a priority for museums (Bartels, 1999; Bailey & Hein, 2000; Bybee, 1998; Oppenheimer, 1968; Yager & Falk, 2008). Science literacy is a broad, complex, and integrative concept. I describe below the formalized effort in the United States to provide a clear definition, set of standards, and educational instructions for science literacy.

Science literacy gained the attention of scientists and educators in the United States in 1983, when the National Commission on Excellence in Education conducted a study in order to address public concern about the quality of the country's educational system. The product of this effort, *A Nation at Risk* (NCEE, 1983), reported that students in the United States were scoring poorly in math and science compared to students in other countries, showing that they were not well prepared for competitive careers in science and technology. In response, the American Association for the Advancement of Science (AAAS) created a program tasked with determining the knowledge and skills that are required for people to gain in order to be science literate by the

time they reach adulthood. The outcomes of this program (AAAS, 1989; 1993) informed the creation of the National Science Education Standards (NSES) (National Research Council [NRC], 1996), resulting in reform efforts for teaching science in K-12 schools.

Among the multiple definitions of science literacy that exist (see Laugksch, 2000 for a review), the NSES have been viewed as the standard (Bailey & Hein, 2000). The desired outcomes of science literacy defined in the introduction to the NSES are 1) The ability to ask, find, or determine answers to questions derived from curiosity about everyday experiences; and 2) The ability to describe, explain, and predict natural phenomena (NRC, 1996, p.22).

The NSES have been criticized for various reasons, including lack of explicit discussion of the theoretical underpinnings (Shiland, 1998); not articulating how to include underserved groups (Rodriguez, 1997); difficulty for teachers to implement in classrooms (Medved & Oatley, 2000); and ignoring the social aspects of science and the needs of citizenship (Lang, et al., 2006). Despite these criticisms, the NSES have represented the most comprehensive set of standards for achieving science literacy in schools, and have also been adopted in museums.

Taking the next step to aid teachers in educating for science literacy, the NRC created a new task force to research *how* people learn science. The resulting report, *Taking Science to School* (NRC, 2007), identified four types of practices required for students to become science literate:

1. know, use, and interpret scientific explanations of the natural world;
2. generate and evaluate scientific evidence and explanations;
3. understand the nature and development of scientific knowledge; and
4. participate productively in scientific practices and discourse (p. 36).

These standards and learning strands all focus on science learning that happens in schools, ignoring science learning that happens for both children and *adults* outside of the K-12

classroom environment. With increasing pressure on museums to justify their education programs, they have been moving toward using clear and measurable goals to show evidence of learning. Most (87% of) science museums are using the NSES to guide exhibit and program development for school groups (Bailey & Hein, 2000). This approach, however, has been criticized by museum educators who argue that museums are unlike schools in that they can influence positive attitudes about science through open-ended experiences with exhibits (Bailey & Hein, 2000).

A more recent NRC report, *Learning Science in Informal Environments* (2009) addresses this concern with the addition of science-learning strands that are suited to informal learning environments. This comprehensive report on learning science in informal environments incorporates the four strands generated by *Taking Science to School* in their list of science-learning activities that are critical to the development of science literacy. The report cautions against using only K-12 standards for defining learning objectives for museum visits, citing the unique nature of the museum learning environment and the fact that many visitors (families and adults) are not in the K-12 system. This set of science learning strands is as follows:

> Learners in informal environments:
>
> Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
>
> Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models and facts related to science.
>
> Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
>
> Strand 4: Reflect on science as a way of knowing; on processes, concepts, and

institutions of science; and on their own process of learning about phenomena.

Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools.

Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science (NRC, 2009, p. ES-3).

The NRC and the National Science Foundation are now encouraging science museums to incorporate these six strands of science learning into the development, evaluation, and research of science-learning programs (Semper, R., personal communication, November, 2009). This reality makes the NRC strands a relevant baseline definition for science learning.

The research question for this dissertation is: Do Exploratorium Field Trip Explainers build identities as science learners, and if so, how? To address this, strand six, the development of a science-learner identity, is the focus of this dissertation. In particular, "learners in informal environments…think about themselves as science learners and develop an identity as someone who knows about [and] uses…science" (NRC, 2009, p. ES-3). The last piece of this strand, "sometimes contributes to science" represents a very advanced stage of identity development that likely applies to a very small percentage of science museum visitors, and so is not included in the focus of science-learning identity development in this research.

Strands one through five are concrete science-learner activities; my assumption is that someone who has a science-learner identity (strand six) is someone who engages in the activities in strands one through five. In an analytical review of identity-related literature, Rounds (2006) argues that identity and actions are reciprocally intertwined. People enact certain behaviors that they believe to be consistent with, and so reinforce, their identities, and people make sense of their identities by looking back on the behaviors they have already enacted. There are limits to

this assumption; however it is a reasonable approach to understanding the science-learning identities of Explainers since this inquiry is within the context of social learning in science museums, for which the NRC Strands of science learning are relevant. Of course, Explainers might have other ideas about their science-learning identities that do not fit neatly into these categories. While these will be interesting and important to explore, I will use the NRC strands as my official definition to provide some consistency and relevance to the field.

### *C. Identity and Museum Learning*

The development of Explainers' science-learner identities is examined in this dissertation using the communities of practice (Wenger, 1998) perspective on identity development. I am interested particularly in how (if at all) Explainers' identities develop within the context of the Explainer community of practice, not independent of it. There is a great deal of literature on the topic of identity, and so this section serves to situate and provide context for this choice of theoretical perspective. Here I briefly review literature that is most closely related to this line of inquiry, particularly research examining identity and science learning in social contexts.

Identity has been explored extensively from both psychological (e.g., Erikson, 1968) and sociological (e.g., Wenger, 1998; Falk, 2009) perspectives in order to better understand a great variety of human issues. Identity is something that has and can be defined by group membership (Tajfel, 1978), ethnicity (Gleason, 1983), role (McCall & Simmons, 1978), personal development (Erikson, 1959), connectedness to nature (Chawla, 1992), or ability to learn (Dweck, 2000), to name a few. Surrounding all of these possibilities is a potential division between a social or personal definition of identity, and a division between whether identity is changeable or static (state versus trait).

Deaux (1993) challenged the pre-existing dichotomies in social identity theory that separated personally and socially defined identities, and static versus changing identities. Instead, she suggested that social and personal identities define one another for each individual, and can be considered together. She also suggested that identities should be examined in terms of how they are structured, what functions they serve, the context in which they are used or formed, and how they change over time. She acknowledged both the usefulness of fixed categories of identity, and the possibility that identities can develop. Deaux' "reconstruction" of social identity theory is very similar to Wenger's (1998) construction of identity within the communities of practice framework, which emphasizes the integral nature of personal and social identity, and the importance of context and change over time.

If identity is viewed as something that is personally and socially constructed, rather than predefined and static, then no matter what lens is used to examine it, identity is constantly under development. From a psychological perspective, the type of identity explored here is *state* identity—identity that can change from one context to another. A person enters every learning situation with an existing identity, and probably many interrelated identities that serve the person in the various aspects of his/her life (see Falk, 2006; Rounds, 2006), whether within the family, at work, or in social situations. And then each learning situation has the potential to influence and possibly alter this identity. Both of these parts of identity development are important, as entering identities may influence a persons' learning experience and potential outcomes, and then the learning experience may in turn influence the outgoing identity.

Classroom learning environments are one place in which researchers have examined the connection between identity and science learning. In this context, the identities of learners can influence their science-learning experiences and level of success. In particular, identity

characteristics relating to gender (e.g., National Science Foundation, 2007) and race (e.g., Tate & Linn, 2005) can have a significant impact on science-learning for students. Furthermore, the identities of K-12 students relating to science can have an impact on their future career choices (e.g., Fadigan & Hammrich, 2004).

Beyond identifiers such as gender and race, people also have identity characteristics relating to their belief in their ability to be a successful learner. The connection between identity and science learning is closely related to goal orientation theory (Kaplan & Maehr, 2006) and intrinsic motivation (e.g., Blumenfeld, 1992; Csikzentmihalyi, & Hermanson, 1995), which have to do with the way that individuals understand themselves, or what Dweck (2000) calls "self-theories." As I described above in the Understanding Museum Learning section, the development of intrinsic motivation in learning science is a critical antecedent to learning science concepts (e.g., Griffin, 1994; Koran, et al., 1983; McManus, 1993; Paris et al., 1998; Wellington, 1990). Similarly, Dweck argues that people who view themselves as able to change and learn (versus people who believe that they are either inherently smart or not) are more likely to succeed in learning (2000).

It is not surprising that similar to school students, the pre-existing identities of museum visitors have an influence on their museum learning experiences. Feinberg & Leinhardt (2002) studied the entering identities of museum visitors to determine what impact pre-existing identities of visitors had on their conversations about museum exhibits during their visits. The authors found that visitors whose identities related in some way to the *content* of the museum visit did engage in more detailed, explanatory talk relating to the exhibition compared to visitors whose identities were not related to the content of the exhibition. In a similar vein, Abu-Shumays & Leinhardt (2002) found that visitors whose identities related in some way to the *process* of

investigating museum exhibits did engage in deeper-level inquiry process in the exhibitions compared to visitors whose identities were not related to the process of museum learning. In both cases, the entering identities of the visitors shaped their experiences in the museums, just as the existing identities relating to gender, race, motivation, and learning ability influenced K-12 students' learning success. However, none of these studies address what impact the learning experiences then had on the learners' identities.

Hull and Greeno's (2006) literature review on identity in both K-12 and non-school learning takes this one step further. They argue that learning situations and incidents contribute to learners' identities, both positively and negatively, and ultimately impact the agency of the learners. They also argue that identity formation in non-school environments tends to help learners develop more agency for science learning compared to the identity formation that occurs in K-12 schools. They attribute this difference to the idea that non-school learning environments often provide examples of "types of people" that participants could become, along with opportunities to enact those roles, take on positions of leadership, and to engage in discourse that helps them to articulate their changing identities.

These authors propose a conceptualization of identity that includes three components: interpersonal, epistemological, and discursive. They describe the components this way:

> Interpersonally, a person's identity includes her or his interactions with other people, including commitments and the ways in which the person is entitled, expected, and obligated to treat other people in interaction. Epistemologically, a person's identity includes her or his interactions with the subject-matter contents of activities, including ways the person is committed, entitled, expected, and obligated to have and seek knowledge, understanding, and use of the contents of a subject-matter domain.

> Discursively, contexts of identity afford models of self and opportunities to enact selves… (Hull & Greeno, 2006, p. 83).

This conceptualization of identity is not so different from Wenger's (1998), in that it is social in nature, and derives from participants' mutual engagement in shared practices. Hull and Greeno applied the communities of practice perspective to a body of existing research, in which they noticed elements that are resonant with the communities of practice framework. This starting point indicates that using the lens of communities of practice to examine how identity develops through learning in a museum setting could be fruitful.

There is also research relating to the identities of museum visitors that does not relate to the communities of practice model. The Museum Visitor Experience Model (MVEM) (Falk, 2009) is a predictive model relating specifically to museum visitors' temporal identities, which includes and expands upon the CML (Falk & Dierking, 2000). The MVEM is based on an extensive research project conducted at the California Science Center (Falk & Storksdieck, 2004). Unlike the CML, this is a predictive model; Falk posits that the trajectories of museum visits can be roughly predicted based on visitors' entering identities and perceptions of the museum's affordances. However, the model does not place much emphasis on how museum visits contribute to the development of visitors' identities beyond the visit.

Falk (2009) diverges from previous museum research in the way that he defines the identity of visitors. Instead of looking at characteristics such as age, ethnicity, income, frequency of museum visits, and the social arrangement of the visitors, Falk examines visitors' identity-related *motivations* for visiting the museum. Falk found that most visitors' identity-related motivations fall into five categories: explorer, facilitator, experience seeker, professional/hobbyist, and recharger.

What each visitor actually does during the museum visit is influenced by the three contexts of the CML (personal, social, and physical). However, the trajectories of the visits are predictable and map onto the five identity-related motivations. The explorers and facilitators do not follow pre-set paths, but follow either their own or their social group's interests and curiosities once inside the museum. In contrast, the rechargers and professional/hobbyist tend to have specific goals and intentions to see specific exhibits in the museum, and do follow through on those intentions. Finally, the experience seekers visit the most famous museum exhibit, and spend time wandering and exploring. After the visit, the meanings that visitors ultimately construct either strengthen, modify, or extend their entering identities.

Both Falk (2009) and Rounds (2006) argue that a one-day museum visit is unlikely to significantly alter the existing identity of a museum visitor. However, Rounds (2006) discusses the idea of "identity work," pointing out that visitors collect a variety of new experiences and perspectives that may not instantly transform a visitors' identity, but will likely contribute to the overall evolution of their identities over longer periods of time. So what, then, would that look like for people who spend everyday in the museum? While the MVEM does not address the complexities of the Field Trip Explainer case and the length of Explainers' involvement in the museum, communities of practice (Wenger, 1998) provides a more appropriate framework for understanding the identity development of museum learners who are also employees.

Bailey (2006) makes a direct link between the identities of museum educators and the communities of practice (Wenger, 1998) framework. She investigated museum educators' perceptions of their roles, identity, and practice, and suggested that their identity formation is best understood from the communities of practice (Wenger, 1998) perspective. Wenger defines

identity as a set of experiences and practices that are socially interpreted. It is a link between an individual self and the community, as each defines the other.

The museum educators interviewed for Bailey's study indicated that their work is integral with their identities. Based on their descriptions of their practices, communities, and values, Bailey posited that it is through working in communities of practice that these educators develop their identities, and it is these identities that sustain them in their work. Wenger describes identity as being a "kind of person." In Bailey's study, the "kind of people" the participants described themselves as were educators working in the museum setting, involving attributes such as flexibility, emotional connection to the work, connection to a higher purpose, creativity, and the ability to learn new things. My dissertation builds on this research to examine more precisely how and to what extent working in a community of practice contributes to the development of Explainers' identities, particularly as science-learners, what this means to them, and how it changes over time.

Finally, there is a study (Gupta, 2009) that explores the influence of a museum experience specifically on identity development of museum educators, but not using the communities of practice framework. Gupta examined the identity development of museum educators (Explainers) working at the New York Hall of Science (NYHS), using Cultural Historical Activity Theory (CHAT) (see Roth & Lee, 2007) as a theoretical framework. Similar to the communities of practice framework, identity development in CHAT involves an evolving relationship between an individual and his/her collective. CHAT is a theory that grew out of the work of Vygotsky (1978), and so it shares the same historical roots that ultimately led to the development of communities of practice (Wenger, 1998).

The goal of the NYHS Explainer program is for Explainers to develop the knowledge, skills, and practices of teachers and to eventually become K-12 school teachers. This is a slightly different focus from that of the Exploratorium Field Trip Explainer program, which does not have an explicitly-targeted career outcome for the Explainers. Instead, the overarching focus of the Exploratorium's program is on science learning, for both the Explainers and their visiting audience. The focus of Gupta's (2009) research was to illustrate the Explainers' development of teacher identities. She found that through practice and the support of the NYHS community, Explainers did develop identities as teachers and increase their confidence in these identities. (Interestingly, Graven (2004), found that confidence-building was a critical element of teacher learning processes, and argued that it should be added to the communities of practice (Wenger, 1998) framework.) My research is a complement to Gupta's work, exploring a different aspect of Explainer identity development through a different lens, communities of practice (Wenger, 1998).

### *D. Theoretical Framework: Communities of Practice*

The Explainers' development of science-learner identities could be viewed from an individual, cognitive perspective. However, I am more interested in looking at the Explainers from a social learning perspective. Wenger (1998) argues that people learn through engaging in sustained practice within communities, and that the learning that occurs is the development of an identity that is mutually negotiated by the community and the individual. This perspective affords a more nuanced view into what I see as a complex identity-development process within the Field Trip Explainer program. In this section, I describe the communities of practice

framework in detail, and highlight its values for my work as well as the potential limitations or difficulties associated with using this framework.

*Overview of the Framework*

The communities of practice model (Lave & Wenger, 1991; Wenger, 1998) is a descriptive tool that was designed to facilitate thinking about how people learn and function in their daily lives. Any group of people that engages in the "sustained pursuit of a shared enterprise" (Wenger, 1998, p. 45) is a community of practice, including families, professional groups, and classrooms. Communities of practice are ubiquitous and usually informal; the practices within the group are developed by participants to "get their jobs done" (p. 6), whatever the "job" may be. Communities of practice can be sustained over long periods of time; the individual participants may change as individuals enter and leave the community, but the community of practice itself is sustained. In the case of the Field Trip Explainers, the program has been in existence since 1970, and approximately 300 people have participated in the constantly shifting group of 15 Explainers.

If communities of practice are ubiquitous, then it may be illustrative to identify what is *not* a community of practice. For example, the residents of an apartment building see one another in passing on a somewhat regular basis, and share the experience of living in the same building. However, this group of people does not actually engage in a shared enterprise; one tenant's living practices have very little bearing on another's. Furthermore, their identities are not formed through engagement with one another. Likewise, the people who are in a shopping mall on one particular day are not a community of practice, nor are the many people around the United States who watch the super bowl on television at the same time. Here I review specific characteristics of groups that *are* communities of practice in greater detail.

Communities of practice are understood within the context of a social theory of learning, in which social participation is a process of learning and knowing. Wenger uses the framework of situated learning that he and Lave developed (Lave & Wenger, 1991), in which learning happens through "changing participation and identity transformation in a community of practice" (Wenger, 1998, p. 11). Participants in communities of practice are engaged in learning, and this learning may be either desirable or undesirable. For example, Explainers may learn from one another how to present a cow eyeball dissection clearly to a large audience (a desirable learning outcome), and they may also pass down pieces of misinformation to one another (an undesirable learning outcome). The recognition that communities of practice do result in learning (whether planned or not) is valuable to organizers or participants who may want to optimize the learning possibilities in their communities of practice.

*Five Elements of a Community of Practice*

The first element of a community of practice is *meaning*. Wenger (1998) defines meaning in practice as something that is constantly negotiated through and about everyday experiences. This occurs through the interaction of what Wenger calls *participation* and *reification*.

*Participation* is defined by the possibility of mutual engagement, although it is not necessarily collaborative. Mutual engagement can be collaborative or competitive, harmonious or conflictive. Participation goes beyond the act of doing something in that it creates the possibility of transforming both the participant and the community. Furthermore, participation is not bounded by the time spent doing a specific activity, but is a part of participants' identities.

*Reification* is the process of giving form to an understanding. For example, the processes of creating a law, a form, a document, a story, or a name are all processes of reification. The objects created through reification serve as tools for completing activities and also signify

meaning. Wenger (1998) argues that the existence of these objects is like the tip of an iceberg, in that they signify a larger body of practice imbued with meanings.

Participation and reification are interconnected as a way of negotiating meaning through experiences in the world. It is through participation in a community of practice that the reification of ideas and understandings becomes possible. Likewise, reification creates shortcuts to participation through communicating shared meanings and providing opportunities to renegotiate those meanings. As participants build experiences of participation and reification, their identities as participants in their communities build. Just as meaning is negotiated among participants through participation and reification, individuals' identities are also negotiated. For example, in Light's (2006) examination of surfers, a surfing community of practice had created official levels of certification that marked participants' progress (a form of reification based on participation). Participants' identities as surfers grew stronger as they attained these increasing certification levels.

The second element of a community of practice is *community*. The word, community, is used in common language to refer to groups of people who share culture, activities, or space, such as a neighborhood. Community in the communities of practice context is more involved, and is defined by *mutual engagement, joint enterprise, and shared repertoire* (Wenger, 1998, p. 73).

In a community of practice, people engage with one another meaningfully, drawing upon their respective relevant competencies in order to further their shared practice. The experiences and competencies gained through participation in a community of practice are markers of membership and constitute participants' identities. Although participants in communities of practice may have common values, traits, or competencies, homogeneity and agreement are not

essential. Rather diversity and disagreement can contribute to meaningful engagement. Participants likely have differing qualities before entering the community, and their mutual engagement may highlight their diverse or complementary qualities or competencies. In this way, participants' identities within the community of practice are refined. For example, teachers in a child development center may all share a love for children, but contribute complementary skill sets to get the job of caring for the children done—one may take the lead on activities, another pays attention to children who need help making friends, while another is attentive to safety.

A joint enterprise, the second element of community, is not only a shared goal; it is a communally negotiated endeavor. The practice of the community is shaped by the participants based on the constraints, opportunities, and demands of their situation. It is not typically determined by an outside force or by only one member of the community, but is continuously shaped by the community as a whole (Wenger, 1998). For example, a child development center may have a mission statement that drives the type of work done, but the practice the teachers develop to actually care for the children with the resources available to them is one that they create themselves. The accountability to a joint enterprise is a component of participants' identities in that it shapes the lens through which individuals view the world. "Identity in this sense manifests as a tendency to come up with certain interpretations, to engage in certain actions, to make certain choices, to value certain experiences…" (Wenger, 1998, p. 153). For example, Merriam and her colleagues (2003) examined identity development in a Wicca community of practice. Once the participants felt that they had become full participants, they also noticed that they began to value and strive for similar qualities, such as introspection and tolerance.

Finally, a community is defined by having a shared repertoire. This characteristic refers to a community's set of shared resources that are used to negotiate meaning. It may include things such as shared stories, routines, interpretations, discourse, and objects. The repertoire is grounded in the community's history and flexible enough to evolve with the community. As individuals participate in a community of practice over time, the community's repertoire becomes the personal repertoire (or set of memories, stories, etc.) of those individuals and a part of their identities.

Because the purpose of the community's repertoire is to negotiate meaning, it is not important that participants share the same beliefs or understandings of the activities or objects, rather the components of the repertoire provide opportunities for those beliefs and understandings to be constantly coordinated and negotiated. For example, the child development center may have a daily activity schedule grounded in historical experience. However, that schedule could change over time as the teachers have new experiences, introduce new ideas, and renegotiate their practice. The sign at the Exploratorium that I discuss later in the Research Context chapter, "Here is being created a community museum dedicated to awareness," is an example of a part of the community's repertoire being used to negotiate meaning. This object and its history provide a touchstone for debate and discussion. Also, it is an object that people view as jointly owned, and a part of each of their own, personal stories.

The third element of a community of practice is *learning*. Learning continuously occurs in communities of practice. The goal, or enterprise, of the community need not be learning, per se, in order for learning to occur. Learning is the process of being engaged in ongoing practice (Wenger, 1998, p. 95). Learning is not an extraneous goal or a special category of activity, and practice is not merely a context for learning something else. Participants in communities of

practice are learning how to be members of that community, and the learning that takes place may be either positive or negative.

Newcomers in a community of practice learn from the old-timers. New participants must learn about the three things that define the community (described above): the mutual engagement, joint enterprise, and shared repertoire. They learn how to engage with other participants, establish relationships, and define identities; to define the enterprise and align their practice with it; and to develop their repertoire. Wenger argues that the learning done by participants in communities of practice involves not only the acquisition of new knowledge and skills, but the formation of their identities. Because participants' learning involves their own identities, they are invested in continuing their practice and learning in order to sustain those identities over time. Bailey (2006) found this in her investigation of the practices of museum educators. Their work and identities became interwoven to the extent that their personal identities as museum educators allowed them to persevere in challenging working conditions.

When new individuals enter into a community of practice, they are exposed to the learning (and identity-forming) trajectories of current and past participants. These stories create sets of possible trajectories for the newcomers to negotiate for themselves. Wenger posits that "exposure to this field of paradigmatic trajectories is likely to be the most influential factor in shaping the learning of newcomers" (1998, p. 156). Hull and Greeno (2006) argued that exposure to possible future trajectories allows students in non-school learning environments to develop identities and agency in subjects that they might find challenging in school.

The fourth element of a community of practice is *boundaries*. Communities of practice have boundaries that distinguish participants from non-participants. The boundaries that define membership are not created by institutional affiliation alone, but are naturally created through

shared practice. There may be objects that mark the boundaries between communities of practice, such as uniforms, titles, or shared language, making the distinction between insiders and outsiders clear (Wenger, 1998).

The fifth element of a community of practice is *locality*. The locality of communities of practice is emergent and depends upon proximity, shared backgrounds, and mutual engagement. It is primarily defined by learning. "…the geography of practice reflects histories of learning, but learning continues to reconfigure relations of proximity and distance" (Wenger, 1998, p. 130). Within the element of locality is the idea that there can be smaller communities of practice nested within or intersecting across larger communities of practice. Constellations of communities of practice provide balance between the reproduction of patterns and practices (both positive and negative) and connections with and permeability to new ideas.

Together, these five components—*meaning*, *community*, *learning*, *boundaries*, and *locality*—define communities of practice and the ways in which participants' identities manifest. I use these five components of communities of practice as a heuristic for analyzing the data relating to whether the Field Trip Explainer Program is a community of practice and to describe how participant's identities manifest within the program.

*Three Modes of Identity Development in a Community of Practice*

In the communities of practice framework, identity is considered from a social perspective; it essentially links the individual and the community, as each defines the other. The development of identity in communities of practice involves three modes of belonging that contribute to its ongoing negotiation:

1) engagement—through our direct experience of the world, the ways we engage with others, and the ways these relationships reflect who we are

2) imagination—through our images of the world, both personal and collective, that locate us in various contexts
3) alignment—through our power to direct energy, our own and that of others (Wenger, 1998, p. 189).

For the purpose of this study, I am most interested in the development of Explainers' identities as science learners. A person with a science learner identity is comfortable with, knowledgeable about, or interested in science (NRC, 2009, pp. 2-13).

The first mode of belonging is *engagement* in the community of practice. Identity building occurs in communities of practice in part through *engagement* in practice and the negotiations of meaning in practice. Through engagement in practice, members develop competencies, discover the boundaries of their community of practice, and determine their own learning trajectories (Wenger, 1998).

Second, identity is negotiated in communities of practice through social *imagination*. In other words, stories shared within the community over time ascribe certain meanings to things and events. When members participate in the generation and sharing of these stories, those stories become a part of their communally negotiated identities (Wenger, 1998).

Individuals also build their identities through *imagining* a broader network, community, or vision to which they belong (Wenger, 1998). For example, a person who volunteers to plant native plants in a park is part of a community of practice that constitutes the set of volunteers who work together. These volunteers may also identify themselves as a part of a large social movement that aims to globally increase native habitats. Although the volunteers may not ever interact with people in other related organizations, they have the knowledge (through the

internet, word of mouth, or television, for example) that other groups of people are working toward the same ends, and feel an affinity with those people.

Finally, identification is built through *alignment* with the joint enterprise—the goals, beliefs, or commitments of the community of practice. It is not essential for alignment to be attained through free choice—alignment with the enterprise of a community becomes a part of a person's identity whether it is achieved freely or by coercion. In some cases, the meaning of the alignment is negotiated, and in some cases it is demanded. This brings issues of power to the forefront—if there are people who control the meanings in a community, then they have more power than those who do not (Wenger, 1998).

These three modes of identity development in a community of practice—*engagement*, *imagination*, and *alignment*—are used as an analytical guide in this research to understand the connection between respondents' participation in the Field Trip Explainer program and the development of their science-learner identities.

*Strengths and Limitations of the Framework*

The existence or acknowledgement of a community of practice does not mean that a positive culture or set of learning automatically occurs. Participation in communities of practice has its strengths and limitations. What is relevant is that understanding how a community of practice functions allows participants and leaders to make adjustments to optimize what does occur in their community of practice.

Several researchers have found the communities of practice framework useful for understanding their observations of workplace learning situations (e.g., Brown & Duguid, 1991; Palincsar, et al, 1998; Knight, 2002; Merriam, 2003; Hodkinson & Hodkinson, 2003; Eames & Bell, 2005; Light, 2006; Bailey, 2006). They all argue for more deliberate design of workplace

learning that leverages, or at least acknowledges, the learning that already takes place through communities of practice. These authors did not test aspects of the framework, but rather found patterns in real-life scenarios that map onto the framework as described by Wenger (1998).

One example of a study applying the communities of practice framework to a workplace is Brown and Duguid (1991). The authors posit that organizations tend to rely on job descriptions, manuals, training programs, and organizational charts to understand and improve work practice, and overlook that most learning happens through legitimate peripheral participation in communities of practice. Through the analysis of Orr's ethnographies, 1990a; 1990b; 1987a; 1987b, ( as cited in Brown & Duguid, 1991) of service technicians, they argue that instead, organizations must acknowledge communities of practice in order to understand and improve work, learning, and innovation. The authors point out that workers diverge from canonical practice, and rely instead on narration, collaboration, and social construction. They argue that learning to do the work happens through legitimate peripheral participation, and that innovation happens through discovery, reflection, and communication. The authors recommend that organizations be reflectively structured to preserve and enhance the autonomy of its communities of practice in order to enhance work, learning, and innovation. Similar to Brown and Duguid, other researchers (Knight, 2002; Traianou, 2006) have argued that teaching in K-12 schools requires complex expertise, and an eclectic set of learning experiences. Among the ways in which teachers learn to do their jobs, learning through working in a community of practice is an important element of developing teaching expertise.

In contrast, Palincsar and colleagues (1998) noticed the frequent use of the communities of practice framework as a model for teacher professional development. While they agreed that there is value in learning through communities of practice, they argued that teachers do not

normally work in communities of practice at all. According to the authors, teachers' practices and workplaces lack key elements of communities of practice: they do not have a shared enterprise because there is no consensus regarding the goals and means of education, and teachers have infrequent opportunities for informal exchange, making their work isolated and lacking in collegial support. Therefore, these authors argue that communities of practice for teachers must be created, despite Wenger's writing that communities of practice are not created, but already exist and evolve over time as people engage in a collective enterprise.

Fuller, Hodkinson, Hodkinson, and Unwin (2004) argue that Wenger's (1998) description of newcomers learning from old-timers in a community of practice is not complex enough to account for the realities of modern workplace learning. These authors conducted multiple case studies of teachers in "complex institutional settings" in order to determine the extent to which Lave and Wenger's (1991) theory of situated learning in communities of practice applies to modern workplace learning. They found that Lave and Wenger's (1991) theory did help to describe teachers' workplace learning in some respects. In particular, participants' engagement in social relations worked as a prime determinant of workplace learning, and legitimate peripheral participation also worked as a determinant of whether participants took on identities of participants or non-participants. However, the authors' findings show that workplace learning can be more complex than what is portrayed by Lave and Wenger (1991); they found that many experienced teachers were learning from newcomers. In the apprenticeship examples used by Lave and Wenger, it was standard for novices to enter the apprenticeship with little or no prior experience. However in today's workplaces, it is common for newcomers to have prior knowledge, experiences, and identities that can be contributed to the new community of practice; newcomers may even be hired directly into leadership positions. This situation leads to novices

at times taking on the roles of experts, and vice versa. This situation is true for the Field Trip Explainers as well, who enter the position with relevant background experience. While newcomers are clearly new to learning the specifics of the Explainer role, they are generally hired with the expectation that they have some skills, knowledge, or experience that will benefit the other Explainers in some way.

Workplace culture has been explored in learning research relating to socially shared cognition (e.g., Levine & Moreland, 1991) or creating a learning culture (e.g., Ritchhart, 2007). Culture could be used to understand the learning of Field Trip Explainers, and is similar to communities of practice in considering interactions between newcomers and old-timers. I chose to focus on the communities of practice framework (Wenger, 1998) because of the utility of its detailed structure and because it has already been applied to understanding learning in informal environments such as museums.

Maynard (2001) criticized Lave and Wenger's (1991) learning through participation by arguing that the framework does not capture the complexity of the tension between newcomers' adopting a new identity and retaining their original identity. She investigated the learning content and processes of student teachers' school-based training using Lave and Wenger's (1991) "learning as participation" as a lens, and found that student teachers were faced with pressure to adopt values and practices that were not in line with their own ideas. The desire to fit-in and be accepted by a new community of practice was in opposition to the student teachers' desires to also be true to their own values and practices, and this dissonance caused a great deal of stress for the student teachers. Due to these findings, Maynard recommends that the theory of learning through participation should not be applied to the design of teacher-training programs to the exclusion of other methods.

Although the enterprise of a community of practice may not be learning, a well-functioning community of practice may be an ideal place for the creation of new knowledge. It is the combination of the solidity of a shared history of practice and the potential of a community's marginalities (or periphery) that creates the possibility for new learning to occur. However, Wenger is clear that learning cannot be designed, but can only be designed *for*. Likewise, he says that practice is a response to, rather than the result of, design. The deliberate design of a community of practice is a way of creating identity and meaning, and must be co-created with the community members.

Despite Wenger's assertion, many practitioners found resonance in the communities of practice idea, and set out to design programs that optimize learning by taking advantage of understanding the communities of practice framework. However, communities of practice are often conflated with or described in conjunction with learning communities and professional learning communities. This conflation does not ultimately have negative consequences, but it does create some confusion about what a community of practice is and is not. A community of practice is not a recipe for creating positive learning outcomes, it is a tool for understanding how, why, and where learning occurs. Learning communities may be desirable, but every community of practice is not necessarily a learning community, and the expectation that a community of practice is automatically a learning community may cause disappointment.

Professional learning communities usually refer to teachers and staff in K-12 schools. These are a specific type of community of practice that is deliberately reflective and learning-oriented. There is an emphasis on collaboration, reflective practice, and action research (Stoll, Bolam, McMahon, Wallace & Thomas, 2006). In one example, Barab, Barnett, and Squire (2002) wrote, "Central to the research described in this article is the idea that learning as

coparticipation in a community of practice can provide a useful model for teacher preparation programs" (p. 490). What they did not acknowledge in this paper is that it is possible for teachers to learn negative or ineffective teaching strategies through working in a community of practice. What they were actually trying to create was a *professional learning community* in which the preservice teachers would learn from experienced teachers in a supportive environment that encouraged experimentation and reflection. The authors concluded that this designed community of practice did improve the learning outcomes of the preservice teachers. In this case, specific learning outcomes were designed for within the structure of the professional learning community. It is important to note that this is a very specific type of community of practice; every community of practice does not necessarily value experimentation and reflection.

Little (2002) addresses this issue with research that pushes on the idea that teachers working in a community of practice will demonstrate improvements in their practice over time. Based on videotaped data of teacher-to-teacher interactions, she points out that not all teacher communities of practice value change or improvement. In order to move the field forward, Little suggested that instead, communities of practice should be analyzed using a framework that includes examination of the representations of practice, the orientation to practice, and the norms of interaction, and how these three things impact individual performance, collective performance, and the development of practice.

In summary, Wenger's (1998) framework has been used to better understand and leverage learning that naturally occurs through communities of practice in both informal learning environments and among groups of professionals, particularly teachers. This dissertation analyzes the appropriateness of applying the communities of practice framework to the case of the Exploratorium Field Trip Explainers to better understand their development of science-

learner identities. In the findings, I explore in depth the framework and its applicability to the case. Specifically, I use the five elements of a community of practice and the three modes of identity development in a community of practice as heuristics for analyzing the data.

