

City University of New York (CUNY)

## CUNY Academic Works

---

All Dissertations, Theses, and Capstone  
Projects

Dissertations, Theses, and Capstone Projects

---

2009

### Identity Development in Pre-Service Teachers Who Are Explainers in a Science Center: Dialectically Developing Theory and Praxis

Preeti Gupta

*Graduate Center, City University of New York*

[How does access to this work benefit you? Let us know!](#)

More information about this work at: [https://academicworks.cuny.edu/gc\\_etds/1785](https://academicworks.cuny.edu/gc_etds/1785)

Discover additional works at: <https://academicworks.cuny.edu>

---

This work is made publicly available by the City University of New York (CUNY).

Contact: [AcademicWorks@cuny.edu](mailto:AcademicWorks@cuny.edu)

IDENTITY DEVELOPMENT IN PRE-SERVICE TEACHERS WHO ARE  
EXPLAINERS IN A SCIENCE CENTER: DIALECTICALLY DEVELOPING  
THEORY AND PRAXIS

By

Preeti Gupta

A dissertation submitted to the Graduate Faculty in Urban Education in partial fulfillment  
of the requirements for the degree of Doctor of Philosophy,  
The City University of New York  
2009

© 2009  
PREETI GUPTA  
All Rights Reserved

This manuscript has been read and accepted for the  
Graduate Faculty in Urban Education in satisfaction of the Dissertation requirements for  
the  
Degree of Doctor of Philosophy

\_\_\_\_\_  
Date

\_\_\_\_\_  
Chair of Examining Committee – Kenneth Tobin

\_\_\_\_\_  
Date

\_\_\_\_\_  
Executive Officer – Anthony Picciano

\_\_\_\_\_  
Anna Stetsenko

\_\_\_\_\_  
Konstantinos Alexakos

\_\_\_\_\_  
Jennifer Adams

THE CITY UNIVERSITY OF NEW YORK

**Abstract****IDENTITY DEVELOPMENT IN PRE-SERVICE TEACHERS WHO ARE EXPLAINERS IN A SCIENCE CENTER: DIALECTICALLY DEVELOPING THEORY AND PRAXIS**

By

PREETI GUPTA

Advisor: Dr. Kenneth Tobin

This dissertation investigates how teaching in a hands-on science center contributes to re/shaping one's teaching identity. Situated at the New York Hall of Science (NYHS) in Queens, New York, my research approach is to conduct a critical ethnography where the focus is on improving the teaching and learning of science for all involved. In particular, Explainers, floor staff at NYHS, who are studying to be science teachers, are invited to become co-researchers with me.

Written as a manuscript style, this dissertation consists of six chapters. Each chapter foregrounds certain events and phenomena, and theory and method are woven in to theorize identity construction. Grounded in cultural sociology, the frameworks of Cultural Historical Activity Theory (CHAT), and the sociology of emotions, illuminate key understandings about the construction of teaching identity. Multiple data sources including field notes, transcribed audio and videotapes, and cogenerative dialogues are used. I employ a hermeneutic phenomenological approach to data analysis.

This research has salient implications for museum-university partnerships, and training for museum floor staff and has the potential to inform policy-making for pre-service teaching clinical fieldwork experiences.

## **Dedication**

I dedicate this research to the New York Hall of Science, which is filled with people, past and present, who encouraged me to enter this endeavor, supported me throughout the process and continue to inspire me with their ideas, activities and interests.

## Acknowledgements

I take this opportunity to thank key people in my life that made this moment possible for me. All of the people described have contributed to my growth as a scholar, researcher and practitioner in unique ways. Each have also personally touched my life so that I continue to inspire and excite others and to innovate, viewing this moment not as the close of a chapter in my educational journey, but as a start of new endeavors.

Dr. Kenneth Tobin nurtured the researcher in me and supported me in countless ways. He helped me understand that theory and practice cannot exist without the other and that I can and should develop my identity as a researcher and practitioner simultaneously. Throughout my doctoral journey, Dr. Tobin worked alongside me as a mentor, advisor, critic and friend and continues to play that role as we delve into numerous activities together. I also thank Dr. Anna Stetsenko whose passion for studying social life fueled me to investigate theoretical frameworks that illuminated new ways of thinking and informed my research in key ways. Dr. Konstantinos Alexakos played a key role in this research because in his role as an advisor, he challenged me and encouraged me to think more critically so that I could strengthen my arguments and he remained a source of support throughout those times. I want to especially thank Dr. Jennifer Adams who worked so closely with me to develop my ideas, listen to my challenges, and offer solutions. She became an invaluable support structure for me as well as a good friend. All three of my advisors demonstrated genuine excitement for my work and I thank them for helping me to develop scholarship and prepare me to become a thought leader for both formal and informal education.