### *E. Chapter Summary*

This case study research is informed by and contributes to the social learning literature. This chapter reviewed the literature relating to social learning theories, science literacy, identity, and communities of practice, particularly as they each relate to learning in science museums.

On visits to science museums, visitors' learning outcomes relate to increasing motivation for science learning, practicing inquiry skills, and understanding natural phenomena. Research about learning that occurs in museum settings focuses on the social and situated nature of learning in these contexts.

The United States' explicit commitment to science literacy has been evolving since 1983, and now includes standards for science learning schools and informal settings such as science museums. This research utilizes the NRC (2009) Six Strands of Science Learning as an analytical tool to examine learning and identity development in this case.

Identity development as a process that is personally and socially constructed was reviewed in this chapter, as well as how it has been applied to museum experiences. The communities of practice framework (Wenger, 1998) describes the relationship between learning and identity development as an individual becomes involved in a community of practice. The communities of practice framework is used as an analytical tool to examine the case and the identity development of Exploratorium Field Trip Explainers. The following chapter describes the research methods used in this case study.

## III. Methods

This dissertation is a case study of recent participants in the Exploratorium Field Trip Explainer Program. The methodological approach is grounded in the interpretivist approaches to research, which involve gathering qualitative data through interviews, observations, and document review. This chapter presents the research question and associated case study sub-questions, situates the research approach, outlines the methods of data collection and analysis, and describes the strengths and limitations of the research design.

### *A. Research Questions*

The structure of the research question was formed using Yin's (2009) recommendation of a general question followed by a specific, theoretical proposition to be analyzed and applied to the case.

Overarching Research Question: Do Exploratorium Field Trip Explainers build identities as science learners, and if so, how?

Proposition: Exploratorium Field Trip Explainers build identities as science learners by working within a community of practice (Wenger, 1998).

In order to answer the research question and to provide a rich description of the case, it is important to have sub-questions about the case to guide the study. The following are the case study sub-questions:

1. What is the individual context of each Explainer participating in the study? In particular, what is her/his pre-existing identity and other non-science learner components of her/his current identity? How do Explainers understand what it means to have a science-learner identity?

2. What is the context of the Exploratorium Field Trip Explainer Program? Specifically, how do Explainer experiences reflect a community of practice, if at all? This question includes understanding the five elements of practice and identity in this context: meaning, community, learning, boundaries, and locality (Wenger, 1998).
3. In which of the six Strands of Science Learning (NRC, 2009) has each Explainer engaged, if any? What are examples of these occurrences? In other words, what is the evidence that each Explainer does have a science-learner identity?
4. In what ways has each Explainer participating in the study experienced the three components of identity formation, if at all: engagement, imagination, and alignment (Wenger, 1998)? In other words, what is the evidence that Explainers' identity has been formed through participation in this community of practice?

The research question of this dissertation is about applying and analyzing the appropriateness of a theory to the case of the Exploratorium Field Trip Explainer Program. Because of the importance of context and the focus of the research on a particular program, this dissertation is an analytical, sociological case study. First, I provide some background on the ontological perspectives in research that situate this choice. Then, in the following sections, I describe case study research, the particular decisions I've made about this case, and the data collection and analysis methods.

### *B. Ontological Perspective*

The research question for this case has two main components: 1) whether Explainers have a science-learner identity, and 2) whether and how this identity was impacted through participation in a community of practice. Identity is a complex construct, which makes it

challenging to understand in meaningful ways. How does one know whether they have accurately assessed the identity of another person? To determine accurate assessment, one must be clear about the meaning of *accuracy* grounded in the particular study.

From a post-positivistic standpoint, one would need to find a way to measure participants' identities as an objective and unbiased truth that is distinct from the participants' and researchers' presuppositions. For example, the Implicit Association Test (IAT) has been used in psychological research to indirectly measure constructs such as self esteem, social identity, racial prejudice, and connectedness to nature (Greenwald, McGhee, & Schwartz, 1998; Greenwald & Farnham, 2000; [as cited in Schultz, Shriver, Tabanico, & Khazian, 2004]). In this test, participants sort cards on a computer screen by categorical associations. The speed with which they are able to "correctly" sort the cards measures their internal psychological state—even if the participant is unaware of this state or is unable to accurately articulate it. Schultz and colleagues (2004) argue that this form of identity testing is more reliable than methods that rely on self-reporting, such as Schultz's prior work (2001) in which he adapted Aron & Smollan's (1992) "Inclusion of Other in the Self Scale" to measure participants' connectedness to nature.

From an interpretivist perspective, on the other hand, it is exactly the participants' own subjective experiences of reality that are relevant to measure. This view of reality, which includes traditions such as constructivism, ethnography, and phenomenology, values the individual, lived experience over an objective and universal truth. It is rooted in the belief that reality is "socially constructed, complex, and ever changing" (Glesne, 2011, p. 8). In interpretivist research, data are often gathered through interviews with open-ended questions; this method allows for the researcher to understand the lived experience of the participants. In order to ensure that participants' experiences and perspectives are accurately understood and

represented, themes are reviewed with the participants (Kvale, 1996; Crotty, 2003). Research in science education, particularly that examines learning through the lens of situated learning (Lave & Wenger, 1991) or communities of practice (Wenger, 1998), tends to fall into the interpretivist camp and relies on qualitative data gathered through interviews and observations (e.g., Brickhouse, Lowery, & Schultz, 2000; Bailey, 2006; Falk, 2006).

The question of which ontological tradition is most appropriate can be answered by examining the underlying purpose of the research. Postpositivism is an appropriate paradigm choice when the purpose of the research is to be able to make predictions. Intepretivism is an appropriate choice when the purpose of the research is to create an understanding of people and their social contexts (Glesne, 2011). The theoretical framework I have chosen, communities of practice (Wenger, 1998), is sociocultural in nature and values social constructions of meaning; this framework then drives my choice of an interpretivist ontology and research methods that seek to understand participants' subjective perspectives and experiences.

### *C. Case Study Research*

In a case study, the researcher focuses on learning about the complexity of one, specific case. This approach can be contrasted with methodologies in which the researcher aims to collect data about an entire population, such as survey research. These two forms of research are complementary and are chosen based on the type of questions being asked. Case study research is often qualitative, but can use quantitative data as well.

A case is a specific integrated and bounded system (Stake, 1995) that is studied within its natural context (Yin, 2009). For example, individual people, communities, programs, or classrooms could be cases, but the topic of diversity could not. As a system, a case is complex,

nuanced, and situated, and it is this complexity and need for contextualization that is of interest to the researcher. In this instance, the "case" is the Exploratorium Field Trip Explainer Program.

Two characteristics distinguish case study research from other research approaches: the inquiry is contextualized and involves many variables. These characteristics drive the appropriate data collection and analysis methods.

Yin's case study definition is as follows:

1. A case study is an empirical inquiry that
    a. investigates a contemporary phenomenon in depth and within its real-life context, especially when
    b. the boundaries between phenomenon and context are not clearly evident.
2. Case study inquiry
    a. copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
    b. relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
    c. benefits from the prior development of theoretical propositions to guide data collection and analysis (Yin, 2009, p. 18).

Case studies are used when the specific case is either intrinsically interesting, or instrumental in building understanding relating to a larger question (Stake, 1995). It is an appropriate methodological choice when the researcher seeks to answer "how" or "why" questions, rather than "who, what, when, or how many", which are better suited to survey research. Experimental research designs are also appropriate for answering "how" and "why"

questions; the key difference between the two methods is that case studies are naturalistic, whereas experimental designs involve manipulating at least one variable (Yin, 2009).

A case study can be further described by the discipline it is most closely connected to and by the overall intent of the study (Merriam, 1998). Identifying these aspects of a case study provides the researcher with some guidance for measuring the success of the study. For example, case studies in education can be ethnographical, historical, psychological, or sociological in nature, depending on what the researcher is studying. This case is most closely sociological, as the focus is on the social relationships among individuals in a community of practice. The intention of a sociological case study is not to understand the development of individuals (psychology), to teach the reader how to behave in a particular culture (ethnography), or to describe how a program has evolved over time (history). Instead, a sociological case study is successful if it highlights social interactions (Merriam, 1998, p. 37). The intent of a case study also guides the research process. The case might be descriptive, analytical, or evaluative. In this study, the research question is designed to analyze and apply a theoretical proposition, making the study an analytical case.

I chose case study for this dissertation because I am seeking to understand *how* science-learning identities are formed in a particular case; understanding the process of identity formation makes the most sense within the contexts of the program and the particular museum. The case of the Exploratorium Field Trip Explainers is both intrinsically interesting and instrumental, as it will contribute to building theoretical understanding of how learners develop science identities.

### *D. Case Selection and Unit of Analysis*

*The Case*

The Exploratorium Field Trip Explainer Program is an intrinsically interesting case. Unlike some case studies, I did not first choose a research question and then select a case that best answered the question. Instead, it was the case itself that first attracted my attention, and the research question followed. The Field Trip Explainer Program is one community of practice within the overall organization of the Exploratorium. Like any other institution, there are many communities of practice, and many Field Trip Explainers are involved in multiple communities of practice both within and outside of the Exploratorium. However, it is my observation that due to the strong work practices and culture of this particular group, the Field Trip Explainer Program is the dominant community of practice to which the Explainers belong within the Exploratorium. This observation is what led me to choose this program as the case for this study.

*Unit of Analysis*

"Unit of analysis" is the choice of case to be studied, as well as the number of cases to be studied. This is a single-case study (as opposed to a multiple-case study), which can be an appropriate choice for a variety of reasons; in this study the reason for a single-case approach is that the case examines a change over time (identity development) (Yin, 2009). Common, concrete units of analysis for case studies include individuals, small groups, or organizations (Yin, 2009). In this research context, the case is the Exploratorium Field Trip Explainer Program, the embedded units are individual Field Trip Explainers, and the context includes Explainers who are not included in the study, the program managers, and the Exploratorium itself. The

following table (3.1) describes the organization of a single-case study with multiple embedded units of analysis.

**Table 3.1: Context, Case, and Embedded Units of Analysis**

| **Context**: The Exploratorium and other Staff | | | | | |
|---|---|---|---|---|---|
| | **Case**: Exploratorium Field Trip Explainers | | | | |
| | | **Embedded Units of Analysis**: Explainers | | | |
| | | Explainer 1 | Explainer 2 | Explainer 3 | Explainer 4 |
| | | Explainer 5 | Explainer 6 | Explainer 7 | Explainer 8 |
| | | Explainer 9 | Explainer 10 | Explainer 11 | Explainer 12 |
| | | Explainer 13 | Explainer 14 | Explainer 15 | Explainer 16 |

In communities of practice, the individual and the community are constantly creating one another through mutual engagement (Wenger, 1998). In order to account for this dynamic, *the relationship* between the individual Explainers and the community of practice of the Exploratorium Field Trip Explainers is considered in the data analysis.

*Selection Criteria*

Merriam (1998) points out that there is no correct number of case study participants, but suggests identifying an approximate number in the proposal stage, with the understanding that this number may change during the data collection process. In a case study, it is not important or relevant to create a generalizable sample that is reflective of a larger population. However, one should include enough participants to collect a reasonable amount of information. There are 24 individuals who met the selection criteria for the case (described below). I planned to include as many of these eligible participants as available, with a goal of a minimum of 9 participants.

Another consideration for creating selection criteria is whether to choose probability or purposive sampling (Merriam, 1998). Since probability sampling is not appropriate for case study, I used purposive sampling instead. An investigator using purposive sampling seeks to

"discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (Merriam, 1998, p. 61). Given the small number of people who fit the criteria described below, I decided to be flexible about including anyone who is willing and available to participate in the study. Appendix 3.1 is an example of the recruitment letter sent to potential participants.

An important criterion for this case study is determining *when* the participants were Explainers. Communities of practice may exist over a long period of time, during which individual members shift and change. The Exploratorium Field Trip Explainer Program has been in operation for roughly 40 years, serving approximately 400 Explainers over that time span. It is not imperative that the participants were all Explainers at the same time; Explainers who participated in the program in different years are potentially all members of the same community of practice. However, communities of practice do change over time, and this case will be most relevant if it reflects the current state of the program as closely as possible. In order to reflect the current state of the program, one might choose participants who are current Explainers. However, my role as their manager introduces a potential bias into the process, and raises the risk that Explainers could feel unintentionally coerced into participating in the study.

Given this thought process, the participants in this study met the following criteria:

1) had been Field Trip Explainers for at least eight months,
2) were no longer participants in the program, and
3) had left the program no more than three years prior to the beginning of the data collection process.

During their tenure in the program, most Field Trip Explainers are in the "emerging adulthood" developmental stage (Arnett, 2000), generally between the ages of 18 and 30 years.

(This definition is distinct from the United Nations' [UN] definition of "youth", which is between the ages of 15 and 24 [UN, 2010].) During this time, emerging adults explore their identities and make decisions that will situate them in their adulthoods, such as their careers, places of residence, and life partners. Emerging adulthood is culturally contextual and involves some level of affluence; it only occurs within social groups in which young people have the flexibility to spend these years of their lives exploring and testing out various identities. Although most Explainers fall into this group, not every Explainer comes from a cultural group in which an emergence phase is possible. While this developmental level is notable and adds to the significance of the study, participants were not restricted to having been emerging adults while in the program.

Participation in this study was entirely voluntary (see Appendix 3.2: Documentation of Informed Consent). Sixteen former Explainers participated in the study, 8 men and 8 women. Consistent with the goal of the Field Trip Explainer program, the participants represented a diverse group of people. At the time the participants were Explainers, their ages ranged from 18 to 32 years. Their length of participation in the Field Trip Explainer program ranged from one to four school years. Participants had a variety of ethnic backgrounds, including some who were first generation American, and two who had moved to the United States from other countries. Some participants identified as lesbian, gay, bisexual, or transsexual (LGBT). Participants' interests and educational backgrounds included the arts, humanities, and sciences, and included people whose highest level of education was high school, college, Master's degrees, and PhD's. They went on to careers in formal and informal education, arts, and science.

### *E. Data Collection*

Data were collected using multiple methods in order to provide a rich description of the case and to triangulate the findings. First, participants completed a reflective activity, comparing their identity as science learners before and after their tenure as Explainers. Next, I interviewed the participants to gather qualitative data describing their experiences as Explainers within a community of practice, and how that may have influenced their identities as science learners. Participants all signed informed consent forms prior to beginning data collection (Appendix 3.2). Participant observation and document review were also used to aid in triangulation. Examples of documents reviewed include the Explainer blog, Explainer calendars and schedules, and Explainers' annual personal reflections. Prior to beginning data collection, the research plan was reviewed and approved by the Exploratorium's Institutional Review Board (IRB) and Antioch University New England's Human Research Committee (HRC).

The following table (3.2) displays the types of data collection in relation to the case study questions that they address. Each case study question was investigated using more than one data source, ensuring triangulation for each question (Patton, 2002). Triangulation is important for understanding multiple perspectives, creating a more complex picture of participants' experiences and responses (Glesne, 2011) and to develop "converging lines of inquiry" (Yin, 2009, p.115). Case study research, in particular, relies on triangulation via multiple data sources for internal validity.

**Table 3.2: Data Sources Corresponding to Case Study Sub-Questions**

| Data Sources | Case Study Sub-Questions | | | |
|---|---|---|---|---|
| | 1. Case Context: Five elements of community of practice | 2. Individual Context: Pre-existing and current identity | 3. Six Strands of Science Learning | 4. Three components of Identity Formation |
| Reflective Activity | | X | | |
| Semi-Structured Interviews with former Explainers | X | X | X | X |
| Participant Observation | X | | X | X |
| Document Review | X | | X | X |

*Reflective Activity*

The reflective activity instrument (Appendix 3.3) is a retrospective comparison of Explainers' science-learning identities before, during, and after their time in the Field Trip Explainer program. Using a Rank Item Scale of 0-5, participants rated their science-learner identities before and after participation in the Field Trip Explainer program, and their current science-learner identities. This scale is inspired by the "Inclusion of Other in the Self Scale" (Aron, Aron, & Smollan, 1992) and Schultz's (2001) adaptation, "Inclusion of Nature in the Self", replacing "other" or "nature" with "science-learner." However, unlike Schultz's (2001) use of this type of instrument, this scale is not meant to create a set of quantitative data from which one can draw generalizations about a population. Instead, the purpose of this instrument was to serve as a starting point for discussion during the in-person interviews.

I piloted this instrument prior to data collection with a group of current Field Trip Explainers, along with an alternative method that I did not use during final data collection. I

asked half (7) of the Explainers to complete the instrument as it appears in this study. The other half (7), I asked to create a visual representation of their science-learner identities for each of the 3 dates in the reflective instrument. After completing the activity, I invited the Explainers to share with me their reactions and trains of thought as they completed the activity. I found that the form of this activity in which Explainers created visual representations of their identities yielded interesting results, but was too open-ended to be easily completed by all Explainers without further instruction and explanation.

Based on the feedback from Explainers who completed the pilot instrument, I expected that some interesting insights would emerge for the participants. First, participants might notice that they have more than one identity besides being a science learner. Second, they might notice that their science-learning identity shifted (or not) during their time as an Explainer (either toward or away from science learning), and that it may or may not have continued to shift (in either direction) after leaving the program. Third, this instrument was intended to provoke participants to think and talk about what a "science-learner" identity means to them, and how that meaning may have changed for them over time. These topics all created interesting starting points for discussion during the interviews, and the instrument itself provided a touchstone for participants from which to begin to answer the interview questions.

The data collected from the scales were not analyzed independently from the interview data. Before participants completed the scale instrument, there was no way to know that there was a shared understanding of the meaning of a "science-learner" identity, or to operationalize the meaning of the relative distances on the scale. The scale was designed to be used in conjunction with the interviews, and so the information collected from them is only meaningful when examined in tandem with the interview data.

*Interviews*

The primary mode of data collection was in-person, semi-structured interviews. The case study questions and data analysis tables (Tables 3.4 and 3.5) were used to create the interview guide, and ensured that all participants were asked questions that related to the case study questions. However, the semi-structured format left room for open-ended responses and probing questions as needed during the interviews. Interviews were conducted face-to-face whenever possible, but some were conducted over the phone for participants who had moved out of state. This choice created a potential limitation of loss of non-verbal cues, but increased the pool of eligible participants (Robson, 2002).

Semi-structured interviews provide some structure, but allow room for in-situ rewording and rearranging of questions as appropriate for each participant. The advantage to a semi-structured format is ensuring that specific research topics are covered, and creating opportunities for better understanding of the participants' viewpoints (Robson, 1993). Highly-structured interviews rely on participants understanding the meaning of all of the questions in the same way, which may not be the case. On the other end of the continuum, unstructured interviews allow so much room for participants to control the content that the researcher may not obtain enough relevant information (Merriam, 1998).

The interview questions (Appendix 3.4: Interview Guide) are organized as: warm-up questions, content about the Explainer identity and enterprise, content about science learning identity and activities, and then cool-off questions (Robson, 1993). The specific questions are designed to be contextualized in the participants' experiences, rather than as direct copies of the research questions. This approach to question-design elicits responses that are based in the reality

of participants' lives and that will build understanding related to the research questions and theoretical proposition (Glesne, 2011). I piloted the interview questions with two former participants of the Exploratorium High School Explainer Program to ensure that the questions were clear and flowed well.

The method of recording interviews is an important decision. Some authors suggest audio recording and transcribing interview data to ensure that no information is lost, carefully choosing which pieces of the data require transcription and which do not (Merriam, 1998; Robson, 1993; Glesne, 2011). This method is especially valuable in narrative analysis, when the specific wording and conversation flow are critical to understanding the data (Glesne, 2011). However, in this case, it is the *meaning* of participants' responses that is more important than the specific words they choose. Stake (1995) recommends against transcribing interviews, and instead listening carefully and taking detailed notes during the interview (using the recordings as a backup measure). Directly following the interview, the researcher should prepare a reconstruction of the account and submit it to the participant to check for accuracy of meaning (Stake, 1995, p. 66). This is the approach that I took, while also audio recording interviews to refer to when further detail is needed in particular instances. While participants were talking, I typed nearly word-for-word, and so was able to pull direct quotes from participants to use in the research findings.

*Participant Observation*

Participant observation is not the primary form of data collection for this research; the goal of participant observation in this study is to gain a richer understanding of the program and to provide context for the interview data (Merriam, 1998). There are many levels of participant observation that occur along a continuum; at one end the researcher is primarily an observer, and

at the other the researcher is a full participant (Glesne, 2011). In this case, I was already a full participant in the Field Trip Explainer program and was simultaneously observing the community. I particularly focused on understanding the five elements of practice and identity in this context: meaning, community, learning, boundaries, and locality (Wenger, 1998). I wrote field notes and reflections during or immediately after making observations. Since the focus of this research is on prior program participants, rather than current participants, the focus of my observations was on elements of the program that can provide contextual information such as documenting the structure of the Field Trip Explainer program and the daily activities of the Explainers. While these notes were not taken during the time that the research participants were Explainers, their experiences were similar enough that relevant connections could be made.

An important decision I had to make about writing field notes was deciding when to do so, and when not to. In many cases, a researcher makes appointments to make site visits for observations, but I am a participant in this case and am present everyday. In order to make sure that I made observations that fairly represented the program, I created a matrix (Table 3.3) crossing the places that Explainers occupy with the times and activities they do in those spaces. I made sure to have at least one observation for each intersection that actually occurs. For example, training sessions can take place in classrooms, at exhibits, or at the demonstration stations, but never take place in the Explainer lounge, at the entrance, and rarely occur off site. The titles of the observation notes appear in the cells of the matrix.

**Table 3.3: Matrix of Observations**

| Places → Times/ Activities ↓ | **Explainer Lounge** | **Classrooms or Meeting Rooms** | **Exhibits** | **Demonstration Stations** | **Outside the Front Entrance** | **Off Site** |
|---|---|---|---|---|---|---|
| **Training:** First two weeks of the year and Tues-Fri, 9:00-10:00am | *Does not apply* | No Rules | Sound Dance | Cone Dissection | *Does not apply* | *Very rarely occurs* |
| **On the Floor**: Tues-Fri, 10:00am-1:30pm | *Does not apply* | *Does not apply* | Visible Effects of the Invisible<br><br>Pulley Table | Cow Eye Dissections (3) | Rainy Day | *Does not apply* |
| **Friday Meeting**: Fridays, 2:30-3:30pm | *Does not apply* | No Rules Follow Up | *Does not apply* | *Does not apply* | *Does not apply* | *Does not apply* |
| **Outside of Work Hours** | Boggle Morning | *Does not apply* | *Sometimes occurs, but very difficult to observe* | *Does not apply* | *Does not apply* | Explainer Retreat |

*Document Review*

The review of documents provides more data for a complete description of the case, and triangulation for the case study questions. A thick description of a case enhances the quality of the research because it allows readers to gain a more complete understanding of the situation and the extent to which it is comparable with other cases (Merriam, 1998). The core documents I examined were the Explainer blog and Explainers' annual personal reflections. Additional program documentation that aided in triangulation were the Exploratorium website, an

unpublished program description, Explainer calendars, schedules, job applications, and concept maps Explainers made of their own learning processes.

The Explainer blog was started by Explainers on their own initiative in 2007, and is an optional, personal-time, tool for Explainers to communicate with each other and other interested people about their reflections on their work as Explainers. Every Explainer may register to be a moderator and contributor on the blog, and generally a few Explainers each year tend to regularly contribute postings. Topics range broadly from everyday experiences that relate to Explainer training sessions, specific sharing about Explainer events, and musings on anything related to the work of an Explainer. Review of this document provided context of the Explainer program, examples of Explainers engaging in the community of practice and science learning activities, and examples from the process of particular Explainers' identity development.

At the end of each year, Explainers take time to reflect on their professional progress by writing about the skills and knowledge they developed over the course of the year. I have copies of these reports from 2009, 2010, and 2011, that I reviewed and included to provide further triangulation of the interview data.

Finally, Explainers create concept maps of their learning processes, of which I have 49 from the years 2009-2011. Each year, Explainers engage in a reflective process in which they create visual maps of their own learning (see Appendix 3.5 for examples). The purpose of these maps is to engage in reflection about their own learning processes and those of their colleagues. They were shared within the Explainer group and used to solicit conversation about the process of learning. They begin by selecting three training sessions in which they remember moving forward in their learning about a topic. They write about what the facilitator did during those sessions, what they as the learners did, and whether they were working alone, with a partner, in

small groups, or all together. Next, Explainers select three to five words or phrases from their writing that they felt were key to their learning processes. Using those words or phrases as a starting point, Explainers create concept maps of their learning, and then share these with the rest of the group.

### *F. Data Analysis*

There is no, one way to analyze data for case study research. In order to ensure that the analysis process is robust, it must be as free as possible from researcher bias, and there must be enough information provided to the reader that s/he can trust the analytical process (Robson, 1993). The method of analysis chosen for case study research must support the research question under investigation. For example, different methods are appropriate for a grounded theory inquiry versus a study in which a theoretical proposition has already been selected to guide the case, or for a case in which the narrative dialogue is of primary importance versus the emergence of overarching social patterns (Robson, 1993; Yin, 2009; Glesne, 2011).

In this case, the data analysis method was designed to follow the theoretical proposition that guided the research question and to examine rival explanations of the theoretical proposition. I employed constant comparative analysis (Merriam, 1998, p.18), using tables to organize the data (Yin, 2009; Glesne, 2011), comparing across units of analysis. I wrote memos and reflections in order to document my thinking as it evolved, including my interpretations of the data and attempts to answer the case study questions (Robson, 1993). The specific steps I took to analyze the data were:

1. I reviewed the participants' responses and wrote summary notes for each question response. This step provided me with the opportunity to read carefully, to make note of

participants' main points, and to make sure that I had understood the meaning of their words. These notes were included in the interview reports, and were reviewed by the participants. All participants reviewed their interview reports; no participants requested changes to the reports.

2. I read through the interviews and created codes based on themes that emerged from the data. I then compared these themes/codes to the elements in the four case study questions. I found that most of my codes mapped into these categories, and created a table to organize them.
3. I organized the data from each interview report into tables such as Table 3.4. This table was designed to visualize connections between the participants' experiences and the components of identity development in communities of practice: engagement, imagination, and alignment. Tables such as this were populated with quotations from the interviews.
4. I wrote reflective memos about trends that I was noticing, and looked for trends that didn't fit neatly into the explanations of six strands of science learning and identity development in communities of practice.
5. I constructed a simple narrative for each participant to make sure that I didn't lose track of the personal contexts as a part of the analytical process.
6. Using the codes developed from the interview analysis, I coded the documents, such as entries in the Explainer blog and Explainers' annual reflections. I also organized these data into tables such as Table 3.5, below. Tables such as this were populated with frequency of occurrences (for example, the number of times that Strand 2:

Understanding, appeared in the blog entries), and the actual data were marked with the same codes to keep track of quotations.

**Table 3.4: Example Organization of Data Analysis**

| **Interview Reports** | **Elements of Identity Formation (Wenger, 1998)** | | | **Other Elements Present in the Data** |
|---|---|---|---|---|
| | Engagement | Imagination | Alignment | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| …16 | | | | |

**Table 3.5: Example Organization of Data Analysis**

| **Six Strands of Science Learning (NRC, 2009)** | **1: Interest** | **2: Understanding** | **3: Reasoning** | **4: Reflection** | **5: Practice** | **6: Identity** | **Other Elements Present in the Data** |
|---|---|---|---|---|---|---|---|
| **Interview Reports** | | | | | | | |
| **Explainer Blog Postings** | | | | | | | |
| **Explainer Learning Maps** | | | | | | | |
| **Explainer Reflection Documents** | | | | | | | |

### *G. Quality of Research Design: Strengths and Limitations*

Compared to research methods that are guided by the post-positivist paradigm, methods of assessing the quality or validity of naturalistic research are still under development (Lincoln & Guba, 2002). Characteristics defining the quality of social science research, qualitative research, and more specifically, case study research have been identified by many authors. For example,

these characteristics include internal and external validity (Stern & Kalof, 1996), descriptive, interpretive, and theoretical, and evaluative validity, and generalizability (Maxwell, 2002), resonance, rhetorical, empowerment, and applicability criteria (Lincoln & Guba, 2002), and validation through triangulation, acknowledgement of subjectivity, and seeking of alternative explanations (Stake, 1996). Given all of the suggestions in the literature, it is helpful to establish a clear and contained set of guidelines to aid in the design of a research project.

Yin (2009) presents the clearest framework for assessing the quality of case study research design and includes specific strategies for dealing with these criteria. Below is a table adapted for clarity from Yin (2009, p. 41) that I used to inform the design of this case study.

**Table 3.6: Quality Criteria for Case Study Research Design (Yin, 2009)**

| Criteria | Case Study Tactics | Phase of Research | Tactics Used in this Study |
|---|---|---|---|
| **External Validity**: defining the domain to which a study's findings can be generalized | • Use theory in single-case studies.<br>• Use replication logic in multiple-case studies. | Research Design | I used the Communities of Practice (Wenger, 1998) theory to guide the research question and case study design. |
| **Construct Validity**: identifying correct operational measures for the concepts being studied | • Use multiple sources of evidence.<br>• Establish chain of evidence (report should cite the data)<br>• Have key informants review draft report. | Data Collection | • I used multiple sources of evidence: interviews, documents, and participant observation.<br>• All evidence is documented and cited when used in the dissertation.<br>• All participants reviewed and approved their own interview reports. |
| **Reliability**: demonstrating that the operations of a study—such as the data collection procedures—can be repeated, with the same results | • Use case study protocol.<br>• Develop case study database. | Data Collection | • This chapter serves as the case study protocol, and follows Yin (2009), Merriam (1998), Robson (1993), Glesne (2011), and Stake (1996)<br>• I have a database of evidence and reflective memos for this case. |
| **Internal Validity**: seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships | • Do pattern matching, explanation building, or logic models.<br>• Address rival explanations. | Data Analysis | • I used constant comparative analysis (Merriam, 1998).<br>• I addressed other theories that could be used to explain the case, such as Reflective Practice (Schon, 1983) and Workplace Learning (Melville & Wallace, 2007). |

The case study method has been criticized for lack of generalizability to greater populations (Punch, 2005). Indeed, in survey research, appropriate sample sizes are much larger than one case. This argument brings up an important distinction between survey and case study

research: case studies are best suited for analyzing theoretical propositions, and not for generalizing to populations. Yin (2009) states,

> case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study, like the experiment, does not represent a 'sample,' and in doing a case study, your goal will be to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization) (p. 15).

Although not generalizable, this case is transferable, as it can provide insights and information that may be applied to other cases. There are numerous "Explainer" programs in museums around the United States and in other countries. They are called by many names, such as docents, guides, or floor staff. These programs are connected through professional networks such as NetLife, Thematic Human Interface and Explainers (THE) Group, and Pilots Hub: the Explainers International Community. The results of this study will be shared with these networks, and has the potential to inform cases connected to other, similar programs.

*My Role as Researcher*

In addition to my role as a researcher, I am also the manager of the Field Trip Explainer program. This role affords me excellent access to the program and its participants, as well as in-depth knowledge and understanding of how the program operates. I have pre-established relationships with the participants that allows for ease of communication. Overall, it is likely that my role in the program provides me with markedly deeper ability to discover information about the case than would be possible had I not been an integral part of the program and community.

However, my role has the potential to introduce bias, both due to my own preconceptions and due to my relationship with the Explainers. In order to minimize this effect, I "explored my

own subjectivity" and addressed my preconceptions by writing reflectively before collecting data (Glesne, 2011). Appendix 3.6 documents my assumptions and expectations prior to data collection and served as a check—if my findings too closely matched these expectations, then that would have been an indication that my subjectivity had interfered with the research process. I also reviewed these assumptions with my colleagues to determine whether they shared my assumptions, or if these expectations represented personal biases.

Additionally, I looked at the data as much as possible through the eyes of the participants, and listened deeply and openly to what they had to say. To check that this process occurred, participants reviewed my reports of their interviews to verify that I correctly captured their meaning (Stake, 1996; Glesne, 2011).

Another potential limitation to the study is a bias effect that Stern and Kalof call the demand characteristics of the on-stage effect, in which the participants want their responses to please the researcher (1996). This was mitigated by relying primarily on former Explainers, who have less reason to bias their responses as they are no longer employed by me. As described in the prior section, the limitations of this study should be examined within the context of a naturalistic, qualitative inquiry, in which quality is determined based on internal validity (Stern & Kalof, 1996). It is difficult to objectively separate the researcher from the participants, as case studies are situated and contextualized in nature (Stake, 1996).

### *H. Chapter Summary and Prologue to the Findings*

This case study examines the science-learner identity development of recent participants in the Exploratorium Field Trip Explainer program. I collected data from sixteen participants through a reflective exercise and semi-structured interviews. Data also included participant

observation and document review, which added depth to the description of the case and triangulation of findings. Constant comparative analysis of data was employed, guided by the theoretical proposition of the research question. The Six Strands of Science Learning (NRC, 2009) and the five elements of a community of practice (Wenger, 1998) were used as analytical tools to organize the data.

The next five chapters of the dissertation present the research findings. The first of these chapters presents the research context of the case, describing the Exploratorium in general and the Field Trip Explainer program in particular. Next, Chapter V presents data describing the contexts and identities of individual participants. Chapter VI examines the extent to which the Exploratorium Field Trip Explainer program is a community of practice (Wenger, 1998) and presents an analysis of how Field Trip Explainers' identities manifest through participation in a community of practice. Chapter VII describes Explainers' participation in the Six Strands of Science Learning (NRC, 2009). Finally, Chapter VIII examines the development of participants' science-learning identities and connections to the process of identity development in a community of practice (Wenger, 1998).

## IV. Research Context

The site of this case study is the Exploratorium, located in San Francisco, CA. This chapter describes the context of the case: the Exploratorium in general and the Field Trip Explainer program in particular. I illustrate this chapter with data from two sources: participant observations and document review. The primary document cited here is the Explainers' blog, which they created of their own volition and contribute to in their free time as a way to converse with one another outside of work. Other documents include the Exploratorium website, example teacher worksheets, an unpublished program description, and Explainer calendars.

### *A. The Exploratorium*

The Exploratorium is a museum of science, art, and human perception, conceived of and founded by Dr. Frank Oppenheimer, brother of J. Robert Oppenheimer. Inspired by his love of physics and his hope that learning could lead to good decision-making, he started building his own exhibits and opened the Exploratorium in 1969 ("Exploratorium History," 2010). Now, hundreds of hands-on exhibits, made on-site, are scattered throughout a cavernous warehouse space. Approximately 500,000 people (school groups, families, and adults) visit the museum each year, and many more experience the Exploratorium's thinking and activities through the website (Exploratorium, 2008).

While the Exploratorium does have a mission statement, which is essentially to nurture curiosity, the actual mission is constantly debated among the few hundred staff members—it could be to teach science, build inquiry skills, display art, provide opportunities for creative projects, to share current science research with the public, and so on. One thing that is sometimes referred back to is an old sign hanging over the workshop that reads, "Here is being created a

community museum dedicated to awareness." I'm not sure that we all agree on exactly what that means, but each staff person seems to sit comfortably with his or her own understanding of the sentence, and of the purpose of the Exploratorium. Despite, or because of, this multiplicity of ideas and propensity for debate, the Exploratorium has managed to thrive, to lead into existence the field of hands-on science learning, and to remain one of the world leaders of science education (Exploratorium, 2010b).

Of the many facets of the Exploratorium, the exhibits in the physical museum are at the core of its work. From the beginning, there have been paid Explainers hired to facilitate the visitors' engagement with the exhibits. The Explainers have always been young people, and have never been required to have any background (or even interest) in science. Oppenheimer's legacy philosophy is that anyone can do science, *and* that this idea should be role-modeled through our own staffing. If the floor staff were trained scientists, this might reinforce visitors' ideas that doing and understanding science are reserved for a select group of people. Instead, Oppenheimer hoped that visitors would interact with Explainers who were young learners, and think that perhaps anyone, even they, could understand and do science (Exploratorium, 2010c; Cole, 2009).

There are two groups of Explainers: the High School Explainer Program, which employs high school students and functions as a youth development program, and the Field Trip Explainer Program, which employs young adults who have some prior experience working with children to work with the school field trip audience. The Explainers in these two programs do similar work with the museum visitors, but the goals of the programs are slightly different. The High School Explainer Program has a rich history and has included approximately 3,000 high school students since the museum opened in 1969 ("The Explainer Programs," 2010), but it is the Field Trip Explainer Program that is the topic of this dissertation. Approximately 500 people

have been employed as Field Trip Explainers since the program's inception in 1970 ("The Explainer Programs," 2010). At this point, there has been only one, small, study about the Field Trip Explainer program (Billings, 2004), which examined the role of hand-held technology in Explainers' work.

### *B. The Field Trip Explainer Program*

The Field Trip Explainers are a crew of 16 orange-vested educators who staff the museum floor on weekday mornings during the school field trip visits. The Field Trip Explainers' primary responsibility is to this audience, supporting the goals of the groups and working to ensure a positive and rich visiting experience. They facilitate demonstrations, give orientations to groups of students, and interact with visitors at exhibits on the museum floor. In order to learn how to do this, Explainers participate in intensive professional development that is comprised of both formal training sessions and reflective practice. Approximately 16% of Explainers' paid time is spent in training, for a total of approximately 130 hours of training each year. A commitment to training and professional development is a requirement of Explainers' employment.

There are two goals of the Field Trip Explainer program:

1. Provide a positive and rich visiting experience for the school field trip groups, supporting their various goals.
2. Provide professional development for the Field Trip Explainers in their growth as museum educators. (Richardson, 2010)

These goals are intertwined; one does not supersede the other. It is critical for Explainers to be engaged in authentic learning experiences that are relevant to their work on the museum floor.

This engagement significantly improves their ability to support the school field trip visitors—both because of the constant development of related skills and knowledge, and because their excitement and curiosity is shared with the visitors. These two goals are fairly open-ended; I will discuss each one in more detail in the following sections. These program goals are not directly linked to the research question, but an elaboration of them will provide some context for the case study.

### *C. The School Field Trip Audience*

After the first day of the 2010 school year, an Explainer posted the following on the Explainer blog:

> To kick off the 2010 Explainer Year, we began by compiling some of our many hopes and dreams for the upcoming year… Read the list below to get insight into what the explainers hope to help people to achieve this year:
>
> I hope to help visitors…
>
> …take ownership of their experiences and have courage to follow their passions.
>
> …be inspired (and to support those who are already inspired) to explore the world.
>
> …understand at least one concept, but also to fully enjoy themselves that they'll want to come back.
>
> …discover the power of their own creative thinking and be inspired to bring it to experiences outside the museum (Explainer blog posting, September 23, 2010).

Teachers bring students to the Exploratorium to create positive experiences in science for their students, for the enrichment of engaging in free-choice, hands-on science, and to make connections to their curricula or the CA science standards. The range of activities of field trip

groups includes focused, curriculum-driven explorations of specific exhibits, open-ended exposure to exhibits and demonstrations related to a school curriculum, active engagement in the inquiry process at exhibits of students' choosing, and free exploration of the museum.

I surveyed teachers who brought students on field trips to the Exploratorium to learn about their goals for these field trips (Richardson, 2007). Of 86 teachers surveyed, most (43%) listed as their top priority "to get the kids excited about science." The second-most popular goal of teachers bringing students on school field trips to the Exploratorium (29%) is "providing a hands-on or inquiry experience." Finally, 9% of teachers listed "learning about a specific content area" as their top priority for an Exploratorium field trip. Although this number is low, other things that teachers said indicated that learning about a specific content area is important to them. For example, 31% of teachers reported that "planning a focused field trip" is the biggest challenge to bringing students to the Exploratorium. These teachers stated things such as: choosing the right exhibits for their grade level (based on age appropriateness or science standards), making sure students actually visit those exhibits, and knowing how much time to spend at exhibits. This discrepancy in goals and concerns is consistent with research examining teacher goals and measures of success for field trips to science museums (Kisiel, 2005; Anderson, 2006).

It seems strange that if teachers' top priority for their students is to get them excited about science, that their biggest challenge is related to connecting the field trip with their curriculum or standards, as these two field trip goals seem somewhat unrelated. What we know from the research literature is that creating clear field trip goals is challenging for teachers, given the multiple pressures they face when planning field trips from administration, parents, and taking students to an unfamiliar environment (Griffin & Symington, 1997; Kisiel, 2005; Anderson,

2006). Students (and likely chaperones) also have their own hopes and goals for the field trip experience, and may be unaware of the teachers' goals (Griffin & Symington, 1997; Griffin, 1994). While students' goals may or may not be in line with those of the teachers, they are still valid and important; addressing those individual goals contributes to the overall success of a school field trip.

Although museums afford learning experiences that are social, free-choice, and student-centered, it is common for museum field trips to be structured in a way that mimics schools—using classroom experiences, docent lectures, and limited choice and social engagement (Griffin & Symington, 1997; Cox-Petersen et al, 2003; Tal & Morag, 2007). This can be exacerbated by the fact that museum programs sometimes operate without any discussion with teachers about their goals (Kisiel, 2005).

In response to all of this information, the Exploratorium aims to be flexible and responsive to the varied goals of teachers, students, and parent chaperones by providing a variety of resources, and by training Explainers to be sensitive and attentive to individuals' needs and experiences. Explainers use these guidelines to frame their work:

1. **Support** visitors in their various needs, whether this means finding a drinking fountain, answering a question, safeguarding their lunches, supporting their learning goals, or helping them complete an assignment.
2. **Inspire** visitors to engage with the world around them.
3. **Empower** visitors to take control over their own learning (Richardson, 2010).

As I discussed in section C, above, the goals of the Field Trip Explainer program include supporting the learning and development of the visiting school field trip students *and* the Field Trip Explainers. Similar to the three guidelines above that Explainers follow for visitors, I work

to *inspire* Explainers and to *empower* them to take control over their own learning as a part of their job training.

### *D. School Field Trip Resources*

The primary way in which most school groups experience the Exploratorium is through self-guided field trips. The roles Explainers play during this time is of primary importance, and is discussed in detail in the following sections. However, there is also a menu of Exploratorium resources from which teachers may choose to help them meet their various field trip goals. Resources include:

**Table 4.1: Exploratorium Field Trip Teacher Resources**

| | | |
|---|---|---|
| Pre-Visit | Pre-Visit and Consultations | Free admission for teachers with reservations to plan their field trip. Some teachers also consult with the field trip managers in advance of their trips to plan a field trip day that meets their goals. |
| | Teacher Planning Days | Free admission to teachers and their families on one school holiday each year. Field Trip Explainers review our resources with teachers, take them to exhibits recommended for their grade level, and help them plan a structure for their school field trip that meets their goals. |
| | Student Planning Pages | A planning tool for teachers to use with their students in advance of the field trip. |
| | Chaperone guides | Similar to the student planning page, but also includes guidelines for chaperones around interacting with students at exhibits. |
| | Pre-Visit Activities | Activities that are designed as warm-ups for using observation skills. |
| | Orientation Video | A video for teachers or school groups letting them know what to expect from the day. |
| During The Visit | Orientations | Every school group is greeted by an Explainer at the beginning of their visit. This experience helps students to make a personal connection with a staff person, to learn the logistical details about their day, and to practice exploring the exhibits and validating their own questions and experiences. |
| | Exhibit Pathways | Worksheets for teachers to use to structure the field trip visit for their students. |
| | Science Studio | An add-on to the field trip experience, led by an Explainer, focused on making and recording observations. |
| | Standards-Connected Exhibits | A list of Exploratorium exhibits that are linked to the CA Science Standards for grades K-8. |
| | Standards-Connected Exhibit Links | Sets of exhibit-based activities that correlate to the CA Science Standards for grades K-8. |
| Post-Visit | Curriculum Packets | *Under Development*. Sets of classroom activities, organized by grade level, connected to the CA Science Standards, and arranged in a sequence that teachers can use before and after field trips. |

("Field Trip Resources", 2007)

Many teachers design their own worksheets or projects for their students. These range from open-ended investigations of exhibits of students choosing to scavenger-hunt style questions about several random exhibits (Appendix 4.1: Example Worksheets). The Explainers regularly discuss these assignments, what they think of them, and how to best support students in completing them.

> As part of explainer training we completed an example worksheet with a very simple question on it concerning the spinning tea leaf exhibit. "Why do tea leaves settle in the center of the cup?" Several of us pondered this for several minutes and came up with some adequate sounding answers, but I sensed I still hadn't grasped what was really going on. After an entire week of quizzing physics students, searching the internet, and staring obsessively and abysmally into the bottom of tea cups, I finally found a satisfactory explanation, which, like any good know-it-all, I am posting here for your reading pleasure. By the way, this problem is commonly referred to as the 'tea leaf paradox', and it remained unsolved for decades until Einstein lent his genius to resolving the problem. It may be a bit unfair to be grading 5th graders on that (Explainer Blog Posting, October 5, 2007).

### *E. The Field Trip Explainers*

The Field Trip Explainers are the educational staff who interact with and support the school field trip audience. Most Field Trip Explainers have prior experience working with children in a teaching capacity, but their backgrounds in terms of work experience and content area vary across the group. Their education levels have ranged from high school to PhD, and everything in between. The Explainers work half-time, are paid, and receive benefits; the term limit on the position is 3 years.

The Field Trip Explainers all work on the same schedule. They begin each day together as a group, and spend the first part of their morning learning together in a structured training session. Each day, they sign into a schedule of possible Explainer roles (described below) in 30-minute blocks of time (Appendix 4.2: Example Explainer Schedule). Explainers are allowed to choose what they want to do each day, and most Explainers tend to gravitate toward favorite roles, depending on their current interests. While they're on the floor, the Explainers spend a lot of time on their own, but are required to continuously engage with one another in order to make sure that the day flows smoothly.

During their time in the Field Trips program, Explainers are expected to be reflective in their practice and to be continually learning and refining their skills and knowledge to improve their performance on the museum floor. Additionally, Explainers are expected to take on leadership roles within the group and ownership in the program. Through this, they demonstrate to each other and to the audience that they care about the visiting school groups and work hard to ensure a positive experience at the Exploratorium.

### *F. Explainer Training and Professional Development*

Explainer training is a pivotal aspect of the Field Trip program. The Exploratorium's philosophy is that training is an investment in the Explainers that results in Explainers investing in their work. The desired outcome of this training is that Explainers become skilled at supporting a culture of learning in the museum that nurtures the curiosities of the visitors. The training program is designed to address the multiple learning styles and experience levels of a diverse group of Explainers, while preparing them to work with a wide range of content and visitor learning styles. The training and development of Explainers can be divided into three

components, which are described below: training sessions, peer mentoring, and self-regulation.

*Training Sessions:* Each morning, Explainers participate in a structured training session before the museum opens. While the training curriculum changes each year to correspond to the unique learning needs of each Explainer group, there are some aspects of the curriculum that are maintained each year. Training topics include areas such as science content, exhibit investigations, National Science Education Standards, techniques for facilitating learning, inquiry experiences, and understanding visitor experiences in museums. Sessions are led by the Explainer managers, Explainers, inquiry-teaching staff, senior scientists, and exhibit developers. Training sessions are always designed to be experiences that are authentic to the Explainers' work and that role model pedagogy and techniques that Explainers can transfer directly to their interactions with visitors.

The general structure of the training year is as follows:

- Fall: Overview of all exhibit areas and demos
- Winter: Peer-led trainings on each demonstration, highlighting specific goals, facilitation techniques, and unique contributions of each Explainer
- Early Spring: Deep focus on one content area from multiple perspectives
- Late Spring: Reflection on our learning processes, and skills and knowledge gained

*Peer Mentoring:* Explainers learn from each other through peer-led training sessions and on the floor through observation and reflection. In the beginning of each year, returning Explainers lead training sessions for new Explainers about the demonstrations, exhibits, and orientations. Throughout the year, they take turns leading training sessions for the entire group with a focus on sharing facilitation strategies and personal connections to exhibits. Explainers also support each other through one-on-one mentoring on the museum floor by working in pairs

when Explainers are learning new demonstrations, and later in the year to provide points for reflection and growth.

*Self-Regulation:* Through individual meetings with the managers, Explainers regularly set and review goals for their individual progress to ensure that they are appropriately challenged throughout the year.

### *G. Hiring the Explainers*

> I can still remember my first day as an Explainer, we all sat in a circle in the skylight area of the museum and talked about why we wanted to work at the Exporatorium. We were people from all walks of life. Teachers, artists, musicians, youth developers, science nerds, tech geeks. We all had different reasons as to why we were at the ExplOratorium, but we all believed that the 'science' of hands on learning was important. I can't believe that was 3 years ago (Explainer Blog Posting June 8, 2007).

There are three primary criteria that guide the selection process for hiring the Field Trip Explainers:

- Explainers must have had some experience working with school-age children, and know that they enjoy doing so.
- Explainers must be interested in participating in the program as a professional growth opportunity.
- Explainers must make up a diverse group in which each member has some knowledge, skills, or experience from which the other Explainers may benefit. The areas in which we seek a diversity of backgrounds include:
    - Types of prior teaching experiences (K-12 schools, summer camps, after-school

programs, tutoring)

- Experience with different age groups (preschool through high school)
- Academic backgrounds (science, art, math, literature, history)
- Language (Cantonese, Spanish, American Sign Language) and special needs skills
- Approaches to teaching.

There are two primary reasons for this hiring strategy. First, the field trip visitors are the Exploratorium's most diverse audience (Exploratorium, 2010a), and include students from a variety of ethnic backgrounds, with a range of learning needs, and with varying levels of success and interest in science learning. The Field Trip Explainers should reflect that diversity as much as possible. Second, the Field Trip Explainers should learn from each other, and so it is important that everyone has something unique to bring to the table.

### *H. A Day in the Life of an Explainer*

The Explainer day in the most basic sense is predictable. Each day follows the same outline: arrival, turning on the exhibits, morning announcements, training, orientation of arriving school groups, interacting with visitors at exhibits, eating lunch, and conducting demonstrations. However, no two Explainers have the same day, and no two days are alike. I organized my observations by the spaces Explainers occupy, and have organized this description of the Explainer day in the same way: the Explainer Lounge, the Exhibits, the Demonstration Stations, and Outside the Front Entrance. The descriptions come from the participant observations and are illustrated with stories from the Explainer blog that take place in each of these spaces. Through these stories, you'll get a sense of the ethos of the Exploratorium, learn about the Explainer roles

and responsibilities, and meet some of the characters that are a part of the Explainer world. The narrative is not linear at all; this is a choice I made to capture the feeling of experiencing a day in the Exploratorium, which is anything but linear.

*The Explainer Lounge*

I walk into the Explainer lounge this morning and the room is unusually quiet and still—I'm used to hearing several conversations in progress, to bumping past Explainers as they hurriedly fill up their coffee mugs, ingest their oatmeal, and scurry around getting ready for the day. Most of the Explainers arrive long before I do, either because their bus runs early, or because they want to have the first chance to sign into the daily schedule. I'm struck by the silence because it's not possible that I'm the first one to arrive. As I round the corner, I see that many of the Explainers are gathered silently around the long picnic table in the lounge, intently focused on a game of Boggle. Others hang back, drinking their coffee without interrupting, and others are still out in the museum turning on a section of exhibits. At 9:00am, in about 15 minutes, we'll all gather here in the lounge to begin our day together.

The Explainer lounge is a room with three walls, a linoleum floor, a long table, a refrigerator, 64 metal lockers, and some shelving scattered with Explainer vests, games, photo albums, markers, decks of cards, backpacks, and sometimes a clear plastic bag full of fresh eyes. It's the place where Explainers begin their day, and it's also where they eat lunch, store their personal belongings, and pop in and out during the day to refill coffee cups and (I hope frequently) wash hands. (Observation Notes: Boggle Morning, January 2011) This space is a prime territory for accidental learning experiences. For example, someone once sprouted an avocado pit somewhere in the lounge, and then an Explainer found it, planted it in his garden, and then blogged photos of its progress. The lounge is also a thoroughfare for many of the other

Exploratorium staff, who at times make themselves available for Explainer questions and debates.

> Two amazing scientific advances to report on today. As we all discussed in the Explainer lounge today [before work], the newspaper had an article about possible scientific plans to clone a woolly mammoth. I'm super psyched about this idea. Imagine driving across Kansas and seeing a herd of woolly mammoths. OMG! After a vigorous debate among Explainers about whether or not it would be ethical to bring back mammoths or the next step…Neanderthals, [senior scientist] walked in the room. We thought he would shed some light on the Woolly Mammoth sitch, but instead he was more interested in talking about another scientific advance. Apparently some researchers at MIT have figured out how to insert a section of DNA into the genes of a E Coli to make the bacteria smell like spearmint instead of like poop. This is pretty cool for researchers who spend all day in a lab working with the malodorous bacteria. But you know who will be most happy about that advance in the field of DNA research and gene therapy? The future zookeeper who will have to clean the woolly mammoth pen. And yes I wish I thought of that joke eight hours earlier (Explainer Blog posting November 20, 2008).

*The Exhibits*

Explainers and visitors spend the majority of their time at the Exploratorium with the exhibits. Explainers engage visitors with exhibits using two primary modes: attracting visitors to exhibits by playfully engaging with the exhibits themselves, and by sensitively approaching visitors who are already interacting with exhibits. The Explainers spend time making careful observations of the students as they interact with exhibits. They then choose appropriate moments to join into exhibit interactions—this may include modeling an interesting way to use

the exhibit, engaging in conversation with the students, or providing them with tools and skills to conduct investigations on their own. Explainer tools and props that can extend or deepen inquiry at exhibits are stored in locked boxes near or underneath the exhibits.

Walking through the exhibit floor of the Exploratorium, one is at first over stimulated by movements, lights, and sounds. All at once, bubbles are forming and popping, bicycle wheels are spinning, mirrors are reflecting rainbows, the drinking fountain is playing music, and a piano threatens to fall from the ceiling. Somehow, the visitors find a way to focus their attention and immerse themselves in one exhibit at a time. The Explainers are there in the mix, learning and wondering right alongside the visitors.

> Today at about 3:30pm, [another Explainer] and I happened to be walking by The Geysers [exhibit]. The angle of the sun streaming through one of the skylight windows with a diffraction grating was just right so that it illuminated the geysers making them into pools of rainbow magic…It happened very quickly (we spin rather fast in space!) so the colored water was very ephemeral and evanescent and enthralling and enigmatic and many other adjectives that do or do not start with the letter e. We're curious if this happens at approximately 3:30 every day at this time of year? Let us know if you witness this beautiful display (Explainer Blog Posting, January 21, 2011)!

> These days, I've been spending a lot of time with [the exhibit,] Catch a Falling Spark. I was with a kid the other day, and we were taking turns cranking the handle at warp speed and smushing the steel down to make the sparks triple in volume. This kid was cranking so hard, he was yelling his manliest, "HAAAAAAAAAAAAH!" yell that his 9-year old lungs could project as he cranked with both arms. After we thoroughly exhausted

ourselves, he asked me if we could start a fire with this thing. Although I knew the answer was no, I said, "Do you have any paper?" He got so excited, he gave me his worksheet, and wore out our arms again as we tried to Catch a Spark onto his Pathways worksheet on Magnetism (Explainer Blog Posting, June 2, 2007).

*Demonstration Stations*

In addition to roaming the floor and interacting with exhibits, the Explainers are stationed around the museum in 30-minute intervals, conducting demonstrations for the visitors. For example, they dissect cow eyes, examine fruits and flowers, look at things under microscopes, conduct magic tricks (this relates to perception), engage visitors in philosophical discussions, and play with vision-slanting "goofy" goggles. The stations themselves do not have a uniform look or construction because they were all made at different times, by different people, for different purposes. Each one does include some type of table surface and a sign that looks like the Explainer vest and says, "Explainer Station." For example, the station in the "Traits of Life" section where the cow eye dissection happens is a long, metal table. Behind it are cabinets displaying models of an eye and a flower, and a dissecting microscope hooked up to a small video screen. In the "Mind" section, the station consists of a tiny, bean-shaped, red table in front of a large, wooden cabinet, and the "Skyhub", where Goofy Goggles is stationed, is a repurposed information desk that is tall and narrow, with an open floor space in front of it.

Visitors come and go from these stations as they please—they don't have to stay from the beginning to end of a demonstration, and are always welcome to join in the middle. Explainers try to be flexible and individualize each experience for the visitors, and they try to keep themselves engaged and entertained as well. There is a shared plan behind every Explainer

demonstration, but Explainers each do things in their own way, with their own goals for the visitors and for themselves.

> 'You know how assassin caterpillars kill you by making you bleed from all the holes in your body…like your nose and ears and eyes? Well, where specifically in the eyeball does the blood come out of when you bleed to death?' This is the question I was asked yesterday by an inquisitive elementary school student while I was dissecting a cow eyeball for his class. Every time I dissect an eyeball I expect the 'normal' questions ('Where did you get the eyeball?') and have an idea of how to answer these queries ('I'm a ninja who steals them from cows each night…kidding…Butchers give them to us because some people love to eat meatballs but not eyeballs'). But this I was not prepared for. I had never heard of assassin caterpillars and sometimes it's strange to be put in the position of explaining to little kids why bleeding can cause death. Questions like this, however, are my favorite, as they knock me out of my comfort zone, make me think on my feet, pique my curiosity to do further research, and expand my mind to new ideas. Here's a great article on these caterpillars that contain a powerful toxin with 'anticoagulant properties currently being explored by the pharmaceutical industry for use in human blood clotting problems' (Explainer Blog Posting, April 14, 2010).

We also use the demonstration stations as spaces for Explainer training sessions before the museum opens to the public. For example, the Assistant Manager led a session about confers so that Explainers could integrate cones into their flower dissections if they were interested in doing so.

> She gave each pair a plastic, cafeteria tray and a hand lens, and had out some tools for cutting and pulling things apart. She even brought a clamp and hack saw so that we could

> cut through the tougher cones. …She briefly explained the natural history of the timing of the evolution of conifers and angiosperms, and then went through examples of each of the species of trees she'd learned about, one by one. Once she'd introduced them all, she let the Explainers choose a tree to explore with their partner. Everyone dove in, looking for the parts that were familiar from the flower dissection or the parts that [the assistant manager] had told them to look for. They took turns putting pieces under the microscope and looking at them together on the video screen (Observation Notes, November 9, 2010).

*The Exploratorium Entrance*

There is always an Explainer (or ten) stationed in front of the Exploratorium entrance to greet, organize, and orient school groups. Every school group is met by an Explainer, who gives them an introduction to the Exploratorium, a logistical overview of the day, and a connection to a real person. The Explainers also bring every group into the museum to explore one exhibit during the orientation. During this part of the orientation, the Explainers role-model the process of using Exploratorium exhibits and allow the students to try things out and get started on their day. Each orientation is different, depending on the Explainer, the age of the group, and the specific needs of the group. The Explainers may focus on inquiry skills, integrating art and science, the validity of everyone's questions, using all of their senses to explore exhibits, or other relevant starting points. The Explainers are always experimenting with new orientation strategies, which they share with each other on the first Wednesday of every month during the training session.

The Explainers also spend time at the entrance waiting for school groups to arrive, awkwardly balancing attempts to look available to any visitors that might come by, to behave in

a playful manner that seems true to the Exploratorium experience, and to take advantage of the down-time to get to know one another. The space itself is a small strip of concrete connected to a small parking lot. This lot is not only used for parking, but also as a space for orienting groups, making giant bubbles, and sometimes a game of Frisbee or hacky sack. One Explainer is always holding a clipboard with the list of school group reservations and a radio, and another attends to the "lunch wagon", a red cart piled high with Rubber Maid bins that is hauled back and forth to the "lunch closet" where the student lunches are stored. Any other Explainers stationed at the entrance are there to help out with orientations.

Similar to the Explainer lounge, the Exploratorium entrance is a place of chance encounters for Explainers—with each other, other staff members, and the visitors.

> This past week we have had a group of bubble enthusiasts from around the world, came to the Exploratorium to talk about, demonstrate, and play with that magical combination of water, soap, glycerin, and other secret ingredients. On Tuesday…a bubble master, gave us a training all about the scientific properties of bubbles. Early in the morning on Wednesday, the participants gathered in the parking lot to see if they could break the Guinness world record for biggest bubble. I'm not sure if they got a confirmed record but some of the bubbling was simply stunning (Explainer Blog Posting, March 5, 2009).

Another blog posting:

> Last week a group of high schoolers from a band in Alaska came on a field trip to the museum, and I was put in charge of giving them an orientation. (During orientations, I try to introduce the museum to the visitors- let them know this is a different type of museum, the people who work inside are approachable, we want to encourage curiosity, hands-on exploration, et cetera. I also really try to convey the fact that we all perceive the world

differently, and everyone's interests and observations are valid. I tell kids that our museum is for everyone- those who love science and those who hate it…and the same with art.) Anyways, before I could even start talking to this particular group of high school students, one kid raised his hand and yelled out, "Why does it smell like cat pee out here?" This funny (yet valid) question started us off on a great discussion about our senses, perception, and the Eucalyptus tree. Half the group hated the smell of the tree (including the boy who thought it smelled like cat pee), the other half of the group found the smell pleasant and perfume-like (I'm in that group). I then asked them whether they thought the tree was science or art. Again the group was split, and we listened to each other defend the artistic qualities of the tree and the scientific characteristics of it. One of the chaperones in the group turned out to be a lichenologist- She stepped up to teach us about the rare type of lichen that was growing on the north side of the trunk and pointed out how it was different from the moss growing on it. The rich conversation we had about the tree led us naturally into a discussion about whether the students thought of music as science, art or both, since they were all members of a band, and I believe it really framed the way they thought about the museum when they went inside (Explainer blog posting March 30, 2010).

That same tree was later cut down for safety reasons, and this same Explainer set about turning the remaining tree stump into a place for Explainers and field trip students to contemplate and investigate trees and the passage of time.

### *I. Chapter Summary*

The Field Trip Explainers are embedded in the Exploratorium, which is carefully designed and constructed to be a place of unplanned questions, discoveries, and interactions, randomly sprinkled with rainbows, loud noises, accidentally-sprouted avocado seeds, scientific ideas, and giant bubbles. It's a place we're collectively making up to be the way that we want the world to be. It's a work in progress, but that is part of the point of the Exploratorium—to be constantly exploring, developing, and learning. After all, the sign hanging over the workshop does say, "Here is being created…."

Throughout the last four decades, people have rotated in and out of the Field Trip Explainer program, becoming a part of this world for one to three years. The experience Explainers have in this context is the focus of this research. They contribute to creating the Exploratorium, and in turn, the Exploratorium likely contributes to their creation as well.

## V. Case Study Question 1: Individual Context

### *A. Introduction*

This chapter addresses the first case study sub-question: What are the individual contexts of Explainers participating in the study? In particular, what are their pre-existing identities and other non-science learner components of their pre-Explainer identities? How did participants understand or define science learning before and after working as Explainers?

This question situates and provides context for the individual experiences of the participants in the study. While the case is the entire Field Trip Explainer program, the case consists of individual people who are the embedded units of analysis within the case. Because I am most interested in the program as the case (not the individuals), and to protect participants' privacy, I chose not to tell the individual stories of each participant, but to point out patterns among participants. Describing the participants' pre-Explainer identities, their motivations for becoming Explainers, and their understanding of science learning creates context for better understanding the overarching research question about whether Explainers build identities as science learners by participating in a community of practice in this setting.

### *B. Participants' Identities and Backgrounds before Becoming Explainers*

As described previously, the Field Trip Explainer Program consists of a diverse group of people. Similarly, the research participants represent a range of backgrounds and interests. Participants' educational backgrounds upon beginning the Explainer position ranged from having completed high school (2 participants) to having completed PhD's (2 participants). Three had completed Master's degrees, including two teaching credentials, two were in the process of completing Master's degrees, and the other seven had finished college. Four of the participants

had studied science before becoming Explainers, including three who had been actively engaged in scientific research just prior to becoming Explainers. One participant had studied fine arts, three had focused on education, and the others had backgrounds in the humanities.

In addition to these more formal types of identification, participants had other interests through which they defined themselves. Four participants identified themselves as artists, as well as two as musicians and two as writers. Other participants had outdoor-related lifestyles such as rock climbing, gardening, and bicycling.

Seven of the participants did mention in their interviews that they were Explainers during a formative period in their lives, and that being an Explainer was an important part of that process.

> It's a special time for me. It was a pivotal moment in my life, changing everything about my life. It fit into that because I completely changed careers, it was a new town I'd moved into, everything about what I used to do and my friends were different, my life was changing completely, so it fit within that, but it enabled that to happen. I remember it as being a very formative and strong experience" (I 16, p. 7).

Another example:

> It was one of those experiences that was incredibly positive and formative and kind of took some things that I had some ability to do and pushed me to find out if I could do them better and helped me get a vision of where I wanted to go next (I 13, p. 5).

Another participant stated:

> Maybe being an Explainer is even more intense because you know each other, and you have so much to talk about, and because we're adults, everyone's trying to figure out what they're going to do and who they are, or at least I was (I 1, p. 4).

### *C. Participants' Motivations for Becoming Explainers*

This section addresses the motivations participants had for becoming Explainers. Even for people visiting museums for only one day, their motivations for visiting are strongly connected to the trajectories and outcomes of their visits (Falk, 2009). Given this, it is also reasonable to assume that people's motivations for becoming Explainers might be related to what they get out of their time in the program. To address this, I asked research participants in their interviews, "What were your reasons for becoming a Field Trip Explainer?"

Half (eight) of the participants said that they became Explainers because they were interested in working in education (not science education specifically, but education in general), usually in an informal setting. The Field Trip Explainer position fit into that general interest, and seemed to some like a good resume-builder. Five people were attracted to the Exploratorium itself, for the institution's reputation or simply that the Exploratoirum seemed like the type of place they wanted to work. Three saw the position as an opportunity to learn while working. Two people were specifically attracted to working closely with a group of other educators. One person was looking for a position in the museum field. One person applied because of an interest in science, and one for an interest in art. Documents written by Explainers in 2011 reflected a similar distribution of motivations for applying to the position.

While these motivations are for the most part not directly connected to the development of science-learner identities, they are connected to some of the participants' learning outcomes. As will be described more in the next section and in the following chapter, many of the science-learning-related outcomes for Explainers have to do with developing understandings of the scientific process and reflecting on people engaging in this process as learners. It makes sense

that since many of the participants entered the position with an interest in informal education, they would focus on the process of how people learn science as their entry point into developing themselves as science learners. The processes of learning science for one's self and engaging in the practice of teaching science to others go hand-in-hand for most Explainers.

### *D. Changes in Participants' Understandings of Science Learning*

The NRC (2009) defines science learning through their Six Strands as 1) emotional engagement with or curiosity about science concepts, 2) understanding well-established, scientific theories and models and connecting them with everyday life 3) asking and answering questions and generating, evaluating, and explaining evidence, 4) reflecting on how scientific knowledge develops, 5) appreciating that science is a social endeavor, and 6) identifying as being comfortable with, knowledgeable about, or interested in science.

Without discussing these six strands of science learning with participants, I sought to understand how *they* made meaning of "science learning" by asking them to describe their understanding of science learning before and after being an Explainer. To get at this sense of understanding, I asked participants to describe the thought processes they used to complete the reflective activity.

Fifteen of the sixteen participants described a *change in their understanding* of science or science learning through their participation in the Field Trip Explainer program. These changes fall into two categories: 1) three participants whose understandings of science learning were strengthened, and 2) twelve participants whose understandings of science learning were completely transformed. Within this second group, most participants (ten) originally had identities as non-participants in science learning, while two had identities as full participants in

science learning before becoming Explainers. This finding is important because it is difficult for a person to engage in the six strands of science learning (be interested in, understand, explore, reflect, participate in, and identify as a science learner) if their understanding of science learning precludes their ability to do those things.

*Going Deeper: Participants Whose Understandings of Science Learning Were Strengthened*

Of the sixteen participants, four described prior understandings of science that were open and positive before becoming Explainers; one of these four reported no change in his understanding of science learning, while three reported a deepened understanding after their time as Explainers. All four of them (a scientist, an elementary school teacher, an artist, and an informal educator who had studied science in college) already had the sense that science was a part of everyday life, and open to them in some way. For example, one participant said, "I think of enjoying being outside, enjoying planting things, little experiments, cooking I think is science based" (I7, p. 4). For these participants, their experience as Explainers affirmed and deepened their understanding of and relationship with science learning. All four (including the participant with no change in understanding) talked about improving their facilitation skills, increasing their understanding of natural phenomena, approaching science concepts from new perspectives, and more fully embracing the process of science. As one of them explained:

> I definitely find myself more approaching things like, if a child asks me something, I'll say 'What do you think? Give it a try.' What could go wrong? Before I would have started with a basic explanation, but now I don't do that. I don't want to put any preconceived thoughts in their mind. Just explore, go with it, have fun, and then we'll talk about it…Working with the girls I nanny for, if they have questions in home work,

> I'll ask them what they think and to problem-solve it first before going into the explanation for them. I could sum it up more with appreciating not just learning the concept of whatever science thing is going on, but appreciating the process of having questions and how you would go about getting to the answer and letting everyone develop their own process (I7, p. 5).

One of these three participants discussed that although she is an artist, she always had an interest in science, but hadn't realized before how important it was to her. She realized through being an Explainer that science learning can happen through art, and that what she wants to do is to communicate about science to non-scientists through her art.