I also want to take this opportunity to thank the members of the “Tobin research squad” that met weekly through my writing process. I would enter the meeting struggling with particular aspects of my research and writing and without fail, the members of squad helped to lift my spirits and offer solutions to the challenges I encountered. I especially want to thank Christina Siry without whom I would have never gotten this far. Her smile, her laughter and her ability to always make things seem not so bad is what helped me to keep going when I felt “stuck”. Together we wrote, we read, we critiqued and we laughed and for that, I thank her.

I am truly grateful to all of the people at the New York Hall of Science and especially the Explainer program, which remains in the center of my heart as a place where good things happen and where young people innovate tirelessly. I thank my co-researchers without whom this research was not possible and I look forward to having you meet them in the dissertation below. I give a special thanks to Eric Siegel who wholeheartedly supported my doctoral work throughout the four years and to the former and current CEO’s of the New York Hall of Science, Dr. Alan Friedman, Marilyn Hoyt and Dr. Margaret Honey who each demonstrate such excitement and enthusiasm for my work and serve as mentors for me as I continue to launch into new projects. I give a very special thanks to Mr. Carlos Lopez, a former employee of the New York Hall of Science. Without Carlos, I would have never fallen in love with being an Explainer, with teaching and with science. The time we spent training on exhibits and discussing the best ways to interact with the public launched my interest in the topic of science education at the early age of 17 even if I didn’t know it then. I owe my twenty-year career as a practitioner and researcher to those wonderful moments with Carlos. I would like to acknowledge Dr.

Laura Saxman, researcher from the CUNY Graduate Center and member of the CLUSTER leadership team, who helped me formulate my thoughts, read drafts of my chapters, co-presented with me and continues to support my research agenda.

I take this time to acknowledge and thank my wonderful family, my father, Mr. Sahib Saran Gupta, my mother, Leela Gupta, and my sister, Deepti and brother, Ruchir.

Without each of these people, I would have been lost and disillusioned as I tried to balance work and graduate school. Each of these people supported me in the smallest of ways, feeding me dinner night after night so I could study and in the grandest of ways by giving me pep talks when I wanted to quit and thought I couldn't handle it. I especially want to thank my sister who would remind me of our family mantra, "Gupta's don't quit"! Finally I thank my best friend, and now my husband, Mr. Frank Signorello, whose unwavering support strengthens my belief in my work and ultimately in me. Countless hours of conversation with Frank about science pedagogy propelled me to consider doctoral education and ultimately complete this dissertation. Our shared understandings, debates about the nature of teaching and learning and passion for science education motivated me to pursue and complete doctoral studies and continue to fuel my interest in new projects.

## Table of Contents

<b>Abstract</b> .....	<b>iv</b>
<b>Dedication</b> .....	<b>v</b>
<b>Chapter 1: Introduction</b> .....	<b>1</b>
<b>Limited Fieldwork Experiences During Teacher Preparation</b> .....	<b>3</b>
<b>A Missed Opportunity</b> .....	<b>6</b>
<b>New York Hall of Science As Learning Laboratory</b> .....	<b>8</b>
<b>Explainers Consider Teaching as a Career</b> .....	<b>10</b>
<b>The Study</b> .....	<b>13</b>
Explainers as Co-researchers.....	14
Students Co-Researchers .....	14
<b>Emergent Questions</b> .....	<b>15</b>
<b>Theoretical Considerations</b> .....	<b>16</b>
Cultural Sociology.....	16
Embracing Bricolage.....	17
Hermeneutic Phenomenology .....	19
Cogenerative Dialogues .....	19
Cultural Historical Activity Theory .....	20
<b>Data Collected</b> .....	<b>22</b>
<b>Data Analysis</b> .....	<b>22</b>
<b>Overview of the Chapters</b> .....	<b>23</b>
<b>Ethical Considerations</b> .....	<b>25</b>
<b>Limitations</b> .....	<b>27</b>
<b>Chapter 2: I Am Not The Expert: Using Cogenerative Dialogues in Informal Science</b>	
<b>Institutions to Support Teaching and Learning</b> .....	<b>29</b>
<b>ISI as Sites for Professional Development</b> .....	<b>29</b>
CLUSTER – A Teacher Preparation Program .....	31
<b>The Need Arises for Cogenerative Dialogues</b> .....	<b>34</b>
<b>Cogenerative Dialogues</b> .....	<b>37</b>
The Study .....	38
The Participants.....	39
Data Sources.....	40
The First Day of Dialogue.....	40
As Time Progressed.....	42
<b>Emergence of Key Ideas as a Result of Cogenerative Dialogues</b> .....	<b>45</b>
I Am Not the Expert .....	46
Power.....	48
Sharing Strategies.....	50
Reflexivity.....	53
Let’s Develop Worksheets .....	56
<b>A Missing Stakeholder</b> .....	<b>60</b>
<b>Catalytic and Tactical Authenticity</b> .....	<b>61</b>