> I came out of it a much better artist with a much better idea of what I wanted to do with my artwork. And so now I'm making these animal-inspired defensive dresses- there are a lot of amazing creatures with fantastic defenses and they're so unusual with such specific evolution, and people should know about these things that I'm interested in if they want (I8, p. 6).

*Out of the Lab and Into My Everyday Life: Participants Whose Understandings of Science Learning Were Transformed*

Before entering the Field Trip Explainer program, most participants (12 of 16) had largely negative associations with or narrow understandings of science and science learning. These participants' prior understandings of science learning can be divided roughly into two categories: 1) that science is limited to certain people, places, or questions, and 2) that engaging in science learning is associated with negative feelings about themselves and/or about science. An example that reflects the first category:

> Before I was an Explainer, I thought that a science-learner was someone who studied science in college, had a major, a master's degree, or a PhD in science, and is good at math. That's what I associated with science… When I was doing my history major, I assumed that I wouldn't be able to do advanced science….I always saw myself as a humanities person and that I just couldn't do advanced science (I 2, pp. 6,7).

An example comment that reflects the second category:

> My impression of science was fluids in beakers and lab coats and dissecting frogs, which I never did. I feel like at first, it was interesting to me, but it was too complicated to be engaged with it I think (I 10, p. 9).

Of these 12 participants (of the total 16), 10 entered the Field Trip Explainer program with identities as non-participants in science learning. These 10 participants transformed their understanding of science from something restricted to scientists in labs to something that they are capable of participating in, is a part of everyday life, or is even an exciting part of life. For example:

> My initial impulse is to cringe because there's a societal construct of science being for elite people, and I'm not part of that elite group of people. But then I remember that science is everyday experience; it's part of all of our lives. Looking at it like that, I'm interested in my everyday life, my surroundings, in why the world does what it does. Of course I have a strong science learning identity, and I'm a curious person. It's taken a long time for me to own up to myself that I like science. I started working at the Exploratorium as a kid who hated science and school, and left as someone who really loved learning and loved science. If you'd have asked me in high school would I teach

> science, I would have either been angry or laughed at you. And now I am a field science educator, *science teacher* is in my title (I 11, p. 8).

Another participant stated:

> Before working [at the Exploratorium] I remember feeling like I totally BS'ed through any sort of science class. I usually had no idea what was going on. And it sort of felt like, 'why are we doing this?' You have no idea that I'm doing this wrong and obviously not getting any of it. And then science started to seem more relevant. Science is such a big topic. I feel like now… I'm going to make a garden. And I'm going to worry about getting nitrogen into the soil and doing ph tests, so yeah, I'm doing science stuff all the time. Right now I'm learning about how bicycle tires are made (I 3, p. 4).

A third example of a participant describing his/her change in understanding of science learning:

> Before becoming an Explainer, I thought of science learning as 'these are the facts, this is the information, it's multiple choice, and it's closed to personal interpretation'. Science learning to me was memorization and not internalizing it. And now, I think it's really thinking about science as a process. It's something you do from multiple entry points. Now I have this feeling that it's impossible to learn everything about electricity and magnetism or light, but the process of learning about it, experimenting, playing with the physical material, or hearing someone talk about how things work is what's important. I now think of science learning as a way of understanding the world around you, instead of just as a way to understand some abstract topic (I 1, p. 8).

*Not Only* Their *Questions, but* My *Questions, too*

Of these twelve participants whose understanding of science learning transformed, two had identified as "science people" and were doing scientific research before becoming

Explainers. They felt highly capable of doing and understanding science, but still had fairly limited understandings of what that meant. Both of these participants said that before and after being Explainers, they strongly identified as science learners, but that their definition of science learning had markedly changed.

> I spent the last 12 years before being an Explainer studying science, so that was pretty obvious to say I was extremely interested. And while doing it, I was interested as well. Being an Explainer we were thinking about science learning all the time, but it was a very different way of being a science learner. So even though they're the same number [on the reflective activity scale], they represent radically different ways of learning about science… I think it went from trusting the process that other people have done, and just picking the fruits of that, learning what other people's science has been…to going through that process for myself…I just started thinking about what was the common ground between the type of science you study about in the context of graduate school and the types of things we do here, in a museum of science, and why do those belong in a museum of science, and came to the conclusion that science is a way of going through the world and asking questions and trying to gather answers to those questions in a certain way…I think maybe the most fundamental thing it taught me, although I'm not sure if I knew at the time, was to trust my own ability to reflect upon things and come to conclusions that are valid…I really felt unburdened in a way from this pressure that I think I felt throughout graduate school to come up with the right stuff, the right experiment, with the right questions, and right answer, and instead just start valuing that it's ok to just have it be *my* question and *my* answer to that question. It's a subtle change but it was really important to me (I 16, pp. 1, 5-6).

*Section Summary*

By asking participants to describe what science learning means to them, I discovered that their understandings of science learning changed through their participation in the Field Trip Explainer program, regardless of whether they had identified as science learners before becoming Explainers. The table below (5.1) reviews the three types of changes experienced by the participants.

**Table 5.1: Changes in Understanding of Science Learning**

| Types of Changes in Understanding | Selected Excerpts from Quotes |
|---|---|
| Strengthened<br>4 participants | Before I would have started with a basic explanation, but now…I'll ask them what they think and to problem-solve it first... |
| Transformed (starting as *non-participants* in science learning)<br>10 participants | Science learning to me was memorization and not internalizing it. And now, I think it's really thinking about science as a process… |
| Transformed (starting as *participants* in science learning)<br>2 participants | it went from…learning what other people's science has been…to going through that process for myself… to trust my own ability to reflect upon things and come to conclusions that are valid |

### *E. Other Findings: Learning about Themselves*

As often occurs in case study research, the data included information in addition to the findings related to the research question. The most noteworthy of this information is what participants said they learned through working as Field Trip Explainer that was not directly related to the research question. One type of learning outcome frequently mentioned by respondents was learning something about themselves. Although not directly related to the research question, these findings are worth sharing because they provide a more complete description of what was important to participants about their Explainer experiences.

Additionally, participants' learning about themselves informs an understanding of their identity development during their time in the program.

Nine participants revealed that working as an Explainer helped them to learn something about themselves. Some participants said that their confidence in themselves as learners—not only science, but learning in general—increased through their participation in the Explainer program. Others said that they gained a better understanding of what they're interested in or want to do professionally, and some talked about learning to trust themselves or that their skills or personalities are valued in the workplace. For example:

> I think being an Explainer made me become more open with myself. Made me feel OK with where I am as a learner…how much knowledge I have and don't have…life is all about asking questions about yourself and everything in the world and trying to find those answers. I feel like it opened the door for me to realize that… I'm still learning just like all of these students and you guys always made that OK (I 10, pp. 11-12).

Another participant stated:

> Between Field Trip Explaining and [my current job], my confidence in my ability as a learner has completely skyrocketed…It might take a lot of work, but provided I give myself the right experiences to learn, I can go do that…I definitely did not see myself as that kind of learner before Field Trip Explaining (I 11, p. 8).

> You have this opportunity to stretch out and test different things about your personality and lifestyle and work-style habits…It allows that flexibility to figure out, 'what kind of worker am I?' You get to do it in a very supportive, dynamic group…You get to explore

> yourself. At the end, you're still the same person but you've tested out all these other things and learned things about yourself because you have all this freedom (I 14, p. 4).

> Independence to pursue what's really important to me, and that includes not being so constrained by the expectations placed upon me by family, society, and also what people expect of somebody…should be doing with his life (I 16, p. 7).

At the outset of this chapter, I described that some participants identified their time in the Explainer Program as a as a formative experience that gave them professional direction. It is appropriate and useful that Explainers learn something about themselves during their time in the program so that they become situated for their next professional opportunities. That Explainers take advantage of this time for personal reflection and growth expands the possibilities for what next steps they will take as adults.

### *F. Chapter Summary*

How can the individual contexts of the research participants be described? Their backgrounds and relationships with science before becoming Explainers varied. Many of them were attracted to the Explainer position because of their interest in education, many for their interest in the Exploratorium itself, and some for the learning opportunity.

Before becoming Explainers, some participants felt alienated by science, some were comfortable with it, and some were actually doing science. Their understandings of science learning largely involved experts following rigorous processes in lab environments. After their time as Explainers, all of the participants' understandings of science learning involved something open to everyone, is a part of everyday life, and exciting and worth sharing with others. The next

chapter explores the extent to which the Explainer program reflects a community of practice, and how the program could be described through the communities of practice (Wenger, 1998) lens.

## VI. Case Study Question 2: How Identity Manifests in Practice

### *A. Introduction*

This chapter addresses the second case study sub-question: What is the context of the Exploratorium Field Trip Explainer Program? Specifically, how do Explainer experiences reflect a community of practice, if at all? This section describes the case of the Field Trip Explainers using the five elements of communities of practice, citing data from three sources: the interviews, participant observations, and document review. Because learning in a community of practice is learning to be a kind of person, the notion of identity is central to the communities of practice framework. Therefore, this chapter also describes the ways in which participants' identities manifest through the five elements of communities of practice: *meaning*, *community*, *learning*, *boundaries*, and *locality*.

I provide a brief overview of these five components, how participants' identities are visible in each of them, and examples of these elements apparent in the data. I used the five components of communities of practice as a heuristic for collecting and analyzing data on the context of the case in order to generate structured, yet rich, description. The five elements of communities of practice provide a strong, although imperfect, framework for organizing the data from this case. The first element, *meaning*, created a useful structure for understanding how identity changes for participants as they gained experience as Explainers. Second, a great deal of the data fell within the *community* element, including the values that are important to Explainers. Wenger's *learning* element is a very close description of how participants learned to be Explainers, but some data fell outside of his framework (as I describe in section ***D***). The fourth element, *boundaries*, did come up in the data collection relating to participants' identities as Explainers, but was not as important as the first three elements. Finally, *locality* was a much less

significant element in the data than *meaning, community,* and *learning* for understanding how the Explainers' identities manifest in practice.

### *B. Meaning*

The first element of a community of practice is *meaning*, which is negotiated through *participation and reification*. The question here is: What does it *mean* to be an Exploratorium Field Trip Explainer?

*Participation and Reification*

Participation in the case of the Field Trip Explainers involves many daily activities, including participating in training sessions, providing orientations for school groups, or conducting demonstrations for Exploratorium visitors. Participation also includes activities that are not necessarily prescribed, such as engaging in conversations with coworkers. These daily activities in which the Explainers engage are the framework, or starting points, for Explainers to create meaning in their practice, as will be further described in the following sections.

In the case of the Explainers, the daily schedule that Explainers enter their names into is an example of a form that signifies a meaningful practice (Appendix 4.2). The Explainers all understand and are capable of carrying out the tasks on the schedule, although they may each do them in their own way (for an example, see Observation Notes: Cow Eye Dissections). Each task signifies a practice that has meaning to every Explainer.

*Negotiating Meaning*

Field Trip Explainers may stay in the program for up to three years. Each year, their title changes to reflect their years of experience (Explainers I, II, and III). As they progress through the program, their basic duties remain the same, but they gain competence and begin mentoring

newer Explainers. The changing of their identities over time seems to be connected more deeply to meaning created through the negotiation of practice and reification than to their titles, which never came up during the interviews.

For example, an Explainer's reflective writing from the end of each of three years showed this type of change over time. At the end of her first year of Explaining, she stated that she had become "more comfortable with approaching people and finding teachable moments" (Explainer Reflection, 2009). The following year she wrote that she had developed "effective ways of questioning to promote inquiry rather than answer-seeking. I can use these skills to be more confident in approaching both visitors and other professionals to ask questions and investigate phenomena" (Explainer Reflection, 2010). And in her third year she wrote, "This year I've led more trainings than any previous year…As a 3rd year Explainer, leadership and peer mentoring feel like a natural transitional role. It's an opportunity to pass on what great Explainers of the past have shared with you (the circle of Explainer life)" (Explainer Reflection, 2011). Her first year reflected a general comfort with the Explainer role, followed in her second year by an increase in expertise and vocabulary to describe her work, and finally in her third year, a responsibility for mentoring new Explainers.

In the interviews, not every participant mentioned all of these stages, but everyone mentioned at least one of them. When I asked participants, "At what point did you know that you knew how to be an Explainer?" their responses reflected a continuum from simply knowing that one is a part of an established group to taking on responsibility for doing the job well. These data indicate that participants' identities as Explainers changed as they gained experience in the program.

For instance: “In terms of being a part of this community of people who are learning and talking, I felt like that on the first day. I had an orange vest. Everyone was open and welcoming.” (I9, p. 6) This represents the most basic level of mutual engagement—the vest is an object with a shared meaning that requires little negotiation. Every Explainer wears the orange vest; it signifies identity and membership. Wearing the vest is restricted to current Explainers who are participating in daily training sessions and committed to coming to work on the regular, half-time schedule, even if they are beginners and haven’t fully learned to carry out all of the responsibilities of the position.

At the next level of mutual engagement, Explainers demonstrated a somewhat deeper level of meaning associated with their work. For example, after only a few weeks of practice, I observed one of the first-year Explainers display a level of participation in her cow eye dissection that was beyond basic membership, but still early in the progression of participation. She had mastered the content and flow of the dissection well enough to carry on conversation about the eye with visitors, and to answer many of their questions. However, she was still developing some of the skills of leading a demonstration:

> Today [an Explainer I] is dissecting the cow eye, and for added pressure, one of our visiting NOAA scientists is there observing her to learn more about our program. She confidently and clearly goes through the whole dissection. She speaks as loudly as she can and moves back and forth across the table, but still not everyone in the second row can hear her. She holds out the eye at each step of the dissection and walks it around to people so that everyone can take a close look. She leaves a lot of room for questions and conversation, spending a lot of time with a drippy eye part in a gloved hand, while

> animatedly discussing eye questions with clusters of visitors and gesturing with her other, goopy hand (Observation Notes: Cow Eye Dissection, October 20, 2010).

Some participants reported feeling solid on the demonstrations after a few months in the Explainer position. "I remember doing a cow eye demo and feeling like I'd totally nailed it, I had my flow down, I knew what to say, I had my timing, the group was engaged" (I 12, p. 5). At this point, an Explainer can confidently perform the basic tasks of the position without needing to rely on a more experienced Explainer. Many participants mentioned noticing that they did not feel nervous anymore before doing an orientation or a demonstration, but felt excited about it instead. By the time an Explainer feels this level of confidence, s/he has moved from peripheral to full participation, contributing to the daily work in a meaningful way.

The next two quotations are examples of Explainers developing enough fluency with the activities of "Explaining" that they could add their own voices or make their own decisions along the way. Many Explainers described developing this type of comfort with the tasks of the position that went beyond simply following a set of instructions. "Initially, I was copying the others, but then I started to create my own way to do things" (I6, p.4).

> I remember doing demos within the first year and breaking away from the structure of how it goes and feeling comfortable letting other people's questions guide what was going to happen and feeling that was a really big breakthrough in teaching…I could let kids lead what was happening and I was facilitating and bringing it back to major things they were bringing up. When this happened in the flower dissection, I thought, I can let this happen again, and I can do this, and I did and it was cool (I9, p. 6).

At a more advanced level of identity development, Explainers are not only capable of independently doing the work, but actually feel pride in the work and a sense of responsibility for doing their job well. For example:

> I wasn't conscious of knowing how to be a good Explainer until my second year…I thought 'I am a contributor'. I'm not just learning from other people, but giving advice to other people and suggestions on how to do things, speaking up more during meetings and trainings… I felt more comfortable and more of a stakeholder…caring if a student comes to the Exploratorium on a field trip and they learn something or get excited about something… in the first year I didn't think that it was my fault if they didn't…it wasn't only *my* responsibility. But my second year, I thought that having responsibility for students' experiences is a good thing, and I should focus on it, and feel proud if a kid does have a good experience (I 2, p. 5).

Finally, one participant's identity-forming trajectory included sharing his Explainer skills and knowledge with other professionals in the field. This participant represents a small number of Explainers who complete three years in the program, as Explainers may choose to move on to other positions after their first or second year of work:

> By then [third year], I felt really comfortable doing a lot of stuff. I remember when I realized that this is what I want to do in my life, and really identified with it. It was when we had the Explainer manager workshop and [another Explainer III] and I were helping. It was very much going from knowing that I knew how to do my job, but people noticed that and it was something that other Explainer managers wanted their Explainers to be able to do. We had something to share with them about how to do the job, teach, run an activity, that got everyone involved, and I totally remember because [the other Explainer]

called me at night afterward and talked about how it was so awesome…This was after realizing I was a good Explainer, but could see that this was something that we had gained a lot of skills/knowledge and had an experience that was worthwhile to other people (I 1, p. 6).

In this example, I had invited two Explainers in their third year to lead an activity for a group of Explainer managers from around the country; both of these Explainers are now working in permanent positions in the Exploratorium. One of them blogged about the workshop afterward:

> The most amazing part of the conference for me was being able to be a part of a community of educators who all faced different constraints and dream different dreams but had similar goals and could share/steal techniques. Although I was supposed to be one of the facilitators, I ended up learning way more than I taught, something that science museum folks may be familiar with (Explainer blog posting, January 2009).

*Section Summary*

So what does it *mean* to be a Field Trip Explainer? The table below (6.1) outlines some of the ways in which Explainers' identities manifest through the first element of communities of practice, *negotiation of meaning*.

**Table 6.1: How Explainers' Identities Build through Negotiation of Meaning**

| Negotiation of Identities | Selected Quote Excerpts |
|---|---|
| Identities build with experience. | had an orange vest<br>totally nailed it…knew what to say<br><br>Create my own way to do things<br><br>felt confident in approaching both visitors and other professionals to…investigate phenomena<br>Contributor…giving advice…and suggestions<br>Worthwhile to other people |

Being a Field Trip Explainer can mean different things at different times, depending on the Explainers' level of experience. As Explainers build experience through practice over time, they continually negotiate the meaning of their Explainer identities. It can mean wearing an orange vest, being capable of leading an engaging cow eye dissection, taking responsibility for the experiences of the Exploratorium visitors, and sharing professional skills that they value with other people.

### *C. Community*

The second element of a community of practice is *community*, which is made up of *mutual engagement*, *joint enterprise*, and *shared repertoire*. The question guiding this section is: What is the nature of the *community* of Field Trip Explainers?

*Mutual Engagement*

Every participant mentioned the diverse and complementary qualities of the Explainers at least once in their interviews. This came up throughout the interviews, although I never specifically asked about it, often in response to the question, "What kind of person is an Explainer?" Just as Wenger (1998) describes, they brought up the diversity of Explainers in two ways: 1) that this diversity furthered their shared practice, and 2) that mutual engagement highlighted their diversity and further defined their identities. Participants even described the diversity of Explainers as core to their work. For example, one respondent stated:

> Explainers do many things from interacting with the public in informal ways to doing structured and semi-structured demos, orientations. There's a lot of things that Explainers do, and probably different Explainers prefer certain aspects over others, and so when you overlap all these areas of interest, you end up covering the entire territory. And so when

you look at the entire territory, it's covered really well, but different Explainers prefer to cover different patches (I 16, p.4).

As this participant describes, Explainers each contribute their various competencies to getting the entire job done each day. While they are all trained to do every possible task, some are more skilled or interested in certain types of activities over others. For example, one participant stated:

> The work I enjoyed the most was the small group or one-on-one interactions with visitors, which meant I didn't want to be up front, where you'd have a 5-10 minute interaction with a large group…I guess I don't like being a performer as much (I12, p. 2).

While another participant stated the opposite, "One of my favorite things to do was…giving orientations, specifically large orientations…I loved engaging kids and getting them excited to be in this place…So I did my best to be a goofball and...My best catch phrase is, 'This is going to be the best day of your life'" (I10, p. 2)!

On the next level of mutual engagement, Explainers were aware that they each had something to learn from everyone else in the group. "I tried to identify what assets different people on the team had and tried to seek those out when I needed that particular refinement in my skill or approach" (I12, p. 4).

> I liked pairing up with different people for different things. Like orientations. I enjoyed watching [a Explainer]…Dissections that were harder like DNA or flower, I liked working with [b Explainer] because... she always knew the answers to things, and even if she didn't she had a nice way of explaining things that satisfied the audience…Walking around the floor sometimes I liked walking around with [c Explainer]…because he had a different pacing that I really appreciated…he always takes the time to really think about the process and the present, what we're doing right now (I14, p. 3) .

Participants identified that complementary qualities not only are important for covering the basic Explainer tasks and to enhance their own learning, but it's one of the ways that Explainers support the visitors. "I think that part of the charm is that people are different. I don't think it would work if we weren't all different because we need to see other people's processes in order to understand how learning happens not just for ourselves but for people in general" (I 5, p.3). Similarly, another respondent stated,

> What we're trying to do when people come to the museum is reinforce the idea that they're in charge of figuring things out and deciding what they're interested in and what they're not. It's a weird shared goal, because that means that everyone can do things in their own way (I 1, p.5).

The diversity of approaches also extended into identities that Explainers created for themselves and each other.

> It's funny because I was talking to another former Explainer about this and I remember that we had this theory that when we're brought on board, it's kind of like the 'Real World'. There's no one thing that's an Explainer. There are certain qualities that are shared, but you have your gregarious person, quiet person, funky hipster, very distinct personalities that fill certain needs for the dynamics of the group (I14, p.3).

This tendency for Explainers to characterize one another based on their complementary qualities also has the potential to reinforce identities that are not desired by the individuals. This happened for one participant, as she describes here.

> There was (sic) definitely parts to be played in a group and it's hard to get a group to not see you in one way. If they've cast you as a certain character, that's how they'll continue

seeing you…It's a challenge, I wanted to be many different things in the group, and not always looked to for 'What do we do with young kids' (I 15, p. 9).

*Joint Enterprise*

For the Field Trip Explainers, the joint enterprise (as described in the Research Context) is to support, inspire, and empower the visiting field trip students. In order to get this done, Explainers navigate a complex and dynamic day, balancing varying circumstances, goals of visitors, tasks they must do, and skills that they have. In doing so, they have a tendency to value similar qualities. The most consistent quality they all value is curiosity. When asked, "What kind of person is an Explainer?" every single participant said something like, "You have to have curiosity, this is very important" (I6, p. 3). To elaborate, "I would say people who are inquiring, who are kind of looking beyond the surface at what's going on, what is cool about it, don't just take things for granted" (I6, p. 3).

No participants said that Explainers are people who have a background in a certain subject area, are able to explain scientific concepts, are skilled at presenting in front of large groups of people, have a certain level of education, or a certain type of work experience. Instead, the data suggest that an Explainer is someone with a healthy sense of curiosity. This quality could be used to characterize the culture of the whole Exploratorium; it was explicitly part of a marketing campaign from 2001 to 2005. "The Exploratorium: for the Curious Ones" (McLean, 2005).

Most Explainers probably enter the program as naturally curious people, but then this quality is developed and nurtured by the community of practice, and comes into central focus for all of them. One participant said,

> They have to be curious. There's an inherent curiosity in all people, so maybe that's not saying much. They should be reflective too…During our time we get better at those things. I think it's a program that nurtures curiosity and reflective-ness. I think it nurtures curiosity by respecting and rewarding curiosity. And also because most of the time we get to follow through with our questions if they are actionable (I 5, p. 3).

When participants talked about curiosity, it often went hand-in-hand with their second shared value: a lack of rigidity was important to all of them in some way. Seven of sixteen participants said that flexibility and/or spontaneity are very important, ten talked about openness, and five talked about pushing boundaries. For them, this lack of rigidity is a way of being in the world. It applies to how they make decisions when they navigate their day, their approach to learning, how people use the Exploratorium exhibits, and an openness to ways of thinking and learning in general. The quotes below, taken from many different parts of the interviews, illustrate the way that their identities manifest through joint enterprise by having a tendency toward valuing flexibility and openness:

"An Explainer is…someone who is open to many different things" (I2, p. 2). "I think being an Explainer for me taught me that it's OK if things don't go quite the way you planned. So spontaneity and just rolling with it…you're going to take risks and try it, and it may blow up in your face, but you're not going to be soured by it, you're just going to try again and move on" (I 14, pp. 2, 3-4). "The general goal for me was always…be open, curious, flexible…" (I 15, p. 4). One participant said that he could think of one way not to fit into the group, and that was "being inflexible" (I 1, p. 5). Another stated:

> Moments when I felt like a real explainer was…I think allowing other people to do crazy things, so to speak. For example, of course explainers know how to use the exhibits

> because we use them all the time. Sometimes you have a visitor who's using the exhibit in a really weird way, and of course it's not that interesting, or maybe it is. There was one time, I went up to a dad and his daughter. She wasn't using the exhibit correctly, but she was having such a great time using it wrong, and so I said, 'that looks fun, can I join you?' and so we were using the exhibit wrong together for a really long time, and it was ok (I 14, p. 6).

Similarly, others stated: "Open. You have to be open to trying things, to learning things, experiencing new things…" (I 9, p. 4) "The type of person you have to be is open to learning new things, open to pushing exploring, and curious about the world" (I 10, p. 4). One participant elaborated:

> It really opened my eyes to different ways to approach science concepts and exploring in hands-on ways [of learning]. Before being an Explainer, I was pretty open and aware, but being an Explainer broadened that even more…There are infinite ways to look at exhibits in the museum, and you can take that further to look at things outside the museum and in life. And even though I knew this, it opened my eyes even more to that (I 7, p. 1).

Five participants went as far as to say that an important Explainer value is not only openness to trying new things, but to actually "pushing the boundaries." For example, when asked whether the Explainers have a shared set of goals, beliefs, or commitments, one participant responded,

> Yes, I think they do, and it's to push boundaries...I think that a lot of the students that came into the museum and others I've known throughout my life are so used to routine and rules in school and at home that one of the exciting things about giving the orientations is you can say that 'you're used to these rules, but here you can do lots of

> things, and try your ideas, and touch the exhibits'. You want to push the boundaries, break the rules, explore and get out of the box (I 7, pp. 2-3).

"It's sort of a rebellious spirit that's important to the Explainers" (I 1, p. 5).

An Explainer story about their use of sea urchins exemplifies this spirit. There is a tank of sea urchins in the biology lab that are used for exhibits, and Explainers can see them when they enter the lab to clean up their cow eye dissection tools. I noticed in my role as a practitioner that at some point, some of the Explainers started taking the urchins out of the tank and bringing them to the demonstration station to show to the visitors. This was never an official Explainer demonstration; I never provided training about it, or announced that it was OK to do (although I do think it's great). Instead, Explainers asked the staff in the biology lab to teach them about sea urchins, some of them taught each other, and some took the initiative to learn more about sea urchins on their own time. One participant said to me that "it was sort of the secret sea urchin demo." This also exemplifies the sharing of stories as a shared practice. A respondent described exploring the sea urchins with visitors for the first time:

> During one of the flower dissections when no one showed up, I got a little impatient. I walked over to the bio lab. I thought, I'm going to do this…. It will be cool…I took a sea urchin out and put it in a little dish and put it on the table… and people came over to look and ask me if they could hold the sea urchin. And I saw [another Explainer] do it later, and then other people too. It was adding onto the flower demo, and giving ideas to look at other things under the scope, keeping it more open. So if someone wasn't interested in doing the flower dissection, we could still do something interesting and science related…You have to be there long enough to know that [the managers] are probably going to be ok with it, but it's still kind of exciting because you're thinking that you're

> not totally sure, and should maybe be doing the flower dissection... I remember the first time I saw a sea urchin mouth. The sea urchin mouth looks so scary—I would put it under the scope to show people what the mouth of this unassuming creature looked like-like from a horror flick (I 8, pp. 3-4).

The idea for Explainers that they can use the tools around them to explore something other than what they think they're supposed to be doing is important to them. As this respondent's comments suggest, it keeps things more open. The Explainers who were doing the "secret sea urchin demo" ultimately developed interesting ways to explore the urchins with the visitors. I observed them comparing the symmetry of the urchins with that of flowers, having discussions with visitors about the differences between plants and animals, and even engaging in small inquiry experiences such as testing out whether and how the urchins would respond to stimuli such as shadows, touch, or moving in and out of the water. Similarly, another respondent stated:

> "The Exploratorium felt the most open. We trust you [learners], we're all for trying things, even if it doesn't work out. That's an awesome environment to develop as a teacher and learner in" (I 9, p. 10).

Although participants all pointed out the diversity of the Explainers, they also recognized that if there are values that they share, they are curiosity and a commitment to openness in the ways they approach their work. This commitment to openness doesn't always work out perfectly or easily, though. One participant talked about rubbing up against this challenge in her first year:

> I think that [the shared commitment is] respect for other peoples' learning processes, an openness to investigation. It's maybe even a radical openness. I feel like I was scolded for not respecting it enough. You're almost kind of a jerk if you just look something up. I think I grappled with these goals or commitments…I feel less frustrated that people were

> frustrated with me for not being respectful of their processes, but more that they didn't respect me for mine. These both point to the same thing: that respect for process is encouraged (I 5, p. 4).

In short, Explainers place a high value on openness, which caused friction when one newcomer struggled with being open to other people's learning. It took a full year before this Explainer felt like a full participant in the group. She then talked about how she feels now:

> I learned how to have faith in other people's process skills and abilities to understand things…It's most obvious to me in the way I feel about the other Explainers. I used to feel more impatient when they didn't understand things, like something about brains, and I felt like I already knew it all and we had to belabor the same point over and over…Now, I don't think they're slow, I just think they're in a different place in the process (I 5, p. 2).

The Field Trip Explainers' identities manifest through their joint enterprise as a tendency to value curiosity as well as flexibility, spontaneity, and/or openness. This tendency includes a willingness and desire to learn about many different things, explore other ways of thinking about ideas or solving problems, and faith in other people to do things in their own way.

*Shared Repertoire*

The Explainers' repertoire consists of many shared routines, experiences, and stories. For example, the Explainer day follows a pre-agreed upon routine, and the schedule consists of a set of tasks that are all known and shared by Explainers, such as conducting orientations or dissecting cow eyes. Every Explainer carries a deck of cards in his/her vest pocket for doing magic tricks. The Explainers take turns "on clipboard" (which means organizing the school

groups) at the front of the museum, and also take turns organizing the "lunch bins," using the "lunch wagon" to take the bins into the "lunch closet."

In addition to the more routine pieces of their repertoire, Explainers have shared experiences each day during their daily training sessions. One participant described this:

> You're spending time together, but you're doing things that are different or unique that you have to figure out as you go. For example, when we did the sound dance with [senior scientist] during training, or the study group when we had to sniff marker trails as a way of learning about how termites navigate, or the study group in which we camouflaged ourselves with the exhibits—funny stuff—something about that reinforces being part of the group because you're not just going through the motions of doing what you need to in the job, but strange things that you have to figure out as you go. I don't think it ever was like everyone in the group is best friends, but I think that you always have a feeling every year that you're a part of this group whether you like everyone or not, and there are people you're closest to, and people you're not, but you have this shared experience (I 1, p. 3).

Other participants also brought up the idea of shared experiences, or simply brought up memories of some of the same stories. "I liked my camouflage study group…as an adult you don't really have the opportunity to do that with a group of people…So I was really glad that I had this community where we could do things like that" (I 8, p. 8).

One respondent recalled a training session in which we went on a "Light Walk" with a senior artist. He said:

> Shadows, in school you learn that a shadow is the absence of light. And then learning that shadows are the absence of an image, images of the sun, that's pretty cool. If I was to tell

> that to a random person on the street, they wouldn't understand what I'm talking about, but because we have a shared experience, you think cool, I get your short hand (I 11, p. 5).

Another participant animatedly brought up her memory of the same training session:

> Also, oh, my God, the Light Walk! You know the light coming through the branches how it makes a pinhole circle and how if you shine a round light through a square? I always tell people about it (I 9, p. 3).

Another piece of the Explainer repertoire is a historical Exploratorium film that they all watch every year called, *Palace of Delights*, which I think is what initially sparked the question among Explainers, "Should there be rules at the Exploratorium?" (from Observation Notes). There's a scene in which an Explainer (prior to the existence of orientations), opens the door to the Exploratorium while announcing to the crowd of waiting visitors, "There are no rules inside!" Some time long after the creation of that film, the Explainers began incorporating three rules into their orientations for visiting students (another piece of repertoire), 1) no running inside (for safety), 2) no eating or drinking at the exhibits (because that's gross), and 3) you have to have an adult with you to go inside the gift shop (because the gift shop manager won't let you in otherwise).

Over the last few years, the shared repertoire of "the rules" (for visiting school groups) has been under negotiation. When asked whether he ever contributed anything that was adopted by other Explainers, one participant said,

> I think I abolished the rules… I take partial credit for that. I think I started not giving the rules in my orientation. I can't take total credit, since [two other Explainers] helped move that forward this year. I don't think I said, 'hey everyone you shouldn't say the rules

> anymore', but I didn't think they were helpful and it wasn't the kind of welcome that I wanted to give people. And then we watched *Palace of Delights* and Frank Oppenheimer [the founding director] didn't have rules and said it was OK to run in the museum, and I always run in the museum, and so I just stopped saying the rules (I 1, p. 5).

In fact, the year following this participant's graduation from the program, the Explainers took up the issue of the rules and finally did abolish them. One Explainer brought up the rules in a meeting with the whole group, and we engaged in a long discussion about their value (Observation Notes: No Rules, October 2010). The year prior, two Explainers had set Frank's quote about running in the museum to music and posted it as a song on the Explainer blog (March 10, 2010). In the end of a long negotiation, we all agreed that we would try out not saying the rules in orientations. Instead, Explainers would ask students to behave in ways that they felt were safe and respectful, and leave it at that. We would use this year as an experiment, and then talk about how it went. The end of the year came, and everyone had the chance to say what they thought about the experiment.

> I asked them whether they felt that it's important that we all agree on one plan of what to say, or if it's OK for everyone to approach this in a way that works best for the individual Explainer. They all looked confused about the idea of having to agree. 'Isn't that what we do already? Everyone does it their own way?' One Explainer suggested that in future years, new Explainers should be made aware that these rules did exist and they can choose whether to say them, that we should have a conversation about it every fall. There was lots of head-nodding and mmm-hmmm's, and so it was agreed. From now on, we'll have a conversation about the rules every fall, and then each Explainer will handle the

rules in their orientations however they see fit (Observation Notes: No Rules, October 2010 and No Rules Follow Up, June 2011).

This negotiation made me reflect on the Explainers' Philosophy demonstration. In this Explainer-visitor interaction, the Explainer suggests philosophical questions for the group to discuss. These questions were generated by Explainers; they generally have no objective answer, and should be engaging to audiences of varied ages. One of their favorite questions this year was, "Would you want to live in a world without rules?" The Explainers noticed (and discussed during a training session) that almost all of the kids answer "no" to that question. They tend to want to know what the boundaries are, they feel safe and comfortable with the idea that things should be fair, that everyone is held to the same rules. This makes me wonder about what the Explainers are proposing in their orientations. Are there really no rules in the Exploratorium? Or is the rule just that you have to be open, flexible…and not have rigid rules.