<b>Implications for Informal Science Institutions .....</b>	<b>62</b>
<b>Chapter 3: There Is No “Off Button” to Explaining: Identity Development in</b>	
<b>Pre-service Teachers in a Museum Setting .....</b>	<b>64</b>
<b>Identity as a Lens.....</b>	<b>64</b>
My time as an Explainer.....	68
<b>Theorizing My Experience .....</b>	<b>70</b>
Cultural Historical Activity Theory .....	72
<b>Cogenerative Dialogues.....</b>	<b>77</b>
<b>Opportunities to Practice in Low Stakes Settings .....</b>	<b>78</b>
Participants .....	79
Data Sources.....	80
<b>Key Indicators of Identity Development .....</b>	<b>81</b>
Epistemologies .....	82
Shifting Ontologies.....	85
Teaching effectively .....	88
Catalytic Work .....	90
<b>Studying Social Life.....</b>	<b>94</b>
<b>Chapter 4: Applying Interaction Rituals Chain Theory to the</b>	
<b>Explainer Experience .....</b>	<b>97</b>
<b>The role of emotions in teaching and learning.....</b>	<b>98</b>
<b>The Contextual Nature of Informal Science Institutions.....</b>	<b>99</b>
<b>Interaction Ritual Theory.....</b>	<b>101</b>
<b>The Context of the Study .....</b>	<b>101</b>
<b>Pre-service Teachers as Explainers .....</b>	<b>103</b>
<b>Being an Explainer: Getting Right Back on the Horse.....</b>	<b>105</b>
<b>Is It Our Public? .....</b>	<b>113</b>
<b>Worksheets as Symbols for Solidarity.....</b>	<b>118</b>
<b>Developing Social Capital.....</b>	<b>123</b>
The Red Apron .....	124
<b>Implications.....</b>	<b>126</b>
<b>Chapter 5: Museum-University Partnerships for Pre-service Science Education</b>	
<b>(Co-written with Jennifer Adams).....</b>	<b>129</b>
<b>The Need For ISI-University Partnerships .....</b>	<b>131</b>
<b>Informal Science Institution Facilitators .....</b>	<b>133</b>
<b>Pre-service teacher Education In Museums: Practice and Potential .....</b>	<b>134</b>
Collaboration for Leadership in Urban Science Teaching Evaluation and Research	
.....	135
The Extended Practicum Beyond the Classroom Option Program .....	137
Bloomfield Science Museum Jerusalem .....	138
<b>Emerging Evidence.....</b>	<b>139</b>
Same Topic, Different Audiences .....	141
Work with Diverse Learners .....	143
Learning Alongside Many Museum Staff.....	147
Opportunities for Self-Reflection.....	149

<b>Next Steps</b> .....	<b>151</b>
<b>Chapter 6: Looking Back and Looking Forward</b> .....	<b>154</b>
<b>Synthesis of Chapters</b> .....	<b>156</b>
<b>Claims Emerging From The Research</b> .....	<b>159</b>
Use of Cogenerative Dialogues.....	160
Purposeful Activity as an Explainer.....	161
Contributing to Theory.....	161
Authenticity Criteria.....	163
Producing Kernels of Thought for Others.....	167
<b>Implications</b> .....	<b>168</b>
Implications of a Doctoral Program at the CUNY Graduate Center.....	171
<b>What More Is There?</b> .....	<b>173</b>
<b>The Immediate Future</b> .....	<b>176</b>
<b>Appendix</b> .....	<b>177</b>
<b>References</b> .....	<b>178</b>

## Chapter 1: Introduction

In this dissertation, I theorize the development of a museum facilitator's teaching identity mediated by the interactions with visitors at exhibits in a science center. bell hooks (1994) inspires us to consider that "theory is not inherently healing, liberatory, or revolutionary. It fulfills this function only when we ask that it do so and direct our theorizing towards that end" (p. 61). Therefore, each chapter of this manuscript-style dissertation is written with theory, practice and autobiographical accounts woven together to illuminate social life in different ways and inspire different ideas and questions.

This research is grounded in my standpoint that one learns to teach by actually teaching in a purposeful activity with others and that identity development is a social process, relational, dynamic and mediated by the cultural tools available in the activity. To launch my thesis, I use the following quote from a floor facilitator at the New York Hall of Science:

I get a certain pleasure out of having kids gather around. And in the Program I got better at it. There was this hands-on exhibit with metal plates, where you make the connection in order to play music. I remember once I showed this little kid. First I tried the complicated explanation and he didn't get it. So I took his hand and put one hand on the plate and the music started playing and I said: "See. You are acting as a wire." His eyes lit up and he called all of his friends over and started explaining to them the concept that I taught him! He said: "I'm like a wire, music is traveling through me in the form of electricity." I imparted information and he actually learned something that day. [Female Caucasian, under 20, high school student] (Storksdieck, Haley-Goldman and Jones 2002, p. 24)

This example illustrates how this facilitator was able to try different strategies of engagement using the resources of the exhibit until one worked and how her experiences mediated her self-perception as an educator. I use this quote even though it is not directly from my study because it is a perfect example of interactions that are commonplace in

science centers. This particular quote is from a facilitator who used to work at the science center and was surveyed as part of an evaluation commissioned in 2002, which is later described in this chapter. As a former floor facilitator in a science center, I have experienced similar interactions and know that they have contributed to my identity development as an educator in profound ways. My lived experiences, as Max van Manen (1990) describes, “do not offer us the possibility of effective theory with which we can now explain and/or control the world, but rather it offers us the possibility of plausible insights that bring us in more direct contact with the world” (p. 9). In extending the idea of harnessing lived experiences to hermeneutic phenomenology as an approach to research, David Jardine (2006) writes,

Hermeneutics suggests that these striking incidents make a claim on us and open up and reveal something to us about our lives together and what it is that is going on, often unvoiced, in the ever-so commonplace and day-to-day act of being and becoming a teacher (p. 280).

By describing my experience throughout the dissertation and theorizing my day to day experiences as an Explainer, as Jardine eloquently describes, this research becomes a vehicle for me to lift up my experience, and the experience of others, examine the ordinary events of social life as they play out in a science center environment, illuminate the extraordinary in it to inform future practices, to make claims for why such experiences are crucial for pre-service teachers and describe its implications.

Both learning to teach and conducting research are forms of cultural production|reproduction and transformation. bell hooks (1994) states: “when our lived experience of theorizing is fundamentally linked to processes of self-recovery, of collective liberation, no gap exists between theory and practice” (p. 61). Using methodologies that leverage lived experiences to inform theory which then continue to

inform practice, I embrace the dialectical view of research where theory and practice presuppose each other and can not exist without the other. Therefore, theory and practice are inextricably linked. Furthermore, in this dissertation I illuminate social life in an informal science institution with theoretical frames that have essentially been applied only in formal settings. Therefore, the knowledge produced through this work is a major contribution for theoretical understandings of learning in informal settings.

My dissertation presents detailed accounts of key interactions among museum facilitators discussing practice triggered by experiences with visitors to a museum. I describe how such interactions support developing an awareness of how we view knowledge production, teaching and learning mediated by sociocultural, historical and political structures in urban schooling, and the role we play in supporting student learning maintaining that these interactions deeply shape our identity.

#### Limited Fieldwork Experiences During Teacher Preparation

The National Research Council Report (2007), *Taking Science to School: Learning and Teaching Science in Grades K-8*, states that teachers,

need opportunities to learn how students learn science and how to teach it. They need to know how children's understanding of core ideas in science build across K-8, not just at a given grade or grade band. They need to learn about the conceptual ideas that students have in the earliest grades and their ideas about science itself. They need to learn how to assess children's developing ideas over time and how to interpret and respond (instructionally) to the results of the assessment. In sum, teachers need opportunities to learn how to teach science as an integrated body of knowledge and practice – to teach for scientific proficiency. They need to learn how to teach science to diverse student populations, to provide adequate opportunities for all students to learn science. These needs represent a significance change from what virtually most active teachers learned in college and what most colleges teach aspiring teachers today (p. 6).

This statement describes what teachers need to support student learning and states, somewhat extremely, that many of our colleges are struggling to meet this need. Too often pre-service teachers learn theory divorced from practice because institutions are not able to create coherent experiences. Linda Darling-Hammond, Karen Hammerness, Pamela Grossman, Frances Rust and Lee Shulman (2005) argue that such teacher preparation programs are overly theoretical and lack connections to practice. Generally, fieldwork and student teaching are two opportunities where pre-service teachers can be exposed to students and develop an awareness of themselves and their students as teachers and learners. In New York State, all pre-service teachers only have to complete 100 hours of fieldwork and 40 days of student teaching. These are not enough hours to support teachers in developing skills they would need to provide quality instruction as described by the National Research Council Report:

Quality instruction entails strategically designing student encounters with science that take place in real time and over a period of months and years (e.g., learning progressions). Teachers draw on their knowledge of science, of their students, and of pedagogy to plan and enact instruction. Thus, in addition to understanding the science content itself, effective teachers need to understand learners and pedagogy design and need to monitor students' science learning experiences (2007, p. 297).

The required hours of fieldwork and student teaching are not nearly enough to support a pre-service teacher's development as a skilled educator which entails designing student encounters that are embedded in science inquiry, learned over time, and draw on the knowledge that diverse learners bring to the table. Empirical studies cited by Linda Darling-Hammond et al. (2005) demonstrate that teacher preparation programs with a clear and coherent vision that weave field work into the courses are more influential and effective at supporting the development of new teachers. A recent study of 400 pre-service teachers also showed that teachers most value their opportunities for fieldwork as

a mechanism for preparing them to teach (Smith and Tev-Ari 2005). A number of models are being tested where fieldwork is being creatively incorporated into coursework in order to deal with the issue of supporting teachers to develop their knowledge of teaching and learning. Two examples of this from the University of South Alabama and from Brock University provide context for the innovative approaches undertaken by colleges to address this issue.