*Section Summary*

So what is the nature of the *community* of Field Trip Explainers, and how does it influence Explainers' identities? The table below (6.2) outlines how Explainers' identities manifest through the second element of communities of practice, *participation in the community*.

**Table 6.2: How Identities Manifest through Participation in the Community**

| Three Elements of Community | Selected Excerpts from Quotes |
|---|---|
| Mutual Engagement: Identities defined through diverse and complementary qualities | identify what assets different people on the team had and...seek those out |
| Joint Enterprise: Identities manifest through the tendency toward shared values or interpretations | have curiosity<br>be open to trying…learning…experiencing new things<br>push the boundaries, break the rules, explore |
| Shared Repertoire: The community's stories, objects, etc, become part of participants' identities | spending time together…doing things that are different…reinforces being part of the group because…you have this shared experience |

The Field Trip Explainer program is a group of individuals with complementary skills and knowledge who work together to support, inspire, and empower the students visiting the Exploratorium. They leverage their diversity by supporting each other and learning from one another. Despite their diversity, they all tend to share common values: curiosity and a lack of rigidity in their approach to the work and to learning. They share a repertoire of objects and stories, some of which (not incidentally) support and feed back into their shared values of curiosity and openness.

### *D. Learning*

The third element of a community of practice is *learning*. The question in this section is: How do Explainers *learn* to be Explainers?

As Wenger (1998) suggests, every participant named multiple "old-timers" from whom they learned to be Explainers. For instance, one respondent stated, "Even when we stopped officially shadowing, we were still shadowing each other" (I 4, p. 4). These were usually returning Explainers, but often included the Explainer managers and other Exploratorium staff who regularly lead training sessions. These learning situations occurred during training sessions, observing other Explainers interacting with visitors, and through casual conversations. They often spoke of the idea that observing returning Explainers exposed them to the range of possibilities of how to go about being an Explainer. They brought up the different types of skills, knowledge, and qualities they gained from several different individuals. The following passages represent the types of responses of all participants:

> At the beginning, I spent a lot of time looking at exhibits or styles of teaching with [two other Explainer I's]…Their style I related to a lot…mostly I would be watching them or

maybe they were watching me, we would talk about it. We would talk about how we do different things and compare to other explainers like [an Explainer II]. I remember with [an Explainer I] watching [the Explainer II] at the magic table and trying to figure out how he had that magic. Both his actual card tricks and his delivery, especially with teenagers. Also just looking at exhibits together and trying things out. And I would see how an engineer approached the gravity well compared to me….Sometimes if something happened, like I saw an orientation while I'm roaming, I might stop and say how I hadn't thought to do something a certain way. Mostly it was reflection, really talking about what works and doesn't, what's a cool part of the museum to spend time in, we did this a lot when we weren't at work. They were in their second year. [Another Explainer I]. too. We started on the same day, and were learning everything at the same time, so she was a good go-to person for me. Towards the end I did a lot of reflecting on teaching and learning with [an Explainer who started after this participant]…. Definitely by watching other explainers. I remember watching [an Explainer II] kneel down and talk to kindergartners in this really nice calm way that set a tone for their trip. Watching [an Explainer II] do magic and asking him to teach me some while we were waiting for groups to come. I remember learning a lot from [an Explainer who started later] about neurology. He had a lot of information that he knew about a lot of things, and his style of teaching and explaining how things worked really suited the way I learned content. I liked how he could explain something. And that was the same for a lot of the people who led our trainings. It was useful to learn content by having an expert to show you things and be right there to answer questions for you so you don't have to look it up on your

> own. So if somebody is right there who understands it really well that's great (I 9, pp. 3, 5).

> [a Explainer] taught me to be silly, [b Explainer] taught me how to step back a little bit, [c Explainer] taught me that it's OK to press a question until just before it could go sour. A lot of them taught me just to be me—[d and e Explainers], all of them, in their own ways, because they were just being themselves and doing their jobs…This was all through role modeling, just doing their jobs while I was observing (I 4, p. 4).

In their personal reflections at the end of each year, some Explainers mentioned that a skill they developed in their second and third years was mentoring new Explainers. For example, Explainers answered the question, "What skills and knowledge did you gain this year?" with: "Mentoring new hires in the beginning of each year" (Explainer Reflection, 2011) and, "Being a good leader…I worked on being fair to everyone, being clear, and role modeling" (Explainer Reflection, 2011). This is not the same thing as learning from newcomers, but it is learning that happens *because* of newcomers, as the presence of newcomers creates the opportunity for old-timers to play new roles.

Learning from other members of the community of practice doesn't fully account for how learning happens for Field Trip Explainers. Nine of the sixteen participants also stated that they learned to become an Explainer through the practice of doing it. "I definitely learned from other people, but you learn by doing. It's a hard job to explain to anyone, you just have to do it" (I 14, p. 5).

> The cow eye. This was one of my favorite things to do, it grossed me out and I didn't think I could do it in the beginning, and I remember really wanting to be good at it but

was grossed out and stressed out. We did it once in training, and then we could buddy up on the floor and so I did that as much as I could to observe a lot of people on it and I also would plan my roaming around watching people I thought were good at it and then I made myself do all three cow eyes in one day and then I loved it! This was around after being there for a month and…I decided to sign up for all three cow eyes and really enjoyed it. I think I did a cow eye almost everyday after that, all the time (I 7, p. 5).

No one mentioned learning by doing in complete isolation, though—other Explainers were an integral part of the learning process for every participant, whether that occurred through role modeling, direct transfer of knowledge, or reflective conversations.

*Section Summary*

How do Explainers *learn* to be Explainers? The table below (6.3) outlines the ways in which Explainers develop identities through the third element of communities of practice, *learning*. The table rows are the three ways in which Explainers learn: from old timers, newcomers, and through practice. The cells of the table are populated by selected excerpts from the quotations used in this section, which describe the identity-related characteristics that Explainers described learning.

**Table 6.3: Identity Development through Learning to become Explainers**

| | **Selected Excerpts from the Quotes** |
|---|---|
| **Learning from Old Timers** | he had that magic…his actual card tricks and his delivery [learning about a piece of the *shared repertoire*] |
| **Learning from Peers or Newcomers** | talk about how we do different things and compare to other explainers [learning about *mutual engagement* through observing complementary or diverse skill sets] |
| **Learning through Practice** | really wanting to be good at it but was…stressed out…and I decided to sign up for all three cow eyes and really enjoyed it [learning about the *joint enterprise* by practicing openness to learning new things] |

Explainers learn how to be Explainers primarily from one another, and also through practice. The process of learning to be an Explainer involves participation in the community of practice, including engaging in and leading training sessions, observing other Explainers, practicing, reflecting, and trying again, and learning to be a role model for newcomers. One participant summed it up as, "A lot of the learning was about absorbing the culture of the museum" (I 12, p. 5); another stated that he became a science learner in part because "there was a whole institution doing that" (I 13, p. 4).

### *E. Boundaries*

The fourth element of a community of practice is *boundaries*. The question in this section is: What are the *boundaries* that define membership in the Field Trip Explainer program?

The most visible definition of membership is that Exploratorium Explainers all wear an orange vest while they are working in the museum. This uniform marks the boundaries of their community of practice, clearly identifying them to outsiders as Explainers. This vest also signifies that the wearer has certain knowledge, skills, or training that allows them to wear the vest. The shared experiences of Explainers also contribute to the creation of shared language and stories, which further serve to mark the boundaries of the community of practice. Some of the participants mentioned these types of boundary-markers in their interviews:

"…from the perspective of the visitors, the explainers are a group. The visitors will not come to me or to a specific person, they will come to someone with an orange vest. So these people have to behave in a common way in some sense…" (I 6, p. 2). "I love dealing with the kids. They love the people in the orange vest" (I 10, p. 12). These participants saw the orange vest as important to the visitors understanding their identity, and what to expect from them. They

indicate that the orange vest unifies them in a way, and that visitors know what to expect from people who wear it. The idea that kids love the people in the vest suggests that all of the Explainers with whom they've interacted have behaved in similar-enough ways that they can be trusted as people to have a good time with in the museum. One participant described the orange vest as not only something that sends a message to visitors about what to expect from you, but that the vest actually turns you into that person. "And putting on the vest is like that. It's the ritual. You come in this undercover agent of spreading delight and knowledge and you put on the vest and 'I now embody that'. It's a transformative thing, putting on the vest" (I 15, p. 5).

"…I felt like yes, I know how to do this and I'm a part of this group. There's physical things, like you're all on the same schedule, and you have a vest, and you're all there at the same time" (I 11, p. 5). "We make up stupid jokes and have our own language and have special handshakes" (I 1, p. 10). For these participants, the boundary-markers are part of what makes them feel included in a defined group. These boundary-markers can also create the perception of barriers to group membership. For example, another participant saw these boundaries as something a bit intimidating that she would need to penetrate if she wanted to gain membership in the group. "…on my very first day when I came into the lounge and I saw everyone talking and I heard relationships and I heard that they already had a bit of their own language going on" (I 15, p. 8).

Although communities of practice have boundaries, they do not exist in isolation; they are always nested within and intersect with other communities of practice. Furthermore, the identities of individuals are not defined by only one community of practice, but by membership in many communities of practice. For example, a student is a participant in the community of practice of his/her classroom, which is nested within the community of practice of the teachers in

the school. The student is also a participant in the community of practice of his/her family, which intersects with the school through parent-teacher conferences and homework.

While boundaries mark discontinuities between the inside and outside of a community of practice, peripheries also exist as areas of connections and continuities. In the peripheries, there is potential access for outsiders into to a community of practice. One main way in which Explainers access outsiders is by other Exploratorium staff members coming in to lead training sessions. One senior scientist was mentioned by almost every participant as someone from whom they learned to be an Explainer. This person never was an Explainer, but does have regular access to their community of practice, as he leads the training session almost every Thursday morning to answer Explainers' physics-related questions using the exhibits. He holds a place of power in the community as an expert, and is someone they all look up to.

Additionally, Explainers are all members of other communities of practice in their lives that do not disappear upon becoming Explainers. "There are people from different backgrounds, races, sexual orientations, everything, while keeping a very open environment and friendly environment" (I 6, p. 7). "We were people from all walks of life. Teachers, artists, musicians, youth developers, science nerds, tech geeks" (Explainer blog posting, June 2007). This creates the opportunity for Explainers to enter or be exposed to the peripheries of multiple communities of practice by getting to know other members of the group.

*Section Summary*

The boundaries of the Field Trip Explainers' community of practice include both explicit markers such as the orange vest, and more subtle markers such as shared language, stories, and jokes. The boundaries of the Explainer community of practice signify to outsiders who is a member and what to expect from an interaction with those people. The boundaries also give

Explainers a sense of belonging in the community of practice, further defining their identities as Explainers. Finally, Explainers have opportunities to learn through interaction at the boundaries of their community—by engaging with Explainers who participate in other communities of practice. The table below (6.4) outlines how the fourth element of communities of practice, *boundaries*, defines the identities of Explainers.

**Table 6.4: How Identity Manifests through Boundaries of the Community of Practice**

| Functions of the Boundaries | Selected Excerpts from Quotes |
|---|---|
| Boundaries Signify Meaning to Outsiders | The visitors…will come to someone with an orange vest. So these people have to behave in a common way. |
| Boundaries Give Members a Sense of Belonging | We make up stupid jokes and have our own language and have special handshakes. |
| Boundaries Create Opportunities for Learning from other Communities | There are people from different backgrounds, races, sexual orientations, everything, while keeping a very open environment and friendly environment. |

### *F. Locality*

The fifth element of a community of practice is *locality*. The locality of communities of practice is emergent and depends upon proximity, shared backgrounds, and mutual engagement. In the case of the Field Trip Explainers, they work together on a shared schedule as a group, in the same place each day.

Within the Field Trip Explainer program, smaller constellations of communities of practice exist, but these are not as significant as the community of practice of the whole program. For example, some smaller groups of Explainers tend to socialize with one another outside of regular work hours. However, participants did not emphasize the importance to them of spending more time with particular Explainers over others. A few Explainers went as far as to say that while they had friends outside of work, this did not influence who they spent time with while at work:

> But the way the schedule is built, even though there are people I'd talk to the most outside of work, I sometimes didn't talk to them at all during work. I'd interact with other people instead. I never set up my schedule so that I'd get to see certain people who I'm close friends with. I signed up based on wanting to do a cow eye or orientations—that was my motivation to sign up, not my friends (I 2, p. 9).

There are also other employees within the Exploratorium with whom Explainers develop professional connections; for example, with particular training leaders or colleagues they work with in a second, afternoon job. This did come up a few times in the data collection process, but was not a focus of participants' responses. For example, some Explainers would say that they sometimes wandered into the Biology Lab or the Workshop to talk with the other Exploratorium staff who worked in those groups. These wanderings were largely fueled by curiosity, and an interest in opening up trajectories that might extend beyond the Explainer position into future career options.

### *G. Other Findings: Working in a Group*

In addition to findings relating to the five elements of communities of practice, there was also evidence from participants that as Explainers, they learned about working in a group. The importance of working in a group came up in fifteen of the sixteen interviews. Twelve participants talked about the value of the group to their success in working with visitors or to their personal experience in the program. In particular, they described the supportive nature of the group, using words such as trust, support, respect, understanding, and diversity.

> All the people are very supportive…I guess that's the big thing. Either supportive of a work thing or if you're having a good or bad day. Without that in the program, I don't think it would work at all…it would cause a problem on the floor (I 4, p. 3).

Another respondent stated:

> We were all learning from each other, teaching each other, and getting excited about things together…it's hard for me [in my current job] to feel inspired and always actively engaged with learning and thinking of new ideas and trying new things when I don't have other people to make it really fun…and you have a lot of similar experiences. Whether you're going to training together, or you know what it's like when lots of kids arrive at the same time. There's a shared understanding. There's a lot of trust that comes out of shared experiences. I think it has to matter from the visitor perspective even in the same way it matters to Explainers…it creates more of a spirit of discovery like we're inviting them into our community (I 9, pp. 6-7).

Nine participants (five of those overlap with the first group) said that they gained skills working in a group through participation in the Explainer program. For example, "Learning how to support each other and how we work better as a unit than each of us individually" (I 7, p. 4). They often pointed out that they valued learning to work with people who were different from them:

> I learned a lot of people skills—getting along with people at work…there are a lot of group activities that we do all together and we learned how to get along with people (I 2, p. 2).

Another example:

> I think I re-learned some basic 'playing nice with others' stuff that I didn't really ever have to rely on as an adult in other jobs I'd had…When I look at it now, I see it as all of the team building I do with my students, and it seems like you were trying to incorporate that into activities that were teaching us about science content. Basically what I felt was that in order to do my job well as an Explainer, I needed to be able to interact in a positive way with the people I worked with…it was modeling from people who'd been there before…and that's what was being modeled by my two supervisors (I 13, p. 1, pp. 3-4).

A third example:

> Before, I only worked with one or two other people, not a team. It was good to have this new aspect, dealing with so many personalities and different points of view…you have to be a team player in coordination with the others, to talk to them, see how they see things, find some common ground. You have to respect the others, hear what they're saying, work together sometimes…I learned to do this by practicing…[and] there were other things like doing study groups and meetings to discuss things and see how people saw things or what they valued in others by giving gold stars, and during the trainings too, we had to form teams to do some of the tasks. So these things expose you to the others and teach you how to work efficiently as a team together (I 6, p. 2).

A fourth example:

> I've learned that there's a lot of different types of people in the world. And they think about the world in different ways and they care about different things, and they can all have the same job in the museum and do a good job at it, maybe because of this (I 16, p. 2).

In the Explainer reflection documents, 26 Explainers listed working in partnerships, groups, or teams as a skill they had developed that year. For example: "Listening…how to validate, respect divergent views while retaining my own perspective; tolerance; patience" (Explainer reflection, 2010).

The ability to work with other people, especially people who have different values, skills, and backgrounds, is an important skill in life, the workplace, and science learning. The NRC (2009, pp. 2-13) calls for informal learning institutions to shed the myth that science is done by individuals working alone in a lab, and to reinforce the idea that teamwork is an essential component of scientific progress. Furthermore, it has been argued in the science-learning literature that learning is created through discourse and social interaction, which provide learners the opportunity to form and revise their ideas (Falk & Dierking, 2000; Leinhardt, Crowley, & Knutson, 2002; Rogoff, 1995; Osborne, 2002).

### *H. Chapter Summary*

Together, these five components—meaning, community, learning, boundaries, and locality—define communities of practice and the ways in which participants' identities manifest. Is the Field Trip Explainer Program a community of practice? The data indicate that it is. More importantly, the previous findings sections above outlined the ways in which Explainers' identities manifest in practice. This chapter described the Field Trip Explainers as a diverse band of orange-vest-wearing people who are curious about the world, require an attitude of openness toward exploring and learning, learn from one another, and constantly negotiate the meaning of their membership in this community.

The next chapter explores the nature of Explainers' identities as science learners, and then the following chapter combines these two sets of evidence to answer the question of whether working in a community of practice contributes to the development of Explainers' science-learning identities.

## VII. Case Study Question 3: Six Strands of Science Learning

### *A. Introduction*

This chapter addresses the third case study sub-question: In which of the six Strands of Science Learning (NRC, 2009) has each participant engaged, if any? What are examples of these occurrences? In other words, what is the evidence that each participant does have a science-learner identity?

The NRC (2009) outlined six "science-specific capabilities supported by informal learning environments [to] serve as a conceptual tool for organizing and assessing science learning" (p. ES-3). This chapter reviews each of these six strands of science learning based on the descriptions provided by the NRC. This chapter also examines which of these activities Explainers participate in, if any, using data from the interviews, participant observations, and document review. I did not directly ask interview participants to give me examples of their participation in each of the Strands of Science Learning. Instead, I asked open-ended questions that allowed room for participants to share stories about their experiences as Explainers. For example, I asked them to describe an Explainer day and to talk about what they learned as an Explainer. Through these open-ended questions, their science-learning stories emerged. I then used the Six Strands of Science Learning as a guide to organize and analyze the data.

In addition to asking participants to describe their relationship with science learning (described in Chapter V), examples of Explainers engaging in Strands 1-6 thicken the description of the case. My assumption is that engaging in these activities supports thinking of one's self as a science learner. I am not interested in assessing their success or sophistication with the Strands of Science Learning. Instead, this chapter serves to document Explainers' participation in science learning activities as a way of better understanding their science-learner identities.

Of course, most instances of engagement in science learning activities cross over multiple Strands. For example, it's not surprising that if someone engages in the inquiry process (Strand 3) in order to develop their understanding of a phenomenon (Strand 2), that they are also interested in the subject (Strand 1). This is the case for many of the examples from the Explainers, but I separate them out across the Strands for the purpose of clarity and analysis. The following passage from the Explainer blog, entitled "Mistake Garden" is an example of combining multiple Strands of Science Learning, from interest to reflection, experimentation, and identity. I present it in a table (7.1), with the strands of science learning highlighted in the left column.

**Table 7.1: An example of combining multiple Strands in one activity.**

| Strands of Science Learning (NRC, 2009) Apparent in Blog Posting | Mistake Garden (Explainer Blog Posting, September 2010) |
|---|---|
| **Strand 1**: Planting a garden or baking bread with the intention of learning from the experience demonstrates an *interest* in science.<br><br>**Strand 2**: Learning from her mistakes is a form of *generating* and *using explanations, models, or facts*.<br><br>**Strand 3**: Planting a garden or baking bread and noticing what happens is a form of *manipulating*, *exploring*, *observing*, and *making sense of the natural world*.<br><br>**Strand 4**: Reflecting that "the deepest learning happens when you just try something, without being sure of the outcome" is *reflection on scientific processes and the process of learning about phenomena*.<br><br>**Strand 5**: While it is safe to assume that gardening and baking involve *scientific language and tools*, this excerpt does not explicitly state their use.<br><br>**Strand 6**: This excerpt describes a transformation from someone who never would have made mistakes to a person who *thinks of herself as a science learner*— someone who tries things, makes observations, and learns from the results. | "Last week a very old friend of mine came to visit and I showed him my garden. 'It doesn't look like much' I said, 'but that's just because I don't really know anything about gardening, and I decided to just plant however it made sense to me and then learn from my mistakes.' He looked at me with a look of utter shock. 'But you used to be the one who never made mistakes.' And I didn't have a garden back then either, and wouldn't have planted one unless I was sure I could keep everything alive. This conversation reminded me of something very, very important I learned from being an Explainer, that the deepest learning happens when you just try something, without being sure of the outcome. And if you live this way you have to be okay with your plants not always surviving, and your bread not always rising, and making a lot of mistakes sometimes. It took me awhile for my ego to be okay with that, but now it seems so second nature I forgot for a moment that I used to be otherwise. Thank you Explainers for teaching me how to mess up." |

### *B. Strand One: Developing Interest in Science*

> Learners in informal environments experience excitement, interest, and motivation to learn about phenomena in the natural and physical world (NRC, 2009, p. ES-3).

Two primary data sources were used to explore this strand: 1) self-reports in the interview data of excitement, interest, and motivation relating to science learning; and 2) postings on the Explainer blog that express excitement, interest, or motivation relating to science

learning or descriptions of behaviors that indicate that an Explainer was excited, interested, or motivated enough to learn more about a science concept on his/her own.

The Explainer blog contains 300 posts, 50 of which are examples of engagement in the Six Strands of Science Learning. This is a conservative number, as I did not include postings that are science-related but did not contain text (such as eclipse photographs), were art-related Exploratorium exhibit interpretations, or discussions of related topics such as creativity. There are also non-science postings relating to social activities such as lunch club, Bike-to-Work-Day, or other Exploratorium events.

Within the 50 postings that fit neatly into the Six Strands, I found 24 examples of excitement, interest, and motivation for science learning. The interview data contained 22 examples of participants expressing excitement or interest in science learning, distributed across all 16 interviews. The NRC (2009, p. 3-4) also considers finding personal relevance in science learning to be a part of Strand 1. As previously discussed, every interview participant described how they came away from the Explainer program with an understanding that science is connected to their everyday lives. In addition, several examples below illustrate other ways that Explainers expressed interest or excitement about science learning.

Some Explainers actually used the words “excited” or “interested” when talking about their experiences as Explainers or topics they wanted to engage with more. For example, “Science became friendly, interesting, and I could let myself get excited about it” (I 12, p. 6). “As an explainer I’ve been exposed to various trainings, exhibits and playgrounds that have expanded my view on math and made it more interesting and relevant to my life” (Explainer blog posting, April 2010).

Explainers often become interested in a topic relating to their work, such as the cow eye dissection, and choose to learn more about it on their own time in order to inform their work and satisfy their own curiosity. For example,

> The first year, I was really interested in the cow eye dissection. I wanted to get good at it because it's so popular and all of the students wanted to see it. I did some research online and learned more about eyes. Eventually I did start talking about when you squeeze the optic nerve, you can see the myelin sheath, and I talked about glaucoma, even though it's not in the standard cow eye dissection (I 2, p. 1).

Explainers also often post additional background information they find on the blog so that other Explainers can access it as well.

> Recently, Tech Nation on KQED radio rebroadcast a 2007 piece about the brain body connection. There is some fascinating stuff in there for us Explainers to learn to better facilitate sheep's brain demos…Tech Nation interview. Here's a similar Science Friday interview on npr [sic] (Explainer blog posting, December 2009).

A third way that Explainers express their excitement, interest, and motivation for science learning is by engaging with work-related science topics in their personal lives outside of work, such as in these two stories:

> One time I was on a picnic with [three other Explainers] and we were talking about if there were two moons, what would happen? What phases would they be in...We were thinking about all of the different parts of it. We were showing the placements and remembering how the earth rotates, being able to enjoy talking about that and enjoy figuring things like that out (I 1, p. 10).

During the picnic, these Explainers used oranges and other objects they had on hand to model the sun-moon(s)-earth system in order to answer their question.

> A few weeks ago in Napa I saw, for the first time, an artichoke flower! Doesn't it look absolutely fantastic? I mean, it's positively wild. And to think that we eat them, and discard the pesky choke that, if left to bloom, will become such a stunning inflorescence. As I was taking photos, I noticed a little bee doing its thing. You know, pollinating. And I remembered that bees are in peril, and with them our whole food supply. I wonder if there has been any progress on that front. I recently read about a researcher in Montana, Jerry Bromenshenk, who has an ingenious and alternative approach to diagnosing an unhealthy beehive: microphones. Apparently bees have a highly developed sense of smell, and within 30 seconds of sensing a dangerous chemical the whole beehive will change the sound it produces. Therefore, Dr. Bromenshenk is hoping, by threading a spaghetti-sized microphone into the beehive, to detect the warning signs of 'colony collapse disorder' early on, and maybe identify its causes. Let's all hope, because I like my fruits and veggies (Explainer blog posting, August 2007).

This blog posting, represents the interest of this particular Explainer in fruits, flowers, and their pollinators. That year, the Explainers as a group became fairly interested in issues surrounding the fruits that we eat, and engaged in several discussions about seedless fruits, bees, and biodiversity that extended into the snacks we ate together as a group and activities they did on their own time.

### *C. Strand Two: Understanding Science Knowledge*

> Learners in informal environments come to generate, understand, remember, and use concepts, explanations, arguments, models and facts related to science (NRC, 2009, p. ES-3).

The NRC lists the following types of abilities as falling into learning outcomes for Strand 2:

> …small pieces of insight, inferences, or understanding are accepted as vital components of scientific knowledge-building… perceiving, noticing, and articulating new aspects of the natural world, understanding concepts embedded in interactive experiences, making connections between scientific ideas or experiences and everyday life, reinforcing prior knowledge, making inferences, and building an experiential basis for future abstractions to refer to (NRC, 2009, pp. 3-7).

Using this definition, every interview contained some evidence of participants engaging in Strand 2. Additionally, every interview participant indicated that they had learned science concepts as an Explainer, either by stating that they had done so, or by talking about something they'd learned or connections they'd made. Additionally, there are demonstrations of understanding of scientific concepts in the writing on the Explainer blog, in Explainers' reflection documents, and on the Exploratorium website.

Fourteen interview participants stated that they had learned about certain science concepts, such as light, electricity, or eyes, but didn't necessarily describe the concepts in enough detail to demonstrate their understanding during the interview. For example:

> There's a lot of scientific knowledge I learned, too. It's hard to list—it's so much stuff. Like an eye and how it works, the parts and their functions…the idea of flowers and their

parts and how different parts can be, and seeds, and fruits, and the similarities and differences…There was a lot. We were learning new things everyday (I 9, p. 3).

In a few instances, participants described their conceptual understanding in enough detail to demonstrate their ability to understand or to use scientific facts and models in meaningful ways. For example:

> I feel like I learned a lot about the moon by realizing that I could. I think that when you usually learn about the moon it's from the perspective of outer space rather than from the perspective of the Earth, and translating that is really hard. If you approach the moon from the inquiry perspective, it's no duh that you have to start from a human observing perspective, and it leads you to all of these details you wouldn't have thought of. Like there's an eclipse we saw on the solstice this year. [My partner] and I were thinking about how strange this is because on the solstice we're tilted away, not straight overhead, so for there to be an eclipse, the moon and sun are in the same plane, and I'd always thought about the moon going around the equator, but it doesn't, which led us into the whole question of how the moon goes around us, and this made us think of it in a way that looking at diagrams wouldn't have (I 5, p. 6).

In this example, the respondent describes using mental models to make sense of a natural phenomenon. She demonstrates asking questions and reasoning out possible answers based on her observations and prior knowledge.

The Explainer blog contains 25 instances of Explainers demonstrating their understanding of scientific concepts. For example:

> Remember that training we did with [senior scientist] where we made wonderful magical wands that could levitate bits of plastic and twine? Best training ever, in my opinion.

> Well, now there's a video up on YouTube showing the whole world how amazing science can be! I remember [him] saying that the electrostatic force repelling the hydra is stronger than the gravitational pull of the whole earth, and in fact that gravity is considered a 'weak' force. If I remember correctly, he mentioned that electricity is 40,000 times stronger than gravity (Explainer blog posting, July 2007).

This is an example of an Explainer remembering and using scientific facts that he had heard during a training session, and then connecting them to something else he encountered (a video) later on.

> I had to confirm all that stuff we've been saying about dandelions. The flowers do indeed become a bundle of dry fruits containing the seed, called achenes, ready to fly fly away. BUT! Many dandelions reproduce without fertilization. This process is called apomixis and looks like an excellent crossword word. You know what else? They have THREE sets of chromosomes in their nucleus! That makes them a triploid. Hee! OH! Strawberries are just accessory fruits! What? The seeds on the outside are achenes and are technically the botanical fruits. The yumminess we eat is just lucky, delicious evolution.
>
> AND! Sometimes we have wondered about corn, yes? Yes! The deal is that each kernel is a fruit. Hmmm! This kind of fruit is called a caryopsis, a less excellent crossword word, but still an incredibly impressive bit of vocab (sic) (Explainer blog posting, May 2007).

The Explainers lead a flower dissection demonstration, in which they dissect flowers (and sometimes fruits they bring in) with visitors, look for the reproductive parts, put them under the microscope, and have conversations about plants and plant reproduction. Some Explainers become very interested in plants through this demonstration, and continue their investigations outside of work. This experience often results in Explainers doing things like growing seeds at

home or collecting fruits and flowers on their way into work in the morning to dissect and explore with visitors. This blog posting is the result of one Explainer's personal investigations into better understanding fruits that she had been exploring with another Explainer. Her descriptions of the fruits and their chromosomes are examples of building on existing knowledge while creating a foundation for new understandings of related concepts, and of making connections between scientific concepts and everyday life.

Of 43 Explainer reflection documents from 2009 to 2011, 22 Explainers stated that they had gained understanding of scientific phenomena that year. For example,

> 1) The shape of the sun makes a difference; We can see this by looking at shadows under trees (I find this idea really exciting!). 2) Fog helps us see all the turbulence that constantly surrounds us. 3) Human scale falls in the middle of very large and very small ways of measuring (Explainer reflection, 2010).

A second example:

> The three key pieces of knowledge that I've gained are: 1) how maps are designed and flawed, 2) how electrical currents flow, 3) how clouds and fog are formed (Explainer reflection, 2010).

A third example: "Fruits are usually receptacles for seeds, what used to be a flower's ovary" (Explainer reflection, 2010).

Finally, there are representations of Explainers' ability to understand scientific concepts on the Exploratorium website. The Field Trip Explainers developed a set of activities for school groups to do at exhibits that connect with the California Science Content Standards for kindergarten through eighth grades called "Standards-Based Exhibit Links" (Exploratorium, 2011). The Exhibit Link descriptions do not contain writing that explains scientific concepts.

However, in order to develop the Exhibit Links, Explainers had to understand the concepts behind the Standards well enough to choose exhibits and suggest questions and activities for students to try that would give them experiences relating to those Standards.

For example, the Exhibit Link set for second grade is called, "Touch the Sound" (Exploratorium, 2011). It connects with California Science Content Standard 1-g:

> Students know sound is made by vibrating objects and can be described by its pitch and volume." The Explainer chose three exhibits for the students to visit and wrote questions for each one. For example: "Exhibit: Xylophone Room. Tap the xylophone bars with a mallet. Listen for lower and higher notes. Notice which size bars make higher or lower pitches. Notice how fast or slow the bars vibrate for higher and lower notes (Exploratorium, 2011).

In order to write this Exhibit Link, the Explainer had to understand sound as vibration, and how pitch and volume are related to everyday life and objects so that s/he could choose three exhibits that demonstrate this concept and point out what students should look for in each instance. The Explainers wrote 1-2 Exhibit Links for each grade level (K-8); some were written by individual Explainers, and some were collaborations by two to three Explainers. While I did not set out to measure changes in understanding of scientific concepts, the participants self-reported learning scientific concepts. Examples from the interviews and documents also revealed examples of Explainers demonstrating understanding of scientific concepts. The following section explores Explainers engagement in scientific reasoning.

### *D. Strand Three: Engaging in Scientific Reasoning*

> Learners in informal environments manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world (NRC, 2009, p. ES-3).

Again, I am less interested in assessing the sophistication of participants' inquiry skills, and more interested in whether they do engage in inquiry as a way of better understanding their identities as science learners. With this in mind, I examined the interview data and Explainer blog for examples of Explainers using inquiry to make sense of the natural world. I didn't directly ask interview participants whether this is something they remember doing; instead, they often brought it up on their own as something they remember learning to do as a part of the Explainer experience.

Ten of sixteen interview participants described engaging in the inquiry process to make sense out of the natural world, and there are 14 instances on the Explainer blog of Explainers describing going through an inquiry process. Explainers' learning maps (see Appendix 3.5 for examples) also describe steps of engaging in scientific reasoning as parts of their personal learning processes. As one respondent stated,

> For example [this actually was shared as an example of how Explainers learn from each other], at cloud chamber, this exhibit is one of my favorites. It dawned on me one day that these are charged particles, and so what if I could create a charge nearby to impact the particles? So I rubbed my sleeve up against the glass and saw this huge cloud inside the chamber. And I had to go run and find another Explainer immediately, 'You've got to try this' (I 4, p. 4)!

In this relatively short interaction, this Explainer asked a question, which was in itself a prediction, manipulated the exhibit by creating a charge with his sleeve against the glass, and

then observed the results. Since the results he observed meshed with his prediction, which was based on the understanding he had so far, he was able to make sense out of something that interested him.

> No, it's not today's lunch club- it's what we got during our fruit dissection today with [senior scientist]! When [another Explainer] and I took on the challenge of dissecting an ear of corn, we didn't realize we were biting off more than we could chew. When we were shucking the corn, we found something unusual…never before seen in Explainer training (even by [senior scientist] who has seen a lot)! We found an undeveloped mini-corn-on-the-cob inside the green, leafy part next to the fully developed ear of corn! It was a-MAIZE-ing! Here are some photos: [pic] We were all ears to hear [senior scientist's] ideas of what this could be. After a chat with her, our theory is that the silky parts of the corn are the stigmas (female part) that contain a tube for the pollen to travel down to fertilize the eggs. Because the silk strands from this tiny corn were enveloped by the green husk no pollen was able to get to them. We believe what these photos show are lots of little unfertilized corn eggs, which do not taste as delicious as grown-up corn kernels (Explainer blog posting, September 2010).

This blog entry is connected to a training session in which Explainers dissected fruits and flowers, looking for the reproductive parts, and finding similarities and differences across different plants. These two Explainers explored natural objects, made observations and comparisons, asked questions, and used all of the information they gathered to make sense of what they found.

> Also in the first year, trainings were like mind blowing. The inquiry with the snails was maybe the first thing I remember doing…It was kind of like a really great presentation

> and synthesis of the kinds of learning that I always did or tried to incorporate into my teaching, and it's a formula that I hadn't pieced together yet. And when I saw it, it was great! We came up with questions we could answer yourself, ones you could investigate, and how to turn questions into investigable ones, and that's still with me everyday and that's awesome (I9, p. 2).