The University of South Alabama tested a unique model for teacher preparation where they increased the amount of time teachers spent in clinical training (Feldman and Kent 2006). The goal was to weave the fieldwork experiences into the courses thereby allowing for more time working with real students and developing skills and dispositions. Results from the pilot program show that pre-service teachers who participated in the pilot felt better prepared to teach diverse audiences upon graduation, and had a deeper understanding of linking theory to practice compared to teachers who followed a traditional model. These teachers in this pilot also performed better in job interviews, and were able to offer substantial strategies for differentiating instruction. Overall, their sense of self-efficacy towards teaching was stronger.

At Brock University in Canada, Xavier Fazio, Wayne Melville and Anthony Bartley (2008) are working to identify the perceptions that pre-service teachers have about inquiry based teaching and the extent to which those perceptions are based on their explicit experiences in hands-on teaching. Particularly, this team is interested in investigating the roles of the pre-service teacher's practicum experiences and classroom observations in augmenting the perceptions formed related to inquiry-based teaching. Their findings thus far demonstrate that the methods and curriculum courses are

influential in a teacher's perceptions towards inquiry-based teaching, but that a supportive practicum experience can strengthen that perception. They also found that pre-service teachers who enter their first years of teaching often find it difficult and challenging to implement inquiry-based approaches to science teaching even *if* they perceive it to be a more appropriate strategy. Elizabeth Davis, Debra Petish and Julie Smithey's (2006) review of research echoes this finding where she learned that a great challenge that teachers face is the misalignment of what they learned in their program and what they experience both in their practicum experience and then their first years of teaching. In response to these issues, Luehmann (2007) recommends that pre-service teachers have an opportunity to practice teaching in low-stakes settings.

### A Missed Opportunity

While the models described above actively work towards providing prolonged engagement experiences between pre-service teachers and students in low-stakes settings, there is a great missed opportunity in using an existing resource in the community. Informal Science Institutions (ISIs) can serve as key partners for pre-service teacher preparation. ISIs are broadly defined as science centers, nature centers, natural history museums, zoos, aquaria, or arboreta. Existing within the larger context of museums<sup>1</sup>, they are free-choice settings with the overall goal of exciting, engaging and educating the public on aspects of science and technology (Falk 2001). These places are referred to as "informal" in title, but Eshach (2007) describes them as non-formal settings, places

---

<sup>1</sup> International Council of Museums definition of "museum": a non-profit making, permanent institution in the service of society and its development, and open to the public which acquires, conserves, researches, communicates, and exhibits, for the purposes of study, education, and enjoyment, material evidence of people and their environment (1989)

where one of the main aspects of the mission is to provide opportunities for learning, although learning occurs in unstructured and non-sequential ways. ISIs have hundreds of exhibits on various topics of science and are visited by thousands of people annually. The National Academy of Sciences report (2009), *Learning Science in Informal Environments: People, Places and Pursuits*, describes ISIs as “designed spaces ... [that] can support science learning. Rich with real-world phenomena, these are places where people can pursue and develop science interests, engage in science inquiry, and reflect on their experiences through sense-making conversations” (2009, p. ES-2).

Most ISIs have floor facilitators, many of them youth and college-aged, who engage visitors in conversations about science. Across the United States, there are approximately 350 science centers and of those, approximately 38% have a youth employment program (ASTC 2007). In Europe, a group called DOTIK (2007) <sup>2</sup> published the results of a survey that was designed to find out how many European science and technology centers used floor staff to facilitate interactions. Thirty-seven institutions from eighteen countries responded, and 43% of them used students in part-time or casual status to fill those positions. The rest used recent graduates from local colleges. Science centers understand the importance of floor staff and prominently engage young people for those jobs. Training floor facilitators to engage with diverse visitors requires significant amounts of training. This is a great area for consideration in the museum field where leaders of science education such as Doris Ash (2009) are employing innovative research programs to support floor facilitators in developing an awareness of visitors to the

---

<sup>2</sup> DOTIK was a two-year funded project from the European commission aimed at developing and testing methods for training museum educators ([www.dotik.eu](http://www.dotik.eu))

museum with the intent to create equitable learning experiences for families of various backgrounds.

Many of the informal science education practitioners|researchers are focused on shifting floor staff from transmitters of information to facilitators of inquiry experiences and theorizing those interactions. The *visitor and her experience* are at the center of that focus. Alternatively, my focus in this dissertation is to put the lens on the facilitator maintaining that the face to face interaction between the facilitator and the visitor is still the site for study, but I demonstrate how the training, mentoring and experience of interacting with visitors actually leads to a confident, competent *science educator*. The DOTIK (2007) study found that the training and mentoring that is provided to the facilitators has been shown to affect that facilitator's science communication skills, comfort with public speaking and ability to engage with diverse audiences. These skills are a solid foundation for anyone who might consider teaching as a career. I argue that ISIs are under-utilized resources in teacher education. ISIs are places where people can practice teaching through different low-stakes activities, have opportunities to become aware of their epistemologies (where knowledge comes from), ontologies (the nature of reality and being in the world) and axiologies (the values associated with knowledge production). While this might not be an explicit focus of most ISIs, they can often become learning laboratories for future teachers.