In the training session described by this participant, we did an inquiry exercise with garden snails. The Explainers made and recorded observations of snails, and then worked in small groups to come up with investigable questions and to design an investigation to find the answer to their question. This participant and her group asked a question about what stimuli snails would respond to by going back inside of their shells. They blew whistles, let the snail crawl on an ice cube, put it in the dark, and then discovered that the only way to get their snail to go back into its shell was when they accidentally dropped it (the snail was not injured in the making of this inquiry exercise).

> Last week I snuck up to drawing board [a harmonogram demonstration] a few minutes after closing…we boldly experimented with the one thing we were told never to… we moved the weight. It was the dawn of a new fascination with this simple exhibit, and its complex mathematical properties. The following is a brief geek out session about the physics of drawing board: When we first learned how to facilitate this exhibit, [another Explainer] told us about how the board has three degrees of freedom, movement along the x-axis, movement along the y-axis, and torque. When the board is moving along both the x and y axes it creates a circle, while torque will create figure eights and more complex patterns. As friction slows the swinging of this giant rectangular pendulum, the shapes become smaller and smaller until they shrink to a point and all that is left is a

> crazy psychedelic image…According to the museum website, the weight on the board and the length of the chains are specifically designed so that the period of the torque is twice the period of the pendulum motion. You can destroy this by sitting (very very still) on the drawing board while it's moving. The result is a more complex harmonogram that can do more loops than just a figure eight. Moving the weight off center will cause the pattern to morph more rapidly than normal. I have no idea why that is, but…I hypothesize that the torque is not entirely independent of the pendulum motion and that motion of one sort either decays faster than the others, or can be translated into it. I also noticed that if I start the drawing board moving along only one axis it will start out as a line, morph into a circle, and end up moving in a line along the other axis. Why does it do that? (Explainer blog posting, November 2007).

In this example, the Explainer engaged in all of the components of Strand 3: manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world. She explored an exhibit, made observations of its characteristics and behaviors, experimented with things that she could manipulate (changing the weight, moving the weight, moving the pendulum in certain ways), shared what happened, and tried to make sense of it.

Finally, evidence of Explainers engaging in scientific reasoning is found in their learning maps, in which Explainers made conceptual maps based on 3-5 key words or phrases that they felt were key to their learning processes. I counted the frequency of words that appear in the 49 learning maps that I have access to. More than half of the words (144 of 263) used by Explainers in their maps to describe their science-learning processes were related to the activities that are outlined in Strand 3: manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world. All of the Strand 3 categories were included in the maps except

"predict." Table 7.2, below, shows the number of times each of these activities appear in Explainers' learning maps, and is followed by a list of other types of words that Explainers used that are not related to Strand 3 activities. The strong presence of inquiry steps in Explainers' learning maps indicates that Explainers connect scientific reasoning with their own construction of scientific knowledge.

**Table 7.2: Word Use in Explainers' Learning Maps relating to Strand 3**

| Categories from Strand 3: Engaging in Scientific Reasoning | Words Used by Explainers | Number of Learning Maps in which these Words Appear (Total: 49 maps) |
|---|---|---|
| Manipulate/Test | Experiment, Work with Materials, Problem-Solving, Creating, Making, Build | 23 |
| Explore | Explore, Play, Researching, Hands-on, Touching, Try new Things | 42 |
| Predict | -- | 0 |
| Ask Questions | Ask Questions, Curiosity | 30 |
| Make Observations | Observe, Watch, Noticing Changes | 14 |
| Make Sense of the Natural and Physical World | Think (deeply/differently), Insight, Analyze, Interpret, New Perspective, Reflection, Make Connections, Noticing Patterns | 31 |

Other types of activities *not* included in Strand 3 that appeared in Explainers learning maps are: communicate (31 times), listen (27 times), learn with others (16 times), enjoy (14 times), and other words (each used 1-6 times).

### *E. Strand Four: Reflecting on Science*

> Learners in informal environments reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena (NRC, 2009, p. ES-3).

The data suggest that Field Trip Explainers spend time in their work reflecting on the nature of science and the processes of learning. This is highly apparent in the interviews; fifteen of sixteen participants discussed their reflections on the process of science and/or learning at least once in their interviews. For example:

> For me I hold true to the idea that everyone is a scientist. They may not self-identify that way and that's ok. Everyone's engaged in inquiry. We may not all use the same language around it, but being curious, asking questions, and making observations is part of science, and all people are inherently interested in those things (I 11, p.9)

Another participant reflected on the meaning of science literacy:

> Being science literate is different from being all knowledgeable. I see the importance of being science literate now. To me, it's about politics…about gaining respect for science, and understanding of it, and what it does. This has ramifications in the world in what you do—how you raise your kids, whether to home school your kids because you don't appreciate the way the science teacher teaches evolution…It informs the way I understand the world, and what is true. I think being science literate is that you understand the importance of the empirical process. It's also appreciating the world around you more (I 2, p. 8).

An example of a participant reflecting on his/her own learning process:

> Working here, it made it fun, and I guess it made me more interested and want to go further than just reading books. Because… you allowed me to touch a cow eye and cut it open. You allowed me to mess with weird machines like the Vandergraaf. Maybe that's the kind of learner I am. For me I'm a different kind of learner now than back then. At the time, I had to have my hands playing with something to understand, or take something apart. Just text, I would pass up… but when I came here and was free to do this kind of stuff, I was immediately engaged. I compare that with kids that come here on field trips. We open that opportunity---feel free to touch, explore more than what the description of the exhibit says…even though that's important too. Feel free to explore in the museum. I think as an Explainer, that was a mission for me…Showing kids that it's ok to explore and showing them strategies and methods for exploring by asking more questions and looking for closely at the simplest thing (I 10, pp. 9-10).

An example of a participant reflecting on teaching and learning:

> It turns out that explainers don't really explain much of anything, and their role as educators is different from that…it was an entire approach to education in general and learning and how learning can happen. I was used to very academic, book-based learning where everybody sort of was expected to learn the same way, from the same sources, following the same path. Those first two weeks of training were a mind-blowing experience for me. I think the main difference was that it didn't provide an answer, but it provided the means to come up with your own answer…So your own exploration of a phenomenon or concept or even an aesthetic principle is really valid as long as it's an honest and earnest exploration…rather than assume that there is a right answer to things

that people who are smarter than you have figured it out, and first you learn that, and maybe one day you'll be smart enough to figure something out yourself (I 16, pp. 1-2).

There are also eight examples on the blog of Explainers reflecting on science and the process of learning. For example:

I got a museum news email today about an Exploratorium website that I've never heard of getting recognized as a site-of-the-week by Communication Arts. The site is called…Evidence : How Do We Know What We Know. It's really cool because users can input their own evidence for or against human caused global warming, the earth being flat, and the existence of ghosts(?). Its nice because the three options are a definite scientific fact, a superstition, and a debatable theory. You can sort the evidence submitted in a variety of categories. Overall, it's a really pretty interface that visualizes these ideas. It's funny because some of us were just talking about the symposium recently held in the mcbean about global warming and other conversations we've had with people. It's good to think about the role of a science museum in these discussions. It was really nice that [Exploratorium executive director] said that it's not our role as an institution to tell the visitors what to think but to give them the evidence and let them figure stuff out for themselves (Explainer blog posting, March 2009).

### *F. Strand Five: Engaging in Scientific Practices*

Learners in informal environments participate in scientific activities and learning practices with others, using scientific language and tools (NRC, 2009, p. ES-3).

The NRC (2009) uses an open-ended definition of participation in informal learning environments. They contrast the ability to measure participation in informal settings (which is

usually episodic, rather than continuous) with classrooms, in which there is time for students to engage in and practice normative behaviors such as scientific argumentation. The case of the Field Trip Explainers is between these two types of learning situations; the Explainers participate in science learning activities as a group on a daily basis, but in an informal environment in which the "teachers", tools, and learning approaches change each day. Standard approaches to researching participation in informal environments, such as measuring the amount of time spent using exhibits, does not make sense for this case. Some researchers have examined learners' willingness to continue participation after the museum experience by looking at online engagement or conversations at home. The NRC also recommends that assessing participation can be done by focusing on indications of personal ownership, creativity, or self-initiation relating to science learning activities (2009, p. 3-16).

The findings provide examples of Explainers taking the initiative to go further with their science-learning explorations, taking personal ownership, or being creative in their learning activities, many of which have been shared already in the sections above. In the spirit of sharing further their creative science-learning enterprises, here are more examples:

> For instance, during a fruit dissection, we saw some fuzzy stuff on the apple seeds. I knew I had seen it before, but I wondered, 'What is it doing'? So we brought it into the bio lab to look at under the microscope, and it looked weird. The bio staff said that we could test the chemical composition to see if it's a sugar or something else...we did an iodine test and found that it did contain sugar. We thought then that maybe it was nutrients for the seeds. We didn't answer our question, but we got closer (I 4, p. 6).

In this example, the Explainer took the initiative to take his question into the lab and investigate it further to find out what he could learn. He didn't need to know anything about the fuzz on

apple seeds in order to do his job, but he decided to see what he could find out anyway, and this experience was memorable to him.

> There was a Myth Buster episode [a television show in which experiments are designed to test the accuracy of cultural myths] where he wore an eye patch and he wanted to see if there was some use behind pirates using these. And so we did our study group- we all had an eye patch and put it over our eye and hung around in the room and looked at stuff. We didn't close the eye that was covered, and waited awhile until our covered eye was adjusted to the dark. We turned the light off, and slipped the patch over the other eye, and it worked. That was the theory—that during a battle they go under the ship and if they flip their eye patch, they'll have a couple of seconds of the eye being adjusted. When we took the patch off, each eye was adjusted to a different level of light, and my eyes had never had that happen before, and it took some time to readjust…That was an experiment (I8, pp. 7-8).

This participant described an experiment based on a question the Explainers had about pirates' use of eye patches. The Explainers designed the experiment themselves, beginning with a hypothesis, testing their hypothesis, and then discussing the results as a group. Although an experiment about pirates may sound silly, this use of their time involved asking their own question, using creativity, taking initiative, and ownership over the process. We don't know whether their explanation is the reason why pirates wore eye patches, but they learned something, had a great time doing it, recognized it as an experiment, and still occasionally bring up the time when they all wore eye patches.

A blog entry describes a similar creative investigation that was entirely conceived of and carried out by Explainers taking initiative.

> Due to my current fascination with trying to make halfway decent sounds come out of a guitar, [another Explainer] and I chose to engage the Explainers in further study of Oscylinderscope last week. One thing led to another and we found ourselves in a dark Cloffice [the Explainers' term for the lunch storage closet, which is also an office in the afternoons], armed with a only a strobe light, violin, ukelele, guitar, string ray, the advice of [senior scientist], a few concerned staff members, and sheer abandon. It was there we discovered- as we so often do in science- that our original idea was not only pretty boring, but it was not going to work (mostly due to the wagon-wheel effect and constraints of space-time in only 4 dimensions). It made intuitive sense that the strobe would illuminate a string's longitudinal wave when that string was bowed or plucked. But why was the strobe light showing us vibrations on different strings that we weren't even playing? It was at this point, that we became interested in/confused by resonance. We started discussing sympathetic resonance, harmonics, 5ths, overtones, etc. during study group, so I will cut straight to the good stuff: Resonance in our bodies. In infrasound there are frequencies (below 20Hz) that resonate with human body functions. They can cause changes in respiratory rhythm, sensations of gagging, and blurred vision. These frequencies have been explored by military scientists in an attempt to find a non-lethal weapon (i.e.- use it for crowd control to make your crowds feel hung-over instead of dead). They also have been explored by television programming, including but not limited to Mythbusters and South Park (Explainer blog entry, March 2009).

These two Explainers were assigned to spend three hours of their paid time preparing a training session on an exhibit of their choice for the other Explainers. As described in the blog posting, they became interested in what they were doing and ended up spending their own time after work

hiding out in a dark lunch closet trying to understand resonance with a strobe light and some musical instruments. Although completely different from a family returning home from a visit to a science museum and continuing to talk about the exhibits, this example contains the common thread of extended, self-initiated, creative participation in science learning activities using scientific tools and language.

### *G. Strand Six: Identifying with the Scientific Enterprise*

> Learners in informal environments think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science (NRC, 2009, p. ES-3).

The NRC defines having a science-learning identity as viewing oneself as a scientist *or* being comfortable with, knowledgeable about, or interested in science (2009, pp. 2-13) *or* having positive feelings, a sense of agency, and a sense of belonging related to scientific practices (2009, pp. 3-16). A science-learning identity is often reflected in the behaviors of the learner (pp. 3-17). The research question guiding this dissertation is about whether Explainers develop science-learner identities through working in a community of practice. Chapter V reviewed the personal context of the participants and found that all participants felt, by the end of their time as Explainers, that science is a part of their everyday lives, and something that they have positive feelings about. These self-reports, combined with engagement in Strands 1 through 5 demonstrated in this chapter, indicate that Explainers do develop identities as science learners.

Every participant talked about this to some extent in the interviews. Here are a few examples of the participants' self-reports on identity:

> I thought that the whole experience was really empowering. I hear all the time that people think they don't 'get' science or math, and I had totally identified in the same way. And then, it was presented in such a way that maybe that wasn't true, and then I had a great time studying science in college. It really showed me that it was not inaccessible to me (I 3, p. 3).
>
> It's something that for me it's become a part of what I do as a job…it really gave me direction and personally gave me enthusiasm, a renewed enthusiasm for looking at science as something fun, exciting, and rewarding. My last experiences with science had been in college chemistry classes and never wanted to go at it again. It was terribly unrewarding—I guess all of the classes I took were so specific in their focus that it was just, it felt like learning for the sake of learning, it didn't have value in a way that I felt related to my life… it's now a part of what I do in terms of being a naturalist and sharing and teaching natural history with students (I 13, pp. 6, 4).

Another participant stated:

> It was a real blow to my self esteem when I didn't do well in a college science course and partially due to that, switched my major. I just felt like I wasn't good at it. But in fact, I *am* good at it and I enjoy it. And so it brought the joy back. And because I wasn't being graded, because I was just learning, and I was starting from my own personal starting point, it felt very comfortable. It was great because we were all going there, and it was a safe space (I 12, p. 6).

Another example:

> I felt like 'this is my job and I should start thinking of myself as a science educator'. The fact that I had this responsibility pushed me in that direction. I think by the end of the

> first year, I saw myself that way because I applied to the Aim High science teacher job. I always felt before that I wouldn't be comfortable applying to teach science. But by the end of the first year of being a field trip Explainer, I felt comfortable enough. I saw myself not as someone who knew a lot about science, but someone who could learn science. And by my second year, I was already thinking about eventually teaching English composition…focusing on teaching reading and writing with non-fiction…and I seriously starting putting more thinking into science texts. There's this book I read my first year called *Guns, Germs, and Steel*. I was interested in this book initially because it's a historical argument, but the author uses science to back up his arguments so it's really a science text. After I read that, I felt that I could assign science texts even though I didn't study in college-it's an attitude toward science that shifted as a Field Trip Explainer (I 2, p. 3).

The results suggest that before becoming Explainers, many interviewees (10 of 16) had developed identities of non-participation in the scientific community, often by struggling in science courses. Through participation in the Field Trip Explainer program, these participants developed identities as participants in the scientific community which they expressed by taking more courses, incorporating science into their everyday lives, or integrating science into their subsequent professional work.

### *H. Other Findings: Teaching and Learning Skills and Knowledge*

While the data indicate that Explainers do engage in science learning, participants cited learning about other things as well. When asked what they learned from working as a Field Trip Explainer, fifteen of the sixteen participants spoke about gaining skills and knowledge relating to

teaching and learning. These responses included learning to communicate well with people of different ages and backgrounds, learning to speak to a large group of people, learning about teaching and learning through inquiry, and reflecting on the teaching and learning process in general. For example:

> My favorite was the emphasis on the inquiry-based education. I've taught a variety of classes since being an Explainer, and have tried to use that. When I'm having trouble with students, I go back to those leading questions that we'd work on" (I 3, p. 1).
>
> "Communication skills…Talking to people who don't care about science, who feel like it's too hard…is really different and you have to alter your approach and change your goals (I 8, p. 2).
>
> Having the confidence to say, 'I don't know, let's figure it out together', or 'what do you think?' Keeping things really fun and exciting and student-centered…being more of an active learner with the kids or co-participating in an experience instead of directing it… (I 11, pp. 1-2).
>
> Definitely my teaching pedagogy has improved greatly…you have to make constant decisions about interactions while teaching. My decision process has changed, it's become more fine-tuned (I 4, p.2).
>
> I gained a lot of confidence, skills, and techniques as a learner and educator…a huge appreciation for experience-based learning; seeing it in action how people were trying things and getting excited asking questions and coming to conclusions…how things are set up, both the structure of teaching, the way a room looks when you walk into it, what kinds of props are around an exhibit…it was like a live laboratory…of human behavior and just getting to experience and seeing what people did and what worked and didn't

work informed my social experience in the world and my experience as an educator (I 9, p. 9).

Of the 43 Explainer reflection documents from 2009 to 2011, 39 Explainers listed improved teaching or facilitation as one of the skills they had learned that year. For example:

> One of the most important things I think I have begun to practice and to think about in earnest is what makes a good question and how and when to ask a certain kind of question…so that students really have the opportunity to make discoveries and conclusions on their own (Explainer reflection, 2011).

It is not surprising that Explainers gain skills and knowledge about teaching and learning, as that is a key aspect of their work as educators. However, it is possible for educators to pick up undesirable skills and knowledge about teaching through working in a community of practice (Little, 2002). The participants, however, talked about teaching strategies that are consistent with recommendations in the informal and science-learning literature such as making adjustments for individual learners (e.g., Cox-Petersen, et al., 2003; Tal & Morag, 2006; Tran, 2006; Vygotsky, 1978) and allowing learners to go through inquiry as part of their learning processes (e.g., AAAS, 1993; Allen & Gutwill, 2009; Dierking et al., 2003; NRC 1996; Rennie et al., 2003; NRC 2009).

Through working as Field Trip Explainers, many participants came to see themselves as educators in addition to learners. For example:

> I think I moved from being interested to realizing: I'm really an educator. I'm really going to spend time refining skills as an educator and I'm going to work with folks in a concrete way for longer periods of time with specific intentions for them and what I hope they get out of it (I 11, p. 7).

It came up several times in the interviews that participants' identities as educators and learners are intertwined. For example, when asked about what kind of people Explainers are, one participant's response included: "For me, being a learner at first…Being an educator, an explorer…I was a learner along with the kids" (I 10, p. 5). Explainers spend a lot of time learning about learning— consistent with the NRC's (1996) recommendations for the training of science teachers, they experience being learners themselves, they reflect on their own learning processes (for example, through the learning maps), they practice teaching while paying attention to the learning processes of others. Explainers also develop confidence in learning alongside visitors as a teaching strategy.

### *I. Chapter Summary*

The data sources—interviews, blog postings, the website, and Explainers' learning maps—provide evidence that Explainers participate in the Six Strands of Science Learning. The table below (7.3) reviews the Six Strands and examples of engagement in science learning from selected quotation excerpts.

**Table 7.3: Explainer Participation in the Six Strands of Science Learning**

| Strands of Science Learning | Selected Excerpts from Quotes |
|---|---|
| 1: Developing Interest in Science | Made it more interesting and relevant to my life |
| 2: Understanding Science Knowledge | Scientific knowledge I learned…an eye and how it works, the parts and their functions…the idea of flowers and their parts…and seeds, and fruits, and the similarities and differences |
| 3: Engaging in Scientific Reasoning | Moving the weight off center will cause…I hypothesize that the torque…I also noticed… |
| 4: Reflecting on Science and the Process of Learning Science | I think that when you usually learn about the moon it's from the perspective of outer space rather than from the perspective of the Earth, and translating that is really hard. If you approach the moon from the inquiry perspective…you have to start from a human observing perspective, and it leads you to all of these details you wouldn't have thought of. |
| 5: Engaging in Scientific Practices | Why was the strobe light showing us vibrations on different strings that we weren't even playing? It was at this point, that we became interested in/confused by resonance. We started discussing… |
| 6: Identifying with the Scientific Enterprise | It's become a part of what I do as a job…it really gave me direction and personally gave me…a renewed enthusiasm for looking at science as something fun, exciting, and rewarding. |

Explainers don't necessarily go into careers in science or even science education after leaving the Explainer position. However, they do all see themselves as people who are capable of engaging in scientific discourse or learning, who have positive associations with science. So how does this happen? Does working in a community of practice contribute to this identity development? I explore the answer to this question in the next chapter.

## VIII. Case Study Question 4: How Identity Develops through Modes of Belonging

### *A. Introduction*

This chapter addresses the fourth case study sub-question: In what ways, if at all, has each Explainer participating in the study experienced the three components of identity development in a community of practice: engagement, imagination, and alignment (Wenger, 1998)? In other words, what is the evidence that Explainers' science-learning identities have been formed through participation in this community of practice?

In the previous findings chapters, I described the Strands of Science Learning in which Explainers participate and the changes in participants' understandings of science learning. During their time in the Field Trip Explainer program, most (15 of 16) participants indicated that they changed their understanding of science learning from something reserved for an exclusive group of people to something that is a part of everyday life. I then asked participants what they thought contributed to that change for them. I analyzed these answers to understand whether working in a community of practice contributed to the development of their science-learner identities; the results of that analysis are reported in this chapter. To provide background for this analysis, I first compare the findings that describe the Explainer identity with the science learner identity outlined by the NRC (2009).

### *B. Comparison of "Explainer" and "Science Learner" Identities*

The tables below review how Explainers' identities manifest through participation in a community of practice (Table 8.1) and how Explainers engage in the Six Strands of Science Learning (Table 8.2, top 2 rows). I omitted the fourth and fifth elements of communities of practice, *boundaries* and *locality*, since they were not a significant part of the findings. Table 8.2

reviews how engagement in the Six Strands of Science Learning (or a science-learner identity) relates to participation in the community of practice (an Explainer identity).

The data reviewed so far suggest that there is substantial overlap between what it means to be a science learner and what it means to be an Explainer. However, the data (which is not all included in the tables below) also indicate that participation in the Explainer community of practice goes beyond engagement in science learning. For example, "spending time together" can include activities beyond those that are science-related, such as creating the many exhibit haikus that are posted on the Explainer blog; "pushing the boundaries" can include things such as allowing students to run in the museum, which is not related to science; and Explainers reported learning non-science skills from one another, such as "commanding attention of large groups" or "being in the present moment."

**Table 8.1: Integration of How Explainer Identities Manifest in their Community of Practice**

| How Identities Manifest in the *Community* | What Participants Said is Important about the Community | How Explainers *Learn* about the Community | What Participants Said about Learning | Functions of *Boundaries* in the Community | What Participants Said about Boundaries | Negotiation of *Meaning* in the Community | What Participants Said about Negotiation of Meaning |
|---|---|---|---|---|---|---|---|
| **Mutual Engagement**: Diverse and complementary qualities | "identify what assets different people on the team had and...seek those out" | From Newcomers or Peers. For example, learning about *mutual engagement* through observing complementary or diverse skill sets | "talk about how we do different things and compare to other explainers" | Boundaries create opportunities for learning from other communities | "There are people from different backgrounds, races, sexual orientations, everything, while keeping a very open environment and friendly environment." | With experience, Explainers begin to share their complementary skill sets with one another. | "Contributor…giving advice…and suggestions" |
| **Joint Enterprise**: Tendency toward shared values or interpretations | "have curiosity" "be open to trying…learning … experiencing new things" "push the boundaries, break the rules, explore" | Through Practice. For example, learning about the *joint enterprise* by practicing openness to learning new things | "really wanting to be good at it but was…stressed out…and I decided to sign up for all three cow eyes and really enjoyed it" | Boundaries signify meaning to outsiders | "The visitors…will come to someone with an orange vest. So these people have to behave in a common way." | Once Explainers master the basic skills and knowledge to perform their jobs, they open up to incorporating their own interests and personalities. | "had an orange vest" "Create my own way to do things" |
| **Shared Repertoire**: Community's stories, objects, etc. | "spending time together…doing things that are different… reinforces being part of the group because…you have this shared experience" | From Old-Timers. For example, learning about a piece of the *shared repertoire* | "he had that magic…his actual card tricks and his delivery" | Boundaries give members a sense of belonging | "We make up stupid jokes and have our own language and have special handshakes." | Explainers develop competence and confidence in performing their responsibilities of interacting with visitors and leading demonstrations. | "totally nailed it…knew what to say" "felt confident in approaching both visitors and other professionals to…investigate phenomena" |

**Table 8.2: Comparison of Explainer and Science-Learner Identities**

| Strands of Science Learning | 1: Interest | 2: Understanding | 3: Scientific Reasoning | 4: Reflection | 5: Scientific Practices | 6: Identity |
|---|---|---|---|---|---|---|
| **Examples of Engagement in the Strands of Science Learning** | "A few weeks ago in Napa I saw, for the first time, an artichoke flower! Doesn't it look absolutely fantastic? I mean, it's positively wild" (Explainer blog posting, August 2007). | "…our theory is that the silky parts of the corn are the stigmas (female part) that contain a tube for the pollen to travel down to fertilize the eggs…" (Explainer blog posting, September 2010). | "I had remembered …each silk being a style and so I took [a corn cob] the other day and broke it open…I asked if each kernel was a fruit with it's own seed inside" (I9, p. 7). | "memories that stand out to me were some of the trainings like flower dissection… there were questions, hypotheses, and attempts to prove or disprove those, so they were informal science, but they were science" (I 16, pp. 1-2). | "during a fruit dissection, we saw some fuzzy stuff on the apple seeds…I wondered, 'What is it doing'? So we brought it into the bio lab to look at under the microscope... we did an iodine test and found that it did contain sugar" (I 4, p. 6). | I was deeply interested in fruit and flower dissection…it was really exciting…and it fueled this whole area that grew for me into nutrition and…it became a life style of the foods that I choose and put in my body... " (I 15, p. 9) |
| **How this Relates to *Community*** | Tendency toward valuing curiosity or openness to learning about new things. (*Joint Enterprise*) | Learning about one part of the *Shared Repertoire*, the flower dissection. | Participating in and remembering a training session, one part of the *Shared Repertoire*. | Participating in and remembering a training session, one part of the *Shared Repertoire*. | Tendency toward valuing curiosity or openness to learning about new things. (*Joint Enterprise*) | Tendency toward valuing curiosity or openness to learning about new things. (*Joint Enterprise*) |
| **How this Relates to *Learning*** | Learning outside of work and then sharing back to the rest of the community. | Learning with a peer. | Continued learning outside of work. | Learning with other Explainers (old-timers and newcomers) | Learning with another Explainer | Learning through practice |
| **How this Relates to *Meaning*** | Acting as a contributor of knowledge and experience to other Explainers. | Developing competence in the skills and knowledge of the demonstrations. | Confident investigating a phenomenon with others (although outside of work) | Developing competence in the skills and knowledge of the demonstrations. | Developing competence in the skills and knowledge of the demonstrations. | Developing competence in the skills and knowledge of the demonstrations. |

### *C. How Participants Developed Science-Learner Identities*

The data suggests that Explainers develop science-learner identities and that working in the Explainer community of practice involves science learning. So, *how* do those science-learning identities develop through the community of practice? Without describing the communities of practice framework to participants, I asked them what they thought contributed to the change in their science-learner identities. The following section outlines the five types of responses participants gave to this question.

The most common response (from 11 participants) was learning in a positive environment in which they were accepted for their ideas, levels of science background, and ways of learning. The second most common response (9 participants) was that participants were influenced by other Explainers or Exploratorium staff. Third, seven participants experienced feelings of excitement for science learning as Explainers. Six participants expressed that just having the opportunity to engage in science learning was important. Finally, four participants talked about having experiences that made science relevant to their everyday lives. These five themes that emerged from the data are described in greater detail in the following sections.

*Positive Learning Environment*

The most common response from participants about what contributed to the change in their science-learner identities was *learning in a positive environment*. Participants in this category talked about a feeling of acceptance, the importance of people learning at their own pace, or learning in a non-judgmental environment. For example: "I never felt that I couldn't voice my opinion or anything was dumb to mention or ask" (I 7, p. 2), or "It never was like in school when you better get this or you'll fail… but instead that anyone could do it and we could help make that happen" (I 3, p. 3). These eleven participants felt that there was space to work

things out for themselves in a safe and supportive environment. One participant described learning in training sessions:

> Probably mostly the permission to take the time to figure it out. I would stop during training and ask questions like, '[senior scientist], can you go back to the first step? What is electricity? What is a magnet?' I would never have done that when I was in school… I just wouldn't. I would just not understand and didn't think I had the ability to do it. I didn't know how to figure it out or ask about it (I 1, pp. 7-8).

Some of these participants talked about the ability of Explainers to all get something out of training sessions, even though they were learning at different paces or levels of depth. For example:

> In the explainer training, I…felt as though there was a lack of judgment. We all came at it from different places and had different levels of science knowledge, and that was perfectly fine, and it seemed to work for all of us…There was always the opportunity to ask basic questions and also to go in depth…Usually the structure of the trainings is that you talk about the core/basic concepts, which would be review for some and new to others, and then we'd dive in a little deeper, so there was something for everyone there (I12, p. 6).

I also observed Explainers expressing the importance of a non-judgmental learning environment during our 2011 annual retreat. The Explainers participated in an activity in which they created and presented representations of how they integrate their non-Explainer skills and identities into their Explainer work. This elicited a conversation on this topic, and the realization that Explainers also transfer their culture of non-judgmental learning to the Exploratorium visitors.

> When we had finished, I asked the group if they had any final reflections or thoughts before we moved on to the next activity. The Explainer who had written the song about her identity shared first. She said that the Explainer program creates a safe environment in which she can not only be herself, but she can safely learn new things without judgment. Because of this, she then tries to create a similar, safe environment for our visiting students to learn at the Exploratorium. The other Explainers jumped in to agree and elaborate on this idea (Observation Notes, March 18, 2011).

Several participants also mentioned this in other places in the interviews. For example,

> I don't think anybody worried about asking a question ever. Nobody thought that somebody was stupid for not knowing or wondering something. If somebody was curious or learned something and shared it, it inspired other people to take it a little bit further, and everybody would be getting more and more in depth as a group (I 9, p. 6).

This finding is consistent with the NRC's assertion that "Learners must feel safe with science…if they are to make progress along the Strands" (2009, p. 6-32).

*Influence of Other People*

Nine participants described the influence of other people as something that contributed to the change in their science-learning identities. These responses included comments about the importance of learning from or alongside other people, as well as comments about observing other Explainers or Exploratorium staff. For example, "I really noticed other Explainers didn't study science in college, but they were taking ownership over being a science educator. And so I was becoming aware of it" (I 2, p. 6). Another participant said, "The other explainers, the variety of their interests and the backgrounds…gave me an intense melting pot of interesting things…" (I 8, p. 8).

> As an Explainer, I encountered a lot of people that were into learning, and into learning new things. I feel like I developed a sense for that, an excitement for that type of feeling of wanting to learn and know more (I 10, p. 9).
>
> I think the explainer program in general is really successful in generating…a community of people who care a lot and are committed to learning and teaching…The community, the philosophy, celebrating curiosity, the way we had in our training access to so many experts about teaching and…science (I9, p. 9).

Participants were influenced as Explainers by other Explainers or staff demonstrating an interest in or excitement for learning science. In some of these instances, the participants seemed to pick up on others' interest or excitement as though it was infectious. One participant realized by watching other Explainers that it was possible to develop a science-learner identity even for people who did not have science backgrounds. Finally, one participant valued the feeling of being a part of a community with shared values.

*Feeling a Sense of Excitement*

Seven participants used the words: excitement, joy, love, fun, and enjoyment to describe what contributed to the change in their science-learner identities. It could be argued that this was a learning *outcome* rather than a catalyst; this finding is closely related to the first Strand of Science Learning, in which learners feel interest or excitement about learning science. As I discussed in the Literature Review Chapter, an interest or motivation to learn science is connected with success in inquiry and understanding scientific concepts (for reviews, see Kaplan & Maehr, 2006 and NRC, 2009). And so, feeling excited about science learning can be both a learning outcome and a contributor to the process of becoming a science learner.

The finding above, *Influence of Other People*, indicates that some participants' feelings of excitement came from the influence of co-workers. Other participants experienced excitement through the experience of doing or succeeding in science-learning activities, or simply enjoying their work. One participant said, "I just felt like I wasn't good at it. But in fact, I *am* good at it and I enjoy it. And so it brought the joy back" (I 12, p. 6). And another stated:

> A big part of that was how much I enjoyed what I was doing… experiencing actually liking what I was doing day in and day out, experiencing how that feels, and how much better you end up at your job when you actually enjoy what you do (I 16, p. 7).

*Opportunity to Engage in Science Learning*

Six participants credited having opportunity to engage in science learning as one of the things that contributed to the change in their science-learner identities. "A lot of opportunities for self directed experiences, but with structure so it's not overwhelming" (I9, p. 9). "Doing science, living it. Researching…" (I 15, p. 9).

> Working here, it made it fun, and I guess it made me more interested and want to go further than just reading books. Because… you allowed me to touch a cow eye and cut it open. You allowed me to mess with weird machines like the Vandergraaf (I 10, p. 9).

Again, this finding is essentially engagement in the Strands of Science Learning, particularly scientific reasoning (Strand 3) and scientific practices (Strand 5). This finding, combined with experiencing excitement, represent a progression of engagement with the Strands of Science Learning. The data suggests that there was a change from having an identity as a non-participant in science learning to actually engaging in science-learning activities, which led to participants adopting identities of participation.

*Relevance to Everyday Life*

Finally, four participants said that finding relevance in science to their everyday lives is in part what contributed to the change in their science-learner identities. As I stated in Chapter VII, finding personal relevance in science is considered a part of the first Strand of Science Learning, developing an interest in science (NRC, 2009, pp. 3-4). For example, one participant said, "Honestly I think it was positive experiences, information conveyed in a way that was directly applicable to my life" (I 11, p. 6). Another respondent described relevance to everyday life in this way:

> As an explainer we were doing dissections and looking at flowers everyday. And now I see flowers and wonder, 'What is it showing'? During my time there, it expanded what science was for me and what I could notice, and how much I came into contact with it. I wouldn't have thought before that my everyday life involved botany, but it does, and I'm curious about it, and it's cool. Also expanding the idea of what is science. Seeing the light come through the leaves and making circles, and doing this with my hands and the more I held them up to the sun, the more it became a circle...oh, this is science! I had seen these my whole life- I was familiar with this aspect of the world, but I hadn't thought of it as a scientific concept before. That opens up so much to make me think of different things in my life as scientific experiences, and so then I'm a science learner (I9, p. 7).

*Section Summary*

Table 8.3 outlines the five contributions to changes in participants' science-learner identities, as described by the participants.

**Table 8.3: Contributions to Changes in Participants' Science-Learner Identities**

| Contributions to Changes in Science-Learner Identities | Selected Excerpts from the Quotes |
|---|---|
| Positive Learning Environment | a safe environment |
| Influence of Other People | I encountered a lot of people that were into learning…new things |
| Feeling of Excitement | fun, excitement, joy |
| Opportunities to Engage in Science Learning | allowed me to touch a cow eye and cut it open |
| Relevance to Everyday Life | opens up so much to make me think of different things in my life as scientific experiences |

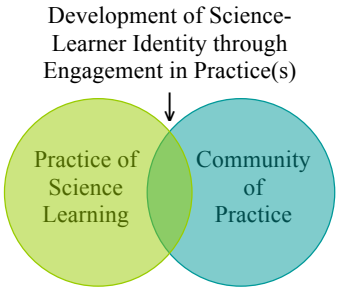
### *D. Engagement, Imagination, and Alignment*

In the previous section, I outlined the ways in which participants described what contributed to the change in their science-learner identities without applying the communities of practice framework. In this section, I analyze how well Explainers' science-learner identity development matches the identity development described by the communities of practice framework: engagement, imagination, and alignment (Wenger, 1998). I described these modes of identity development in detail in Chapter II, section D: Theoretical Framework.

*Engagement*

In this case, I explored whether participants developed identities of participation in science learning through engagement in practice. But what practice? Engagement in the *practice of science learning* is a part of engagement in the *community of practice* (Table 8.2). Science-learner identity development occurs at the intersection of participation in the community of practice and engaging in science-learning practices. The Venn diagram below illustrates this intersection.

**Figure 8.1: Intersection of Engagement in Practices**




Engagement in practice—the community of practice and science-learning practice— was evident in the descriptions provided by ten participants of how they developed their identities. As I described in the preceding chapters, Explainers engage in science-learning activities everyday. They begin each day learning something as a group during their training session, and then they spend the rest of the day interacting with visitors at exhibits and through demonstrations. For some participants, engagement in these science-learning activities elucidated for them the connections between scientific knowledge and processes with their everyday lives and the world around them. For example:

> It was the perfect setting to learn about a whole bunch of new things and to fall in love with where I'm living and what I'm doing with my life. Doing science, living it, researching. Like, what happens with an avocado flower: it first blossoms as a female and then a male, and then I never looked at an avocado the same way, what that plant goes through to make a fruit. It makes sense that you shouldn't eat too many of them! That's what I call doing science. Also, living your exploration. You start to see that interest everywhere. You start to hear songs about birds and bees and you take your allergies and think 'I know what's going on now.' All this intertwined knowledge. That was more about experiencing the joy of finding stuff out. Maybe the love of flowers and fruits isn't

> doing science, but I think it is. In terms of doing experiments, we did stuff in training, and in so far as you can say 'well let's find out' and you can call the act of 'let's find out' as science, then being an explainer was doing science everyday (I 15, p. 9).

I found that all participants engage in science-learning practices through the Six Strands of Science Learning. Although they did not all explicitly state that this is what contributed to their science-learner identity development, it is fair to assume that this was the case based on the quotations that I shared throughout the findings chapters.

*Imagination*

A form of social imagination that is different from what Wenger (1998) describes was important to three participants. These participants imagined their own potential identities by observing the trajectories of other participants or Exploratorium staff. This category of identity development overlaps (although not completely) with the finding above that some participants' identities were influenced by other Explainers or Exploratorium staff. For example:

> If I had to pinpoint the moment when I got an identity as a science learner, it was during the summer between my first and second year. The end of the first year, I really noticed other Explainers didn't study science in college, but they were taking ownership over being a science educator. And so I was becoming aware of it (I 2, p. 6).

This participant began the Explainer position as a self-identified "humanities person." The summer after his first year, he decided for the first time to apply for a science teaching position because he realized that he was qualified for the job. As this quote suggests, he saw that other Explainers who didn't have science backgrounds were becoming science educators, which opened up the possibility that he could, too. That summer solidified for him that he was

comfortable in the realm of science. “I was teaching at Aim High and I became known as the science teacher and people came asking me science questions.”

Role modeling provided by staff scientists is also important to Explainers, but is not exactly social imagination as described by Wenger (1998). Explainers have regular contact (almost weekly) with Exploratorium senior scientists who lead training sessions. In other parts of the interviews, ten Explainers mentioned one senior scientist who frequently leads training sessions, whom they clearly admire. One participant said, “Meeting people like [senior scientist] blew my mind” (I9, p. 2). These participants mentioned learning science content and/or science teaching strategies from this senior scientist. For example, “one thing I learned from him is how to adjust explanations to different people. He’s really good at doing that” (I 5, p. 5). Participants did not directly say that interacting with staff scientists contributed to their ability to see themselves as scientists or science learners, and I did not get the impression that participants imagined that they might become like this scientist. However, respondents’ comments indicate he is a role model for Explainers in teaching science, and that he has directly facilitated their ability to learn science concepts.

Only a few participants explicitly stated that social imagination was important in the development of their science-learner identities. However, throughout the data, there are indications that Explainers engaged in *social imagination* by sharing and remembering stories and experiences, realizing that other people without science backgrounds were able to become science learners, and seeing an Exploratorium scientist as a role model. While this is not a perfect fit with Wenger’s (1998) definition of social imagination, in these ways, some Explainers *imagined* the potential for a science learning identity.

*Alignment*

It was the goals, beliefs, or commitments of the community of practice that contributed to the science learner identity development of ten participants. As previously discussed, the data indicate that the Field Trip Explainers interviewed share a commitment to curiosity and openness to multiple ways of learning and approaching their work. Seven of the participants' responses related to curiosity or an openness to learning or trying something new. For example, "I would stop during training and ask questions like, '[senior scientist], can you go back to the first step? What is electricity? What is a magnet?' I would never have done that when I was in school" (I 1, pp. 7-8). It could also be argued that every participant who changed from having an identity of non-participation to participation in science learning at some point demonstrated curiosity or an openness to science learning during their time as an Explainer.

The findings also reflected a commitment to a positive, or non-judgmental, learning environment. These participants emphasized that the Field Trip Explainers are committed to a certain way of learning together that involves demonstrating an excitement for learning and supporting other people's questions, even when they seem like review for someone else. Allowing oneself to become open to science learning because of the positive environment created by other Explainers is a form of alignment with the shared commitments of the community of practice.

> I was not an active learner as a young person because …my brother got in a lot of trouble, even though I was an A-student, in high school teachers treated me like I would be a bad kid, and so I took on that identity and eventually that's how I saw myself. As an Explainer, the attitude I was given and witnessed in others was, of course you're a great person, an active learner, and have something to contribute. It's assumed that you're

> going to be successful. I feel like that's a great place, just assume that everyone is going to achieve (I 11, pp. 6-7).

There were participants for whom the desire to fit in with the shared values of the group was, at times, a painful experience. Although this occurred for only a very small number of participants, it is important to consider. One participant, when she began talking about the shared goals and commitments of the group said,

> It's not just expected, but enforced by the group. Maybe that's not true. There are people who are respected as sources of authoritative information like [senior scientist]. It's acceptable to just ask him for the answer, so maybe the Explainer group has a strong sense of hierarchy in that way, which kind of pissed me off (I 5, p. 4).

As I described in depth in the previous chapters, this particular community of practice has a strong sense of shared commitments, community boundaries, and tacit agreements about who holds privileged positions. For most respondents, being an Explainer was a joyful experience to find a group with whom to explore these commitments of openness, curiosity, and learning. However, the very strength of the community identity made the experience of becoming participants difficult for two people. When managing such a group, it is important to keep in mind the stress that can be experienced when an individual's identity comes into conflict with that of the rest of the group. As one participant said, "there's a lot of power and a lot of responsibility in that process" (I 15, p. 11).

### *E. Chapter Summary*

Did participants develop identities as science learners through engagement, imagination, and alignment, as Wenger (1998) asserts people do in communities of practice? Yes, they did.

While this framework is not a perfect fit to describe the science-learner identity development of the Field Trip Explainers, it is a good fit. Wenger (1998) argues that what one learns through a community of practice is to become a "kind of person." In the Exploratorium Field Trip Explainer program, participants learn to become Explainers. A logical question for them, then, is: "What kind of person is an Explainer?" I am particularly interested in the extent to which Explainers identify themselves as science learners, and how these identities develop.

According to the interviewees, an Explainer is a curious person who is open to and interested in learning about anything, and open to multiple approaches to learning. Science learning activities are an integral part of their practice, and they come to see science learning as a part of their everyday lives. Explainers' identities are not limited to science learning, as many of them are interested in learning about and engaging in other topics as well, such as literature and visual arts. What changed for them is their understanding that in addition to their pre-existing identities and interests, science learning is also possible and becomes an exciting part of their lives.

Explainers develop identities as science learners through engagement in practice, social imagination, and alignment with the shared commitments of the community. Participants identified that engagement in the practice of science learning with other Explainers and adopting the shared values of curiosity, openness, and non-judgmental learning contributed to their understanding that science is a part of their everyday lives, and that science learning is a part of their identities. The following chapter discusses the findings in more detail and offers implications for related theory and practice.

# IX. Discussion and Implications

## *A. Introduction*

### *Review of the Case Study*

This dissertation research was a case study examining the science-learner identity development of emerging adults who participated in the Exploratorium Field Trip Explainer Program. The NRC (2009) Six Strands of Science Learning and Wenger's (1998) communities of practice theoretical framework were used as analytical tools to understand the case.

This research is significant because of the urgent need for adults to engage as science-literate citizens in the pressing environmental issues that the world faces today. Climate change, loss of biodiversity, and public health issues, to name a few, require swift and well-informed decisions and actions to protect human lives and the environment. If adults are to make scientifically-informed decisions in the polls and marketplaces, then they need to have opportunities to engage in science learning.

Science learning for most adults occurs outside of formal settings, and yet most science museum programming (63%) is actually designed for families or children (Sachatello-Sawyer et al., 2002). While adults indicate an interest in learning science through museum programs, museum programming designed specifically for adults tends to be in the form of lectures that adults indicate are "boring" (Sachatello-Sawyer et al., 2002). This situation indicates that there is an opportunity for science museum programming that is designed to meet the learning goals and needs of adult audiences.

### *Review of Findings*

This case study research consisted of interviews of sixteen recent participants in the Field Trip Explainer Program, participant observation, and document review. Five chapters presented

the case context and findings from each of the four case study sub-questions. In brief, this case study revealed the following:

1. Before becoming Explainers, most participants felt that science learning is an exclusive activity. By the time participants finished their time as Explainers, all of them understood science learning as something that is a part of their everyday lives.
2. The Field Trip Explainer Program is a community of practice in which the participants' shared values include curiosity and openness to multiple ways of learning and approaching their work. Participants learn from one another and through practice, and continually negotiate their identities as they gain experience in the program.
3. Explainers regularly engage in all Six Strands of Science Learning (NRC, 2009) as a part of their participation in the Field Trip Explainer program.
4. Participants' development of science-learner identities occurred through the three modes of identity development in a community of practice (Wenger, 1998): engagement, imagination, and alignment. Specifically, participants identified the following as contributing to the development of their science-learner identities: a positive learning environment, influence of other people, feeling a sense of excitement, the opportunity to engage in science learning, and finding relevance to everyday life.

The themes that emerged in the data relating to Explainers' development of science-learner identities through participation in a community of practice are reviewed in Table 9.1. In this concluding chapter, I discuss the theoretical, practical, and research implications of this work.

**Table 9.1: Review of the Data Relating to Identity Development in the Explainer Community of Practice**

| Aspects of a Community of Practice (Wenger, 1998) | Components of the Explainer Community of Practice that Supported the Development of Science-Learner Identities |
|---|---|
| **Elements of the Community of Practice** | |
| Meaning | Explainers participate in the community of practice for a substantial period of time—one to three years—allowing them time to negotiate their identities as they gain experience. |
| Community: Mutual Engagement | The Explainer program is diverse, creating authentic opportunities for participants to learn in a diverse environment, and for participants to leverage their complementary skills and knowledge. |
| Community: Joint Enterprise | The Explainer community shares values that support science learning: curiosity and openness to multiple ways of thinking, learning, and working. |
| Community: Shared Repertoire Learning | Explainers have a shared repertoire of experiences, stories, language, and practices that provide a foundation for their identity development. The community is made up of a constantly shifting group of people, which creates space for newcomers to arrive with fresh knowledge, skills, and perspectives. Simultaneously, experienced participants can stay on for multiple years, passing on their expertise to new participants as they continue to gain experience and develop as well. Explainers learn from one another how to *be* an Explainer. |
| **Modes of Science-Learning Identity Development in the Community of Practice** | |
| Engagement | Explainers regularly engage in science learning activities as a part of their Explainer practice, consistent with the Six Strands of Science Learning (NRC, 2009). |
| Imagination | Explainers are exposed to other Explainers and staff members, including scientists, who role model potential trajectories of identity development. |
| Alignment | The Explainer community of practice supports and nurtures a positive learning environment, in which new Explainers are given the psychological space to develop their science-learning potential. |

The main finding of this research is that the Exploratorium Field Trip Explainer program offers one example of a way to create opportunities for emerging adults to develop identities as

science learners, and possibly become more engaged and capable, science-literate citizens. The communities of practice framework (Wenger, 1998) proved to be a valuable tool with which to examine and understand the Field Trip Explainer program and could be applied to other, similar informal learning and workplace contexts. The following sections review the implications of this case in the areas of: 1) science literacy; 2) informal science learning; 3) adult learning; and 4) the communities of practice theoretical framework (Wenger, 1998).

### *B. Science Literacy for Adults and Non-Dominant Groups*

The knowledge, skills, and attitudes of science literacy include understanding natural phenomena, the ability to engage in the process of inquiry, and having motivation and an identity as a science learner (AAAS, 1993; NRC, 1996, 2009). As efforts to improve science instruction in K-12 schools are still underway, the United States continues to produce high-school graduates lacking in science literacy. In this section, I describe the contribution of this research in understanding how adults and people from non-dominant groups become science learners.

#### *Beyond K-12: Science Learning for Adults*

The findings of this study indicate that participants in the Exploratorium Field Trip Explainer Program developed identities as science learners during their time in the program. For most (ten) of the research participants, the development of science-learning identities was connected with their understanding of the definition of science learning. These ten participants understood science learning as a rigid process reserved for a select group of people, but as Explainers changed their understanding to include science learning as a part of their everyday lives. In part, this understanding had to do with their perceptions of their abilities in science, and in part with their ideas about who has access or permission to do science. Many participants

connected these ideas with their past science-related experiences, which for most of them happened in formal school environments. According to the NRC, "much of science instruction in schools focuses narrowly on received knowledge and simplistic notions of scientific practice" (2009, p. 1).

The NRC asserts that existing approaches to science instruction are weak, spurring them to create a new *Framework for K-12 Science Education* (2011). This new framework represents an evolution from the prior standards (NRC, 1996) and includes a new focus on students' ability to pursue careers in science and engineering. Evidence for the weakness of science instruction in K-12 schools is presented in a recent report on the state of science in California schools (Dorph, Shields, Tiffany-Morales, Hartry, & McCaffrey, 2011), which states that only 10% of California K-12 students receive the quality and quantity of science education that meets the NRC (2007) vision laid out in *Taking Science to School*.

Given that efforts to improve science literacy for K-12 students are still not actualized, the imperative to provide opportunities for adult science learning is even greater. Although people who developed an interest in science by middle school are more likely than those who had not to pursue careers in science, technology, engineering, or math (STEM) (Dabney, Tai, Almarode, Miller-Friedmann, Sonnert, Sadler, & Hazari, 2011), the findings of this dissertation research suggest that adults—regardless of their pre-existing abilities and identities in science learning—can become science learners through participation in an informal, workplace learning environment.

In addition, the findings of this study have implications for the way that not only schools, but scientists, communicate about science. Most of the participants in this study began the Explainer Program believing that science is reserved for a select group of people. Nelkin (1995)

accuses the media of portraying scientists as elite and their work as inaccessible to most people. Some groups of scientists, such as the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) now communicate directly to the public through their websites and are actively engaged in educational outreach relating to their research ("Education Resources," 2011; "Educator Features and Articles," 2011). This type of work could prove to play an important role in the way that children and adults develop ideas about who has access to science learning, and deserves careful attention to the way in which science and science learning are portrayed.

*Increasing Diversity: Science Learning for Non-Dominant Groups*

Magnifying the problem of limited science instruction for K-12 students is the fact that there are persistent gaps in science achievement between dominant and non-dominant groups (see NRC, 2009 for a review). On an international scale, gender stereotypes and inequity in science education diminish opportunities for women to pursue STEM careers (Buccheri, Gurber, & Bruhwiler, 2011). In California, a state in which citizens and educators have identified science education as a top priority, there is a significant gap in proficiency between Caucasian students and Latino, African American, and economically disadvantaged students (Dorph, et al., 2011). Further reducing the potential to close these gaps in adulthood, adults who have not completed high school or college are less likely than those who have to participate in continued learning in adulthood (Merriam et al., 2007).

Increasing engagement of traditionally non-dominant/non-mainstream groups of people in science learning has been identified as a priority for both schools and informal learning institutions (Banks, et al, 2007; Buccheri et al, 2011; NRC, 2009), yet the need for programs to

engage these audiences still exists. The case of the Exploratorium Field Trip Explainers illustrates one way to successfully engage a diverse adult audience in science learning.

As was represented by the participants in this study, the Exploratorium Field Trip Explainers are a diverse group of people. They vary in ethnic backgrounds, gender, degrees earned, languages spoken, subject-areas studied, personal interests, and life experiences. Ten participants entered the Explainer program believing that science was too difficult or not relevant to their lives. By the end of their tenure as Explainers, all sixteen participants left the program with identities as science-learners who see science as connected to their everyday lives. Furthermore, most participants (13) are now pursuing further education or careers in science or science education.

Although informal science institutions such as museums are likely places for non-dominant groups to engage in science learning, visitors are disproportionately Caucasian, have high household incomes, and high levels of education (Sachatello-Sawyer, 2002); and people outside of this group may perceive science museums as unwelcoming or irrelevant (NRC, 2009). Among other programmatic recommendations, the NRC recommends that "Given the diversity of community members who do (or could) participate in informal environments, front-line educators should embrace diversity and work thoughtfully across diverse groups" (p. 9-14). This recommendation should extend beyond front-line educators *working with* diverse audiences to include front-line educators actually *representing* diverse communities themselves.

Explainers work and learn together as a group and develop skills in communicating with people who are different from themselves. As previously discussed, Explainers value the diversity of life experience, skills, and knowledge of the community members and actively learn from one another through their practice. In this case, people who were outside of the science-

learning community became Explainers and then science learners, and through interacting with the museum visitors, increased science engagement for a more diverse audience. Based on the findings from this case, I recommend that science museums consider hiring staff from non-dominant groups as a way of creating opportunities for people to enter into the science community. In any community of practice, there are boundaries to participation; this reality means that there is always someone who is left out of the community. As practitioners work to assemble diverse frontline staff, they should be mindful of who is included, who is excluded, and how hiring requirements should be adjusted to support the diversity sought.

### *C. Adult Workplace Learning*

#### *Museum Staff as Learners in the Workplace*

Museums are known for creating opportunities for *visitors* to engage in learning that is free-choice (Falk, 2001), non-judgmental (NRC, 2009, p. 2-14), and constructivist and social (Falk, et al., 2007; Hein, 1998; Rennie & Johnston, 2007), which can result in increasing visitors' interests and motivation for science learning (Pace & Tesi, 2004; Perry, 1994; Rennie, 1994; Tran, 2006), inquiry abilities (Allen & Gutwill, 2009; Dierking et al., 2003), and understanding of science concepts (Bamberger & Tal, 2008; Falk & Storksdieck, 2005; Gottfried, 1980; Mortensen & Smart, 2007; Orion & Hofstein, 1994).

This case study provides an example of recognizing not only *visitors*, but museum *staff* as learners in the museum environment. Museum educators typically spend considerably more time in the museum than visitors, and so great potential exists to leverage the affordances of the museum environment for educator learning. In the case of the Field Trip Explainer Program, the community of practice values curiosity and openness to learning. In addition, many participants

felt that the positive learning environment of this community contributed to the development of their science-learning identities. This set of values could be contrasted with a community of practice in which staff members are already expected to be science experts and the role of learning is reserved for the visitors. Whether they value learning, communities of practice already exist in many workplaces (Bailey, 2006; Brown & Duguid, 1991; Eames & Bell, 2005; Hodkinson & Hodkinson, 2003; Knight, 2002; Light, 2006; Merriam, 2003; Palincsar, et al, 1998). Bailey (2006) found that museum educators have to continuously learn on the job to keep up with their practice. There are power dynamics in the workplace, and expectations relating to learning are culturally embedded; this situation impacts how and what people learn in the workplace. It makes sense then for managers of museum educators to be mindful of the existing communities of practice, what is explicitly and implicitly valued and expected, and to encourage participants' learning as a community value.

The case of the Exploratorium Field Trip Explainers can serve as an example of an adult-learning program that nurtures the science-learning identities of participants through a community of practice. As previously discussed, simply "creating" a community of practice does not necessarily lead to accomplishing the designer's intended outcomes. Instead, the values and practices of the community are co-created and negotiated among community members, over long periods of time (Wenger, 1998). Consequently, my recommendation is *not* for managers of Explainer or other adult-learning programs simply to set out to create communities of practice; the establishment of a community of practice in itself is not enough. Rather, the value of this case is in the recognition of the aspects of a community of practice that can be nurtured to support intended outcomes. For example, frontline staff working in an informal learning setting

that values conservation increased their conservation-related knowledge, attitudes, and behaviors through exposure to training and other staff (Groff, Lockhart, Ogden, & Dierking, 2005).

*Adult Workplace Learning in a Community of Practice*

As the data suggest, the elements of communities of practice and the modes of identity development within them are complex: they interact with one another, occur over long periods of time, and involve a changing set of individual people, each with their own interests, perspectives, and experiences. Even so, there were two clear themes that emerged as important contributors to Explainers' development of science-learning identities, described below.

*1. One Community of Practice:* First, it may not seem surprising that the Field Trip Explainers are a community of practice, as communities of practice are ubiquitous and do not need to be designed in order to exist (Wenger, 1998). However, the data suggest that the Field Trip Explainers comprise *one* community of practice, rather than several. Within this community of practice, Explainers develop shared values of curiosity and openness to trying new things and multiple ways of learning.

Science museum education programs are commonly comprised of staff with variable schedules who do not work together as a group, creating fragmented communities of practice (Dean, S. and Bones, D., personal communication, October 2011). Due to the personal commitments of staff members and the budgets of museums, it can be challenging to find times to come together for regular staff meetings and training sessions. In these cases, programs are challenged to foster *one* community of practice through which participants may develop identities. Museums for whom this is the case could examine the ways in which museum educators can share elements of one community of practice so that they build shared experiences, learn from one another, and share values across participants. As Wenger (1998) states, learning

in communities of practice cannot be designed, but can be designed *for*. In other words, it is important to create the structures in which learning through a community of practice can occur. For example, learning about the shared values of the community of practice in the Field Trip Explainer program often occurred through peers working together on the museum floor. Additionally, study participants indicated that the influence of other Exploratorium staff (such as the senior scientist who frequently leads training sessions) was important in the development of their science-learner identities.

*2. Participants Engage in Science Learning*: It also may not seem surprising that Field Trip Explainers regularly engage in the Six Strands of Science Learning (NRC, 2009), as they do work in a science-learning institution. However, aside from a few exceptions (such as the New York Hall of Science or the Ruben H. Fleet), science museum educators are rarely paid to learn science on the job (Dean, S. and Bones, D., personal communication, October 2011). Furthermore, very little time is set aside in most museums for staff to engage in learning together (or alone), and when training is offered, the focus is often on learning about communication or customer service rather than on learning about science and science learning (Silva & Bultitude, 2009). This case study illustrated that opportunities to engage in science learning activities directly contributed to participants' development of science-learning identities. Based on the findings from this research, I recommend that museums consider ways to incorporate opportunities for educators to engage in science learning activities together. For example: set aside time for educators to suggest and investigate their own questions relating to the museum's exhibits or education programs; create a shared online space such as a wiki or blog where educators can post learning resources that interest them; or structure time during the work day for educators to explore exhibits together or with other museum staff.

When asked what most contributed to the development of their science-learning identities, most study participants (11 of 16) indicated that it was learning in a positive environment in which they were accepted for their ideas, levels of science background, and ways of learning. This characteristic of a learning environment is well-suited for children's programs or adult programs in which performance is not imperative. It may seem inefficient for adult educators to be paid to learn science on the job, and to do so in whatever way best suits them. In fact, Tran and King (2007) suggest that the field of museum education could be professionalized to include a license to practice. While it is valuable to recognize the specific skills and knowledge required of museum educators, limiting the profession to those who do not require on-the-job training would limit many people from entering the profession. Conversely, the findings of this research suggest that creating opportunities for museum educators to learn science (and other professional skills and knowledge) on the job can result in increasing science literacy in adults who do not have science backgrounds.

The Exploratorium Field Trip Explainer program invests heavily in training and professional development time. However, this investment reaps returns in Explainers becoming motivated to teach and learn science. Future research could explore whether their excitement and motivation for learning in turn positively impacts the visitors with whom Explainers interact on the museum floor.

With those two things in place—1) a community of practice in which 2) participants engage in science learning—it is important to consider what the community *values* and *how* the science-learning activities happen. In the case of the Field Trip Explainers, participants share values that support science learning: curiosity and openness to multiple ways of thinking, learning, and working. To the participants, what it means to be an Explainer is to be a curious

and open person, not to be knowledgeable about or skilled in science. This is an important distinction, as this means that Explainers are learners in an environment in which one is not judged negatively for lacking in scientific ability. Instead, space is created for Explainers to *become* knowledgeable about and skilled in science. My recommendation relating to these findings is for museum education leaders to consider what their communities of practice value, and what the implicit or explicit expectations are for participants' identities. In doing so, museum education leaders may consider how they can foster community values and identity expectations that support the development of science-learner identities.

*Reflective Practice*

Findings from this study demonstrate that Field Trip Explainers regularly engage in reflection on the processes of science, learning, and their own practice as Explainers. For example, Explainers: complete annual reflective documents about the skills and knowledge they gained during the year; create visual maps each year of their own learning processes; observe their peers and engage in informal discussions about their practice; and have the option to contribute to a shared blog about their learning, practice, and other thoughts and experiences. Interviews created a further opportunity for participants to reflect on their experiences and learning, and demonstrated participants' ability and willingness to be reflective.

The ability of learners to reflect on the nature of how scientific knowledge is constructed, and the nature of science as a social enterprise is core to engaged citizenship. Related, and equally important, is the ability to reflect on the process of learning science, both for oneself and for others (AAAS, 1993' NRC, 2009). In addition to those reflective skills is the ability to reflect on one's professional practice.

While workplaces do not necessarily have embedded opportunities for reflection, Schön (1983) argues that professionals can develop expertise by reflecting on their work, stepping back to examine their practices and decision-making. Since Schön coined the notion of *reflective practice* in 1983, the concept of developing expertise through reflective practice has been explored widely in teacher professional development (e.g., Bright, 1996; Ferry, 1998; Jay & Johnson, 2002; Loughran, 1996; vanManen, 1995). Wenger (1998) posits that within a community of practice, the combination of two of the modes of identity development—engagement in practice and social imagination—result in reflective practice because they involve both participation and viewing the work within a greater context.

Based on observations of pre-service teachers, Loughran (1996) further operationalized reflective practice into anticipatory, retrospective (reflection-on-action), and contemporaneous (reflection-in-action) reflection, and noticed that pre-service teachers are able to increasingly use reflection as they progress through their course of study. The reflective process defined by Loughran (1996) is based on Dewey (1933); this reflective cycle involves suggestions, problem, hypothesis, reasoning, and testing. This case study did not examine the reflective processes of Explainers to this level of detail. Also, only one participant reported that the Explainer community of practice values reflection. Despite this, reflection is a part of Explainers' regular activities and is related to the values of curiosity and openness that participants did identify as important to the community of practice. Future research could explore the extent to which Explainers engage in each of the phases of reflection, what circumstances lead to Explainers engaging in reflective practice, and what impact it has both on their work and their identities and abilities as science learners.

### *D. The Communities of Practice Framework*

When viewed through the lens of adult learning in the workplace, the communities of practice framework (Wenger, 1998) is very similar to other frameworks such as learning communities, learning organizations, and professional learning communities. It is possible that examining this case using one of those similar frameworks would also have produced interesting and useful results. As I discussed in the Literature Review, communities of practice are sometimes conflated with learning communities, learning organizations, and professional learning communities, and so I will clarify the distinctions here.

In a community of practice, learning occurs as people become full participants; this does not always mean, however, that learning itself is a shared value in the community. A *learning community* is a community of practice in which learning is at the "core of its enterprise" (Wenger, 1998, p. 215). In this type of community, participants not only acquire knowledge about how to play their roles, but the community also creates new knowledge through bringing in and testing ideas from outside of its own boundaries. This type of community is reflective and always evolving. A *learning organization* is similar to a learning community; but unlike a community of practice which can naturally occur despite formal boundaries of an organization or department, a learning organization relates to members of one, specific organization. The goal of a learning organization is to improve the organization through individual and group reflection relating to: personal mastery, mental models, shared vision, team learning, and systematic thinking (Wesley & Buysse, 2001). Finally, *professional learning communities* are comprised of teachers and staff in K-12 schools. Similar to learning organizations, professional learning communities are deliberately reflective and learning-oriented, but with a focus on teaching and learning strategies for K-12 classrooms (Stoll, Bolam, McMahon, Wallace & Thomas, 2006). In

the next two sections, I review the strengths and limitations of using the communities of practice framework (Wenger, 1998).

*Strengths of the Communities of Practice Framework in this Case Study*

The communities of practice framework (Wenger, 1998) is a theoretical tool that can be used to understand how learning happens among groups of people. While the communities of practice framework did not fit perfectly with the Field Trip Explainer program, it was the most suitable tool to use to examine the case. The communities of practice framework is comprehensive, flexible, and nuanced, making it a functional analytical framework.

In addition to its functionality, Wenger's (1998) theory that learning and identity are interwoven proved to be important in this case study. Indeed, the data indicated that participants' learning trajectories and identity development occurred over time and influenced one another. As Explainers gradually mastered the skills and knowledge of their practice, their identities as science learners, educators, and curious people developed and solidified. Simultaneously, as Explainers identities developed into people who were allowed to ask questions and explore new ideas, their abilities and opportunities to learn new things about themselves and the natural world expanded.

*Imperfections of the Communities of Practice Framework for this Case Study*

Wenger (1998) defines practice as the act of doing something within "a historical and social context that gives structure and meaning to what we do" (p. 47), and identity as a set of experiences and their social interpretation (p. 151). He describes five essential components of practice, which are: *meaning, community, learning, boundaries,* and *locality*. The findings of this study indicate that, yes, Exploratorium Field Trip Explainer experiences do reflect a community of practice. In particular, the data indicate that the components of *meaning*, *community*, and

*learning* are important to understanding the Explainer community of practice and how Explainers' identities manifest within that community. *Boundaries* and *locality*, however, emerged as less important components for understanding how Explainers identities manifest in their community of practice. These findings might suggest that the components of the communities of practice framework can vary in value depending on the characteristics of the case under examination. It is also possible that these two elements of a community of practice did not emerge strongly in the data because they are so pervasive and central to the community of practice that they did not warrant mentioning by the participants. In future research that employs the communities of practice framework, researchers might consider what elements of the framework are so fundamental that participants may not mention them and design questions that elucidate these elements more deliberately.

This dissertation research also employed Wenger's (1998) three modes of identity development—*engagement*, *imagination*, and *alignment*—as an analytical frame. While these three modes emerged in the data as contributors to Explainers' identity development, they were not ideal constructs for understanding the data. While participants' ways of talking about their experiences included elements of Wenger's (1998) definitions of these terms, they did not fall neatly into those categories. For example, this research indicates that Explainers' identity development through *social imagination* occurred but in a way that was somewhat different from Wenger's (1998) description. The data suggests that the generation and sharing of stories related to science learning occurred for participants, and surfaced as a part of how their identities manifest in practice throughout the interviews. I quoted many of these stories in the Findings chapters—for example, the light walk, the secret sea urchin, and the flower dissection training sessions. However, participants did not talk about these stories in their interviews as something

they thought contributed to their science-learner identity development in the way that Wenger describes it. Additionally, only one participant expressed that his identity development was related to placing himself within a broader network (the example of the Explainer who participated in a workshop for Explainer managers).

Rather than using the three modes of identity development as a separate heuristic for data analysis, it may be more productive for researchers to tie evidence of identity development back to the five elements that describe a community of practice: meaning, community, learning, boundaries, and locality. The first mode of identity development, *engagement*, is essentially the act of engaging in the practice(s) of the community, which are described throughout the five elements. Second, *imagination*, is closely related to the third element, *learning*. In this case, participants extensively described learning from other people—more experienced Explainers, their peers, incoming Explainers, and other Exploratorium staff. As they did so, they engaged in the act of imagining possible trajectories—something that Wenger (1998) describes as a key type of learning that occurs in communities of practice. Finally, *alignment* is the act of aligning with the joint enterprise of the community of practice—a process that is described in detail within the *community* element. Given these overlaps, I recommend that researchers examine identity development in communities of practice using the Wenger's (1998) five elements as an analytical tool rather than engagement, imagination, and alignment, and further explore the distinctions and interconnections among these elements.

*Considerations for Using the Communities of Practice Framework*

The communities of practice framework helps researchers and practitioners understand *how* learning occurs, however it does not help them understand *what* people are (or are not) learning. As previously discussed, not all learning that happens is communities of practice is

necessarily desirable—any knowledge, skills, habits, or practices can be passed on among participants. In this case study for example, the community of practice exists within a science museum. One might apply the communities of practice framework to understand how learning happens among Explainers and assume that these participants are learning science. Using only the communities of practice framework, however, misses an opportunity to better understand when science learning is in fact the type of learning taking place.

In this case study, I employed both the communities of practice framework (Wenger, 1998) and the Six Strands of Science Learning (NRC, 2009) to create a more robust picture of Field Trip Explainer learning and identity development. The NRC (2009) framework created a structure for understanding the content of Explainer learning. I recommend that the communities of practice framework be used on concert with a second framework in both research and practice as a way of constructing a more complex understanding of the communities of practice under examination.

Finally, Wenger (1998) does warn that communities of practice do not necessarily result in perfect, easy, or positive experiences for all participants. As I described in depth in the previous chapters, this particular community of practice (the Field Trip Explainers), and probably many others, has a very strong sense of shared commitments, community boundaries, and tacit agreements about who holds privileged positions. For most participants, it was a joyful experience to find a group with whom to explore these commitments of openness, curiosity, and learning. However, the very strength of the community identity made the experience of becoming participants difficult for a small number of people (two). When leading or participating in such a group, it is important to keep in mind the stress that can be experienced

when an individual's identity comes into conflict with that of the rest of the group. As one participant said, "there's a lot of power and a lot of responsibility in that process" (I 15, p. 11).