#### New York Hall of Science As Learning Laboratory

This study is situated in the New York Hall of Science (NYHS), a hands-on science center in Queens, New York, which has a formalized youth employment program called the Science Career Ladder Program. In this program, high school and college students are

employed as floor staff and are called Explainers<sup>3</sup>. For many of them, the Hall of Science becomes a hands-on lab where they practice teaching science.

Explainers are a diverse group of people. The average age is 15-24 and gender breakdown is 50% male and 50% female. Ethnic breakdown in 2007 was 18% African American, 25% Asian American, 27% Latin American, 18% West Indian/Indian, and 12% Caucasian. As the percentages show, there is diversity in the makeup of the staff and this is because recruitment is conducted from approximately 29 New York City public high schools and 23 colleges. Walking around the museum you see both the Explainers and visitors engaged and speaking in many different accents and sometimes even dressed in styles from their culture.

Explainers are recruited from the same populations as the visitors of the NYHS, and almost all Explainers are first generation immigrants. Often students who apply to work at NYHS are simply looking for an interesting job and are not concerned with developing their understanding of teaching and learning. When hiring, the museum considers the potential of the applicant to work regular hours throughout the year. Student grades are not a factor in the decision-making process; interest in working with people, learning, and teaching are considered positive attributes. Ability to communicate effectively is gauged through interview activities. Students who appear shy are not disregarded because it is not indicative of poor communication skills, nor does it correlate with the potential of

---

<sup>3</sup> While the title Explainer is inappropriate for the role ascribed to floor facilitators as it implies a transmissionist model of teaching, it is a historical construct with recognition in the museum community. Additionally, it is a formal title as designated by a capital "E." From hereon after, I will use this title to describe the floor facilitators at the New York Hall of Science.

becoming an effective science communicator. Many students who are selected are not expert at communicating concepts during the time of the interview, but they show potential to learn and grow. Students in the program work an average of two years at which time they either graduate, go away to college, leave for personal reasons, or possibly get promoted into a higher position at the museum.

### Explainers Consider Teaching as a Career

The New York Hall of Science has used the Explainer model of floor facilitation for over twenty years. In the early years of the program, many Explainers chose careers in science teaching and claimed that working as an Explainer contributed to their decision in pursuing a teaching career. Frank Signorello (2001) examined how the job of being an Explainer at NYHS mediated the in-service experience of those who pursued teaching careers. He used surveys and follow-up phone interviews. Results showed that 80% of those who participated in the study (n=27) reported that they felt more comfortable, competent, and confident in their careers as formal educators because of the training they received at NYHS. This study motivated the New York Hall of Science to pursue this query further.

In 2002, the Institute for Learning Innovation conducted an evaluation of the impact of the Hall of Science program on Explainers who had graduated from the program. Of the many outcomes measured by this study, one key area was the choice of career as influenced by their experiences as an Explainer. Of those alumni who participated in the research (n = 100), 68% provided their current occupation. Of those, 42% (n=25) were teaching in some sort of capacity and 40% of those (n=10) self-identified as a science

teacher. According to the report, some of those people knew they wanted to teach and working at the Hall further supported their goals. The following quote from an alumnus Explainer provides evidence,

The Career Ladder Program was my first experience being in the classroom. I was in education but I was not at the point in my studies where we were doing any teaching. I knew how much science I knew but the Program was great because it was structured and repetitive. They provided you with scripts, so you were definitely prepared to go out there and teach, but over time you were able to develop your own flair. And having the repetition was critical. You always got to try a lesson again and perfect it. That's really something great. [Female Caucasian, 31-35, teacher] (Storksdieck, Haley-Goldman & Jones, 2002, p. 25)

For others, teaching was a career option that they were introduced to as a result of their experiences as Explainers. Many students begin employment simply to have a part-time job. They often have not decided a career path or are open to exploring different options. The following two quotes describe how working in the museum mediated these two Explainer's interest in teaching:

I actually wrote an essay to go into college about this. It was an experience I had at the Hall's playground, where I played with this kid, and they tugged my apron and told me before they left that they had a lot of fun. That was sweet. And then the mom came back to me and told me that I was great at this, and didn't I think about becoming a teacher, because she was impressed on how her daughter and I interacted. That happened right at the time when I thought about changing my major. [Female Pacific Islander, under 20, college student] (Storksdieck, Haley-Goldman & Jones, 2002, p. 22)

I never thought of myself as a teacher before, since I had that experience it made me see I could do this, that I had the ability. [Female Asian American, 20-25, college student, SAT teacher] (Storksdieck, Haley-Goldman & Jones, 2002, p. 23)

Both of these quotes describe how the Explainer is either being ascribed the identity of a teacher or can envision herself as a teacher because she has experienced successful interactions with visitors. The Institute for Learning Innovation evaluation demonstrates that institutions like NYHS can be considered learning laboratories for pre-service

science teachers. Working as an Explainer, one gets the ability to practice teaching to different audiences throughout the day. An Explainer also gets opportunities to meet different kinds of people and construct social interactions with them. Through routine, but unique social interactions, an Explainer develops effective teaching techniques and begins to appreciate the act of teaching and also how different people learn.

The results of this evaluation propelled the New York Hall of Science to develop a partnership with a local college for science teacher preparation. In 2006, a National Science Foundation research project, Collaboration for Leadership in Urban Science Teaching Evaluation and Research (CLUSTER), was granted to the New York Hall of Science in collaboration with the City College of New York and the Center for Advanced Study in Education at the CUNY Graduate Center. Undergraduate students in the project work as Explainers at the New York Hall of Science while taking secondary science education courses at City College. They are called CLUSTER Explainers, but they function as regular Explainers, responsible for all of the tasks and programs designated for Explainers. The big difference is that these Explainers have the opportunity to take their experiences working at the museum and reflect on them during their mandated education coursework.

Undergraduate students who apply to the CLUSTER program are pursuing a major in one of the sciences, biology, chemistry, physics or earth science. Explainers who join the CLUSTER program are selected based on a successful interview with a CLUSTER project team member demonstrating their commitment to the project goals, good standing in their academic field of study (GPA of B or better) and consent to participate in CLUSTER research. As part of their commitment, CLUSTER students must take four

state-mandated education courses, a Capstone course, and work as an Explainer for at least 7 hours per week for the entire time they are in the CLUSTER program (average of two years). As of January 2009, there are 39 CLUSTER participants.

### The Study

My study is embedded in the CLUSTER research program. I examine how a group of pre-service teachers in the CLUSTER program work as Explainers and participate in cogenerative dialogues (Tobin and Roth 2006). Cogenerative dialogues are meetings with a mutual goal of improving practice and working through contradictory experiences and opinions towards a focused goal. Each participant in the cogenerative dialogue has voice and creating a supportive and open environment for discussion ideally minimizes power imbalances. In tandem, participation in these two activities, interactions with visitors and reflection during cogenerative dialogues, mediates their identity as teachers and learners. In this research, the pre-service teachers are positioned as co-researchers with me. Together we examine our practices, create goals for improvement and develop our understandings of how we teach and learn science. We develop an affiliation to the profession of teaching as we continually improve as teachers and we develop solidarity with each other, gaining a sense of belonging to a group that cares about science teaching and learning.

Specifically, we audiotape and videotape our interactions with visitors and then reflect on them during the cogenerative dialogue meetings. The conversations that emerge are triggered by the interactions we have with visitors. Over time, these conversations support praxis and allow us to become aware of what we were unaware of and transform as teachers and learners.

*Explainers as Co-researchers*

Researching on the Explainers as opposed to with the Explainers would have been a disservice to this study. The multiple meanings, perspectives and standpoints would not have been represented. In a study designed to make claims about identity development, only one-sided patterns and contradictions would have emerged, void of the richness that comes with the voice of the Explainers discussing their teaching and learning experiences from their own and other's interactions. Kenneth Tobin (2005) states that it is important to consider how the research questions are answered for the different stakeholders and the types of meanings they are constructing from the experiences. Explainers as researchers means that they can select which vignettes to study, they can bring different artifacts to the research and provide insider perspectives not only for examining identity development, but also for improving praxis for us all (Elmesky and Tobin 2005). The forthcoming chapters detail how this happens and contributes to the structures of a cogenerative dialogue.

*Students|Co-Researchers*

The participants for this study were selected based on interest, availability and a mutually comfortable schedule, thus the cogenerative dialogues include approximately nine people. I am the educator researcher, Jan is the explainer administrator researcher, and seven people are CLUSTER Explainers serving as student researchers. On average, four out of the seven students, not always the same people, are in attendance for the meetings. Jan and I are present for almost all of them, except the few times when we are pulled

away for work-related reasons. If less than five total people are available, we do not meet because too many people would be left out of that day's conversation.

All nine of us either immigrated to the U.S. as a child or are the first generation in our family to be born in the U.S. In addition, our ethnic backgrounds are from the South Asian diasporas, except for Jan who is Latin American and one student who is half South Asian and half Puerto Rican. The similarities in our ethnic background contribute to our solidarity as a group but do not become a focus for this thesis. Two students are male, the rest are female. All seven students are undergraduate science majors (four biology, one chemistry, one earth science, and one engineering) at a CUNY college. Jan is currently not enrolled in a college but expects to eventually finish her undergraduate degree in Computer Science and pursue a Master's in Education. I am a doctoral candidate at the CUNY Graduate Center, have a Master's in Education and a Bachelor's in Engineering. At the time of writing this dissertation, two students have dropped out of the CLUSTER program, but have participated in many of the cogenerative dialogues and are included as data sources for this chapter. Henceforth, the CLUSTER pre-service teachers who participate in this study are referred to as co-researchers. For the sake of clarity in writing, I refer to "we" when addressing those of us who participate/lead the research and I also use the pronoun "she or her" when addressing other Explainers or visitors.