### *E. Recommendations for Practitioners*

This case study research offers insights to inform practitioners as well as researchers. Suggestions include:

1. Informal science institutions that are interested in serving diverse audiences should consider that this audience might include their paid staff. These institutions may decide to hire staff from groups that are underrepresented in science museum visitation (non-Caucasian people and emerging adults) as a way of creating opportunities for people to enter into the science community.
2. Science-learning institutions should build in opportunities for educators (and other staff) to engage in science learning activities together. For example:
    a. set aside time for staff members to suggest and investigate their own questions relating to the museum's exhibits or education programs;
    b. create a shared online space such as a wiki or blog where staff members can post learning resources that interest them;
    c. structure time during the work day for staff members to explore exhibits together.
3. Organizations should be mindful of their existing communities of practice and encourage participants' learning as a community value.
4. Organizations should consider what their communities of practice value, and what the implicit or explicit expectations are for participants' identities.

5. Organizations should regularly engage adults in reflection on the processes of science, learning, and professional practice. For example, adults may:
    a. complete reflective documents about the skills and knowledge they have gained during the year;
    b. observe their peers and engage in informal discussions about their practice;
    c. have the option to contribute to a shared blog about their learning, practice, or other thoughts and experiences.

### *F. Limitations*

Every study has limitations, and this case study is no exception. This research examines only one case, at a specific point in time. This research does not make comparisons to other, similar cases, and does not examine the trajectories of Field Trip Explainers beyond the first three years after leaving the program.

In order to strengthen the findings from this case, I would have liked to include the following:

1. A comparison between the Exploratorium Field Trip Explainer Program and similar adult educator programs in other science learning institutions.
2. A comparison between the Exploratorium Field Trip Explainer Program and other workplace communities of practice outside of the field of education.
3. A longitudinal study of Explainers examining the long-term trajectory of their science-learner identities, including their choices of hobbies and occupations.
4. An external research partner (not a part of the Field Trip Explainer community of practice) with whom to triangulate findings.

5. A closer examination of the lives of participants leading up to their decision to participate in the Field Trip Explainer Program, including their interests, educational experiences, and participation in other communities of practice.

### *G. Questions for Future Research*

This case study examined only one case of science museum educators among many that exist around the globe. The findings of this case provide an example for other programs to build understandings of how emerging adults develop science-learning identities through participation in a community of practice. This research also creates a starting point for the construction of new knowledge through future lines of inquiry. Based on the implications and limitations of this case, below are additional lines of inquiry that would build on the findings of this research.

1. This study found that Exploratorium Field Trip Explainers develop science-learner identities through participation in a community of practice. Do science museum educators in other institutions also build science-learner identities? What are other examples of ways in which this can occur?
2. Do science museum educators in other institutions also reflect communities of practice framework? If they do, how are those communities of practice similar to and different from the one at the Exploratorium? What else can be learned about the values and practices of other communities?
3. This study found that Field Trip Explainers' science-learning identities persist at least three years after leaving the program (based on the constraints for participation in the study). How much longer does the science-learner identity developed by Field Trip Explainers persist after leaving the program?

4. This study found that participants' science learner identities manifest in their lives, career choices, and civic engagement after leaving the Explainer Program. To what extent does this manifestation occur, and what are specific examples of this impact?
5. This study found that Explainers develop teamwork and communication skills. More specifically, what skills do they learn, and how do they learn them? How do they apply these skills to subsequent life and work experiences?
6. This study examined what facilitated the learning of Field Trip Explainers. What experiences or aspects of the program hinder their learning?
7. In addition to building identities as science learners, do Field Trip Explainers also build leadership identities and skills? If so, what contributes to that outcome?
8. To what extent do the expectations of employment influence Field Trip Explainers' motivations for becoming science learners? Do adults in similar, non-paid programs also develop identities as science learners?
9. To what extent do Field Trip Explainers engage in reflective practice? What are the elements of this process? What circumstances in the workplace best support reflective practice? To what extent does reflection influence their work and their identities or abilities as science learners?
10. In this case study, the organization in which the case is embedded, the Exploratorium, shares the values of the Field Trip Explainer community of practice. How might the outcomes be different for a case in which the larger organization does not share the values of the embedded case?

### *H. Chapter Summary*

This research demonstrates that Exploratorium Field Trip Explainers develop science-learner identities through participation in a community of practice. In addition to science learning, Explainers gain teaching skills, the ability to work in a diverse group, and learn things about themselves. This case study can be used as a model for other programs to engage people from culturally-diverse groups in science learning, design programs that recognize museum educators as learners, and design programs for adult learners that leverage the communities of practice framework to support the development of science-learner identities. This case has implications for theory, practice, and research in science literacy for adults and non-dominant groups, adult workplace learning, and communities of practice. Future research should build upon this case and continue to deepen our understanding of how science museum educators can develop identities as science learners. The hope is that facilitating the development of a more science literate and engaged citizenry will help to avoid future environmental challenges and lead to solutions of existing ones.

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## Appendices

### Appendix 3.1: Recruitment Letter

Dear _____,

I have exciting news, which is that I am now ready to begin the research process for my dissertation, and I would love to include you as participants in my research! *Your participation in this study is entirely optional.* Here is some specific information about it:

**Title of Dissertation**: Explainers' development of science-learner identities through participation in a community of practice

**Purpose of Research**: The purpose of this study is to create a rich description of the experiences of people who participated in the Exploratorium Field Trip Explainer program within the last three years. I am doing this research through Antioch University New England in partial fulfillment of the requirements for a PhD in Environmental Studies.

**Eligibility Requirements for Participation in Study**:
The participants in this study must:

1) have been Field Trip Explainers for at least eight months,
2) no longer be participants in the program, and
3) have left the program no more than three years prior to the beginning of the data collection process.

If you are receiving this letter, then you do meet the minimum eligibility requirements. I'm hoping to include 9-15 of you as participants in this study.

**What it Involves:**
Your participation in this study will involve:

1) Completion of a 10-minute reflective survey. This can happen from any computer and be returned to me via e-mail. (October-November, 2011)
2) Participation in a one-hour interview. (October-December, 2011)
    a. If possible, these interviews will be face-to-face. If you cannot meet with me in person, interviews may be conducted over the phone.
    b. Interviews will be audio recorded for my review.
    c. Interview questions will explore your perspectives about your experiences in the Field Trip Explainer program, your engagement in science-learning activities, and your perception of your identity relating to science learning.
    d. I will share my reports of our interviews with you to review for accurate representation of your perspectives and experiences.

**If you want to Participate**:
You may contact me with any questions. Please reply to me by email no later than October 15, 2011 to indicate your interest. You will need to read and sign the attached Documentation of

Informed Consent form. I will respond to you by October 31, 2011 to notify you of your inclusion in the study and to schedule our next steps.

Thank you!
Anne Richardson
Manager, Field Trips
Exploratorium
anner@exploratorium.edu
416.674.2889

**Appendix 3.2: Documentation of Informed Consent**

**Documentation of Informed Consent**
**For Participation in:**
**Explainers' development of science-learner identities**
**through participation in a community of practice**

I am asking you to take part in a research study on the Exploratorium Field Trip Explainers' experiences and ideas about their work. Data from this study will be used in my dissertation and may be published—the information below is meant help you make an informed choice about whether you choose to participate.

**Purpose of Study**
The purpose of this study is to create a rich description of the experiences of people who participated in the Exploratorium Field Trip Explainer program within the last three years. I am doing this research through Antioch University New England in partial fulfillment of the requirements for a PhD in Environmental Studies.

**Voluntary**
You are not required to participate in any way, answer questions you do not wish to answer, or allow me to use data involving you. Your participation is completely voluntary and may be withdrawn at any time without penalty.

**If you decide to participate:**
Your participation in this study involves:

3) Completion of a 10-minute reflective survey. This can happen from any computer and be returned to me via e-mail. (October-November, 2011)
4) Participation in a one-hour interview. (October-December, 2011)
    a. If possible, these interviews will be face-to-face. If you cannot meet with me in person, interviews may be conducted over the phone.
    b. Interviews will be audio recorded for my review.
    c. Interview questions will explore your perspectives about your experiences in the Field Trip Explainer program, your engagement in science-learning activities, and your perception of your identity relating to science learning.
    d. I will share my reports of our interviews with you to review for accurate representation of your perspectives and experiences.

I will also review documentation as part of my data collection process. Documents that may be reviewed include the Explainer Blog and documentation of Explainer training sessions. I may also review progress reports and other reflective writing statements, only with your express permission.

**Anonymity**
In order to protect your privacy, all participants will be anonymous. During the data collection process, I will create a system that allows me to separate your names from the data.

**Risks and Discomforts**
This study should not pose any risk to you. It is in no way connected to your previous, official employment status as a Field Trip Explainer at the Exploratorium.

**Benefits**
You: This study gives you the opportunity to reflect on your Field Trip Explainer experience and to share your experiences and ideas.
The Program: The results should inform the work of the Field Trip Explainer program as a whole, providing information that will allow the program to be better designed.
The Field: If the results of this study are published, they will inform the field of science museum education and provide information for further discussion.

**Investigator**
Anne Richardson
Manager, Field Trips
Exploratorium
3601 Lyon Street
San Francisco, CA 94123
415.674.2889
anner@exploratorium.edu

**Human Rights Statement**
If you have any questions regarding your rights as a research participant, please contact the Director of Research, Department of Clinical Psychology, Antioch New England Graduate School, at 603.357.3122 ext. 236.

Name _____

Signature _____

Date _____

**Appendix 3.3: Reflective Activity Instrument**

Dear _____,
Please complete this reflective activity comparing your relationship with science learning before and after your tenure as an Exploratorium Field Trip Explainer. If you're unsure of the meaning of the questions, answer them based on your own interpretation. You may leave comments in the spaces if you need to. We'll talk about your interpretations and responses in more detail during your interview. Thank you!

1. Please mark an X on the scale that most closely represents your relationship with science learning *on the day before you began* work as a Field Trip Explainer. Date that you began working as a Field Trip Explainer: _____

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I was not interested in, did not enjoy, or did not participate in learning science. | | | | | I was interested in, enjoyed, and participated in learning science. |

2. Please mark an X on the scale that most closely represents your relationship with science learning *on the day after you finished* working as a Field Trip Explainer. Date that you finished working as a Field Trip Explainer:_____

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I was not interested in, did not enjoy, or did not participate in learning science. | | | | | I was interested in, enjoyed, and participated in learning science. |

3. Please mark an X on the scale that most closely represents your relationship with science learning *now*. Today's date: _____

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am not interested in, do not enjoy, or do not participate in learning science. | | | | | I am interested in, enjoy, and participate in learning science. |

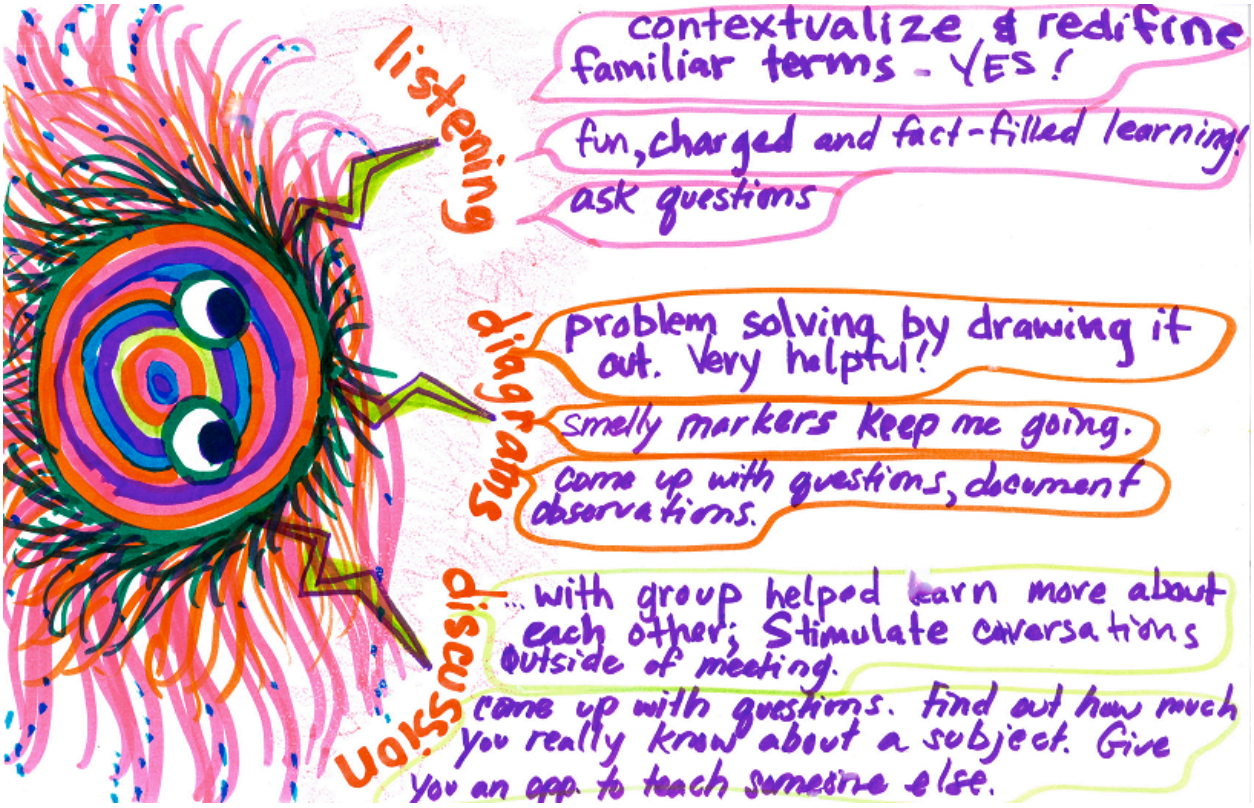
**Appendix 3.4: Interview Guide**

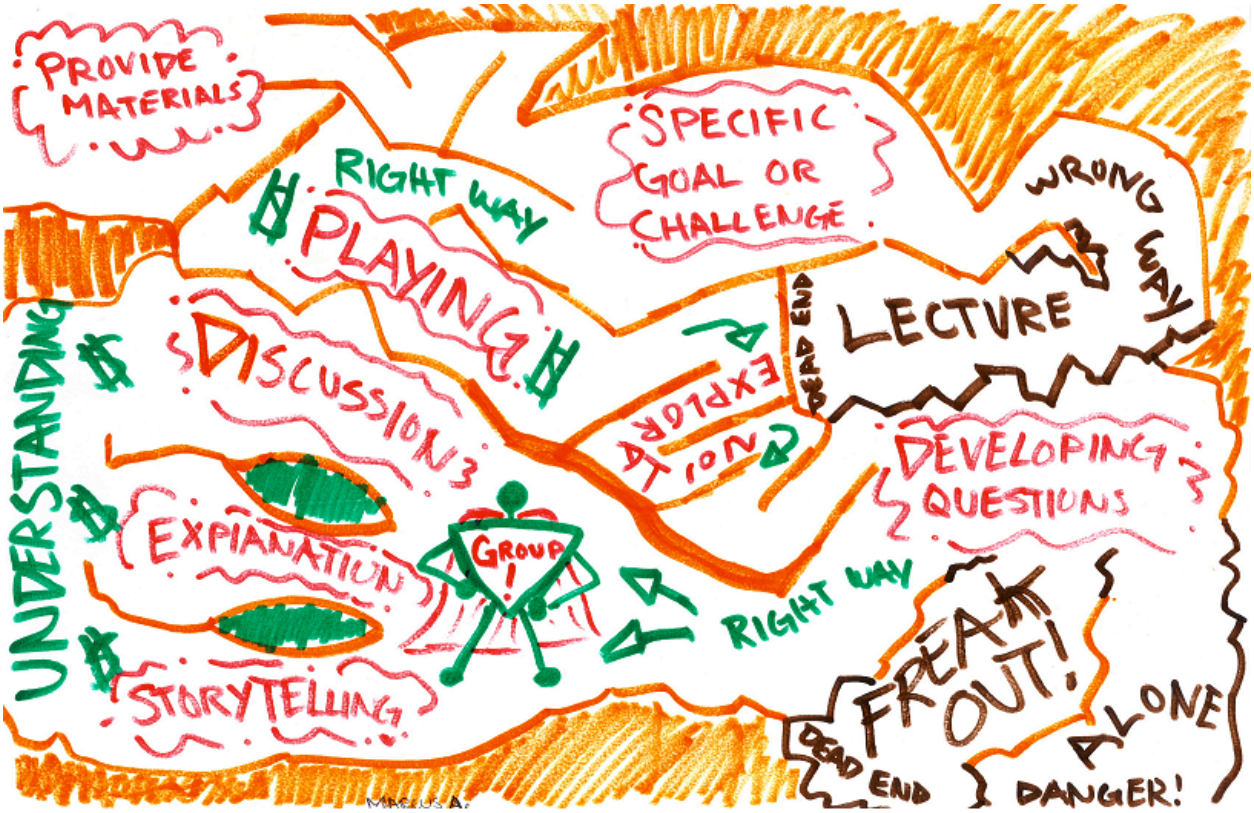
| Interview Questions | Connections to Case Study Questions |
|---|---|
| **Part A: Introduction** | |
| Thank you for agreeing to participate in this interview. It should take about an hour. As I mentioned in the letter I sent you, the purpose of this interview is for me to gain a better understanding of your experiences as a Field Trip Explainer. There are three sections to this interview: your ideas about Field Trip Explaining, your engagement in science-learning activities, and reflections on your reflective activity. You may stop me at any time to ask for clarification.<br>First, remind me: During what years were you a Field Trip Explainer?<br>What were your reasons for becoming a Field Trip Explainer? | |
| **Part B: Field Trip Explainer Identity and Enterprise** | |
| In this first section, I'm interested in your general ideas about Field Trip Explaining. | The first two questions are warm-up questions, designed to ease the participant into the interview. |
| 1. What did you do as a Field Trip Explainer? | Practice |
| 2. Can you tell me about a day in your life as an Explainer?<br>a. What kinds of things would you do?<br>b. What types of decisions did you have to make?<br>c. What kinds of daily experiences did you most value? | Enterprise of the Community of Practice |
| 3. What kinds of skills and knowledge did you develop as a Field Trip Explainer through your practice? | Engagement and Identity |
| 4. With whom did you interact most regularly to get your work done?<br>(pay attention here to differences between interactions relating to getting the work done, and learning to do the work) | Boundaries of the Community of Practice |
| 5. In your opinion (or experience), what kind of person is a Field Trip Explainer (or what kind of person were you as a Field Trip Explainer)<br>a. Before they become a Field Trip Explainer?<br>b. During their time as a Field Trip Explainer?<br>c. After they leave the Field Trip Explainer Program? | Wenger (1998) argues that what one learns through a community of practice is to become a "kind of person." In the Exploratorium Field Trip Explainer program, |

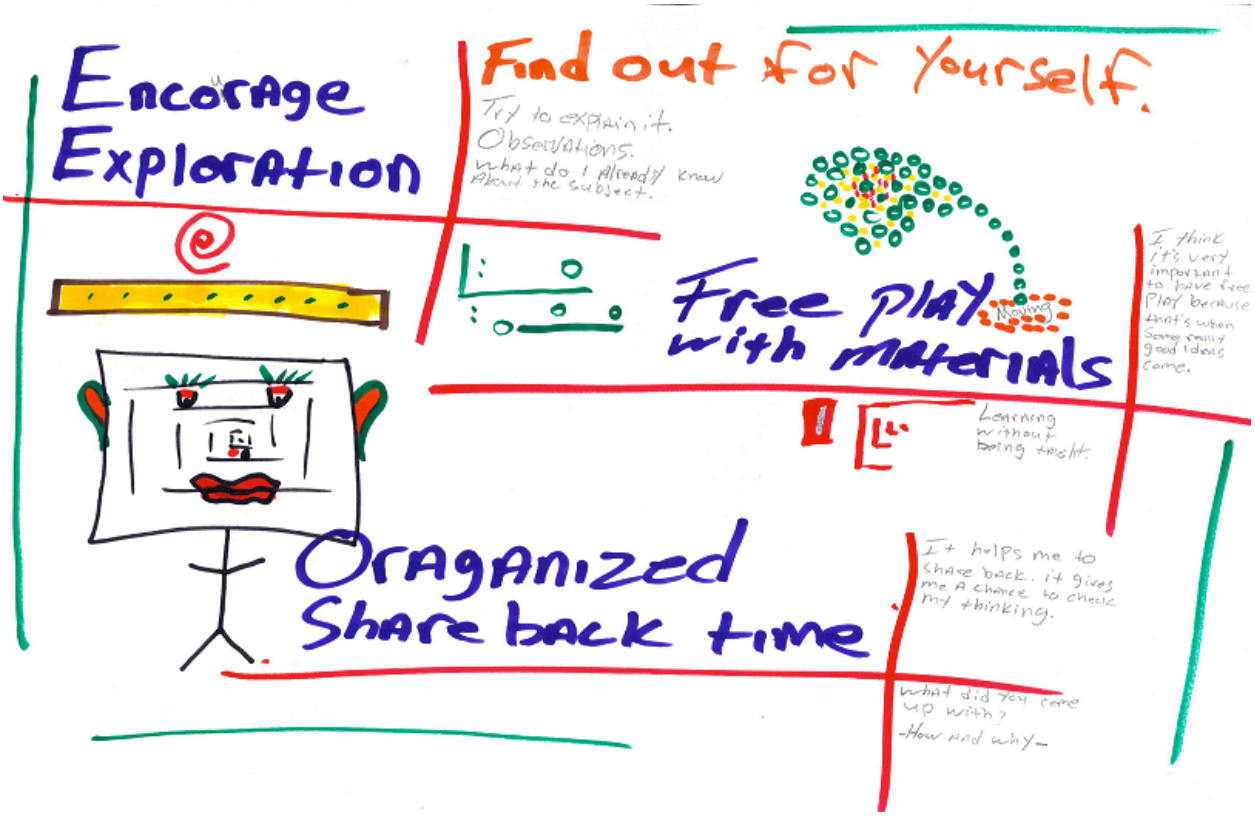
| | |
|---|---|
| | participants learn to become Explainers. |
| 6. Do you imagine that the Field Trip Explainers are part of a broader group of people with a similar vision? If so, what group would you say that is? What are the characteristics (or qualities) of that group? | Imagination and Identity |
| 7. Do you think that the Field Trip Explainers have a shared set of goals, beliefs, or commitments? If so, what do you think those are?<br>a. Did you share those goals, beliefs, or commitments with the rest of the Explainers?<br>b. If so, was this your choice or was it expected of you? How so? | Alignment and Identity |
| 8. Did you ever contribute any ideas, objects, or words (such as a floor walk, an Explainer box prop, etc.) that were adopted by the Field Trip Explainers? Can you give an example? | Engagement and Negotiation of Identity |
| 9. Are there any stories that have been shared over time among the Field Trip Explainers that you participated in generating and sharing? Can you give an example? | Imagination and Negotiation of Identity |
| 10. How did you learn to be an Explainer?<br>a. Were there specific people from whom you learned to be an Explainer? What did they do to teach you?<br>b. Where there certain activities you engaged in that helped you learn to be an Explainer? What were they?<br>c. At what point during the program did you feel that you knew how to be an Explainer? How did you know? | Learning and Identity |
| **Part C: Reflections on the Reflective Activity** | |
| Let's take a look at your reflective activity, in which you marked your identity as a science learner before and after your participation in the Field Trip Explainer program. | |
| 1. What did you notice about how your science-learner identity changed over time?<br>a. What do you think contributed most to that change? | These questions provide context to help me interpret the reflective activity data. They serve |

| | |
|---|---|
| 2. What does a "science-learner" identity mean to you?<br>b. Did this definition change for you at any point after entering the program?<br>c. Did that have an impact on how you marked your identity on the scale?<br>3. Did any issues arise for you as you attempted to mark your identity on the scale?<br>d. Are there other types of identities that you would use to describe yourself?<br>e. Where does the "science-learner" identity fit into that for you?<br>f. Is this an identity that you retain outside of your work as an Explainer? In what way? | as a point of reflection and discussion around the idea of a science-learner identity, and provide personal context about the participants' sense of his/her own identity. |
| 4. Do you see yourself as a person who changes and develops or as a person who has a set-level of science-learning ability? | This question connects with Dweck's (2000) self-theories. |
| **Part D: Science Learner Identity and Activities** | |
| Please discuss what you gained from your experience in the Field Trip Explainer program. | This question opens up the data to include learning other than that which is science-related. |
| What are some memories you have of engaging in activities related to learning science? | Case study sub-question 3: evidence of science learning activities. |
| **Part E: Wrap-Up** | |
| Thank you for answering all of these questions!<br>1. Is there anything else that you'd like to share with me that you think is important for me to know about your time as a Field Trip Explainer?<br>2. Is there anything else that you'd like to share with me that you think is important for me to know about your identity as a science learner? | These questions create the opportunity for participants to bring up ideas that are not yet on my radar. |

**Appendix 3.5: Sample Explainer Learning Maps**




Encorage Exploration
Find out for Yourself.
Try to explain it.
Observations.
What do I Already know About the subject.
Free play with materials
I think it's very important to have free play because that's when some really good ideas come.
Learning without being taught
Oraganized Share back time
It helps me to share back. it gives me A chance to check my thinking.
What did you come up with?
-How and why-

**Appendix 3.6: Reflective Writing on My Expectations**

**Pre-Research Reflective Writing**
**Exploring my Assumptions/Expectations**
**January 2011**

**Research Question**: Do Exploratorium Field Trip Explainers build identities as science learners, and if so, how?
**Proposition**: Exploratorium Field Trip Explainers build identities as science learners by working within a community of practice (Wenger, 1998).

In addition to my role as researcher, I am the manager of the program that is the case of this study. In this position, I naturally have preexisting ideas about the nature of the case. This writing is a reflective exploration of those ideas, and will then serve as a check against the findings of the case—the knowledge discovered through the research process should not be exactly the same as my preexisting knowledge.

**Part One: Do Explainers build identities as science learners?**
"As an Explainer I have gained the ability to see the world as a playground of knowledge and to assist others in learning about and enjoying that world."
"By being an Explainer, I gained a desire to never be complacent—to continually make things better, gain more knowledge, and improve."
"Being an Explainer has given me the confidence to know that I can be dropped into any situation and have the skills to succeed. I know that I may not have the answer, but I do have the tools to figure out how to accomplish my goal."
"Being an Explainer is more than a job you can turn off and on, it is a way of being in the world everyday."
-Anonymous Explainers

These are some examples of things that Explainers have told me, and I interpret them to mean that Explainers feel that they are building science-learning abilities, and that this is somehow a part of their identities. The purpose of this study is to listen to the *Explainers'* perspectives on whether this is the case, and what elements of their experience contributed to making it so.

**Part Two: If so, how?**
This writing outlines the elements of the Explainer experience that, before beginning the research, *I* think have an impact on the Explainers' science-learner identities. I have identified six aspects of the program that I expect Explainers will describe as influential in the development of their science-learning identities.

**1. The Program Goals**
The goals of the Explainer program are to:
• Provide a positive and rich visiting experience for the school field trip groups, supporting their various goals.

• Provide professional development for the Field Trip Explainers in their growth as museum educators and leaders in their future professions.

These goals are two sides of the same coin. I strongly believe that it is critical for Explainers to be engaged in authentic learning experiences that are relevant to their work on the museum floor. This engagement improves their ability to support the school field trip visitors—both because of the constant development of related skills and knowledge, and because their excitement and curiosity is shared with the visitors. The result of these goals is that Explainers regularly engage in learning activities as a part of their work. When Explainers are hired, they are made aware that they are expected to be active learners during their time in the program.

I expect that the goals of the program impact the Explainers' experience—both because they guide the actual day-to-day activities, and also because Explainers are aware of them.

**2. What the Explainers Do**

These three ideas guide the Explainers in their interactions with visitors. Explainers:
**Support** visitors' goals,
**Inspire** visitors to explore the world around them, and
**Empower** visitors to take control over their own learning.

Explainers are expert explorers, engaging their own and others' curiosities. They are not meant to be experts in the content behind each of the exhibits, but in exploring any exhibit with any visitor, facilitating experiences that are meaningful to each person.

I expect that the Explainers' role in supporting the curiosity of the visitors and helping visitors to take control over our own learning feeds back into the development of their own learning identities.

**3. Training Sessions**

Every morning, Explainers participate in a structured training session before the museum opens. Explainers' learning situations in training sessions are a reflection of the social learning context of the museum, and usually involve group work and collaboration. During these training times, Explainers investigate phenomena and work to find answers to questions by conducting deep explorations of exhibits, doing hands-on activities, and engaging in the inquiry process.

I expect that regular engagement in these activities influences Explainers' science-learning identities. Each Explainer likely experiences a few training sessions that turn out to be powerful learning moments for them, and this probably supports their feelings of enjoyment and capability for learning science. I also expect that the social environment during this time influences Explainers—they are working during these times to fit into the group, which includes engaging in science learning behaviors.

**4. Peer Teaching and Mentoring**

A focus on peer teaching and leadership development is central to the program. In the beginning of each year, returning Explainers lead training sessions for new Explainers about the demonstrations, exhibits, and orientations. Throughout the year, all Explainers take turns leading

training sessions for the entire group with a focus on sharing facilitation strategies and personal connections to exhibits. They choose what sessions to lead based on their own interests and skills. Returning Explainers often partner with new Explainers for "study group" sessions, in which they study one exhibit for a week and present back to the entire group. As Explainers progress in the program, their leadership roles as peer teachers increase.

Explainers also learn from each other through partnership on the floor and peer observation and reflection. This mentoring process is one of the most important ways in which Explainers learn to do their work. Explainers mentor each other in the beginning of each year by working in partnerships on the floor with visitors, directly sharing ideas and techniques through conversation and role modeling. Throughout the year, Explainers tend to casually watch each other while they're working to pick up new ideas and techniques. Toward the end of the year, Explainers partner in their work again to provide points for reflection and growth. During these times, Explainers are not only learning how to do their work, but are learning from one another about how to *be* Explainers.

I expect that the desire to succeed in front of one's peers, and to progress as a leader in the group influences Explainers' science-learning identities. And, I expect that Explainers are especially eager to learn from their peers and to follow their lead.

**5. Other Exploratorium Staff**
Many of the Explainer training sessions are led by Exploratorium staff scientists or artists who provide in-depth content information. Exhibit developers occasionally lead training sessions to share their exhibit goals and design processes, and solicit feedback from Explainers about the visitor experience. Also, the Exploratorium's Teacher Institute, the Institute for Inquiry, and the Play, Invent, Explore Institute have each developed specialized processes for teaching science. Teachers from these groups lead workshops that expand Explainers' facilitation toolkits.

I expect that Explainers look up to some of these visiting training leaders, who then influence and serve as mentors for Explainers.

**6. Reflection**
During training sessions, Explainers take time to process discoveries and reflect on how their own learning informs their work with visitors. Explainers also regularly engage in reflection of their daily practice through informal conversations, team meetings, retreats, and progress meetings with the managers.

I expect that taking the time to reflect, whether formally or informally, gives Explainers the opportunity to construct ideas about how they understand their own identities in relation to the Explainer role.

## Appendix 4.1: Example Worksheets

**6th Grade Exploratorium Field Trip**

Name _____ Date _____
Homeroom _____ Due Date - Monday, 10/27/08

Directions:
1. In each area, choose one exhibit that you are interested in.
2. Explore the exhibit. Carefully read the information and explore how it works.
3. Take notes (below) on what you see, feel and understand.
4. Write *at least* one question you still have about the science concept.

1st Area_____Exhibit:_____

I see/I feel/I understand……

_____
_____
_____
_____
_____
_____

Question(s):_____
_____
_____

2nd Area_____ Exhibit:_____

I see/I feel/I understand……

_____
_____
_____
_____
_____
_____

Question(s):_____
_____
_____

# Exploratorium Focus

Students will spend an extended amount of time in an area or at a specific exhibit in order to answer the following questions:

* Area/Exhibit of interest _____

* Draw a picture of the exhibit on the back of this sheet.

* Describe what is going on in this exhibit:

_____
_____
_____
_____
_____.

* What is/are the scientific concepts being demonstrated – explain:

_____
_____
_____
_____
_____
_____
_____.

* Write a few question you have about the exhibit and/or the science concept being demonstrated

_____
_____
_____
_____
_____.

Name: _____

Date: _____ Period: _____
Physics, Mr. Ferraro & Mr. Lee

**Field Trip: Exploratorium**

Today you will be taking a field trip to the Exploratorium! You will have the opportunity to visit and interact with numerous exhibits that demonstrate some of the physical phenomena that you learned about in Physics.

***Phase I: Exploration***

While you are going from exhibit to exhibit, choose four (4) that you would like to discuss later today. Write their names below, along with a brief description.

| **Exhibit Name** | **Description** (what does it do, how does it work, etc.) |
|---|---|
| | |
| | |
| | |
| | |

***Phase II: Lunch***

Please check in with your chaperone.

***Phase III: Discussion***

With your group, you are going to discuss some of the exhibits you visited earlier. After this discussion, you are to select one of the exhibits from earlier today to write about for homework.

Questions to be asked/answered:

- Which exhibits were the most interesting?
- How do you explain how the _____ exhibit works? What are the physics involved?
- Which exhibits would you recommend to a new visitor?
- Which exhibits should you revisit later?

**Appendix 4.2: Example Explainer Schedule**

| | 9:25 | 10:00 | 10:30 | 11:00 | 11:30 | 12:00 | 12:30 | 1:00 |
|---|---|---|---|---|---|---|---|---|
| Clipboard | | | | | | | | |
| Door | | | | | | | | |
| Door | | | | | | | | |
| Door | | | | | | | | |
| Door | | | | | | | | |
| Door | | | | | | | | |
| Door | | | | | | | | |
| door | | | | | | | | |
| door | | | | | | | | |
| | | | | | | | | |
| Bio Clean | | | | | | | | |
| LunchWagon | | | | | | | | |
| Outdoor | | | | | | | | |
| Roam Mezz | | | | | | | | |
| Drawing Board | | | | | | | | |
| Traits | | | Flower | Cow Eye | Flower | Cow Eye | Flower | Cow Eye |
| Roam Back | | | | | | | | |
| Seeing | | | | Magic | | Light | Light | Light |
| Mind | | | | | | | | |
| Studio | | | | | | | | |
| Skyhub | | | | | | | | |
| Goofy Goggles | | | | | | | | |
| Roam Mid | | | | | | | | |
| Break | | | | | | | | |
| Break | | | | | | | | |
| Break | | | | | | | | |
| Break | | | | | | | | |