### Emergent Questions

This research was initiated with a broad interest in investigating how working with visitors in a low-stakes environment mediated each of our identity development as an educator. Emerging from the cogenerative dialogues are the following research questions:

1. In what ways do cogenerative dialogues serve as a useful methodology and method for ISI facilitators' growth as a teacher?
2. How is identity development mediated by interactions with visitors in a low-stakes setting?
3. In what ways do emotions mediate and become outcomes of face-to-face interactions and allow us to document identity development in pre-service teachers?

The chapters that follow will address each of these questions in detail using vignettes from the research, theory and autobiographical experiences.

### Theoretical Considerations

#### *Cultural Sociology*

I embrace William Sewell's (1999) ideas of cultural sociology where culture is experienced as schema, resources and practices that exist in thin coherence, producing both patterns and contradictions. To theorize cultural production, I employ the construct of fields, which are sites with porous boundaries where culture is produced, reproduced and transformed. The agency of those who are in a given field is mediated by the structures of that field and dialectically mediates the schema, resources and practices enacted in that field. I employ critical ethnography as a method because this approach seeks to give meaning, and support the growth and transformation of all involved in the research with the intent of catalyzing change (Roth 2005). I also employ an authentic approach to ethnography (Pitts 2007) where I provide rich descriptions of what is happening and then look for patterns and contradictions. This approach seeks to theorize

the nature of social life rather than control the enactment of culture in social life.

Ontologically, I am unable to consider research methodologies where social life has to be studied and described as a step-by-step process.

### *Embracing Bricolage*

David Jardine's (2006) words echo in my ears, "something is waking up here at the edge of familiarity" (p. 280). As a former Explainer and as a teacher educator, I experience a complex array of experiences and emotions related to teaching and learning of science. I aim to shed light on those complexities by applying a bricolage of sociocultural theories. Kathleen Berry (2006) distinguishes between solving a problem and problematizing accepted practices. Problem based research assumes that some entity needs to be changed or fixed. I agree with her in that these approaches may isolate the "object of the study from the multiplicities and complexities in which the object is situated" (p. 103).

Engaging visitors in conversations at exhibits is part of social life at the New York Hall of Science. It is part of the cultural re/production and commonly accepted practice.

Problematizing allows me to "rethink and resee, not solve" (p.103) so that we can think critically and transform.

Berry (2006) argues that a bricoleur contextualizes, situates and decenters as a dynamic and ethical part of the research process. I bring so many identities to this research that the act of playing a bricoleur excites and challenges me. Using a bricolage approach allows me to tackle issues of positivistic data collection, but it also creates complexities in how I analyze what is happening in social life. The act of contextualization reminds me to be thoughtful about categorization and labeling of data.

In my research, I attempt to link what is said and how it is said to the individual's experiences, without reifying and essentializing particular voices and standpoints. Where possible, I use polysemicity and use of metalogues and voice overs to contextualize social life. The identities I bring to the forefront with my co-researchers situate me in particular ways as will be evident in the following chapters. This research continues to be an emotional experience as the student researchers in this study mediate my development and growth as an educator, a researcher and as an administrator in my current role as Vice President for Education and Family Programs for the New York Hall of Science. Decentering is one way of creating some distance and objectivity to the data analysis without divorcing myself from the research. Jardine (2006) writes that while something from the familiar calls out to us for research, hermeneutic phenomenology requires one to isolate the incident and decenter from it in order to then look for other instances that either create a pattern or contradiction with it. He recommends researchers to deal with the dialectical position of having familiarity with such incidences and decentering from those experiences by:

working these matters out in public, in writing, in talking to colleagues, in reciting this incident to new student teachers and listening to the buzz that is created, in reading more and thinking more, and therefore in letting the potential distortions of my subjectivity work themselves out into a worldly territory that can comfort and contain and cultivate and limit and, sometimes, humiliate them (p. 281).

Following his advice, the writing of these chapters, presenting this work at local and national conferences, especially for those who might be unfamiliar with this approach to research, and discussing it with my colleagues supports me in my endeavor to pursue rigorous research, but also feel connected and passionate with this research.

### *Hermeneutic Phenomenology*

“Hermeneutic phenomenology serves to be educative in its intent. It wants to listen, to affect and to invite, not merely to inform” (Jardine 2006, p. 269). This type of interpretive research aims not to clarify and organize the messiness of complexity of social life, but to bring out the evocative instances that allow us to step back, theorize, and re-enter the messiness with the aim of making sense of and transforming cultural production. For this type of research, data is not there to be collected, but emerges from enactment in social life. I apply cogenerative dialogues as a methodology and a method to create structures where the researchers in this study can step into a field, defined as a space with porous boundaries, and be reflective and reflexive about teaching and learning in the context of the complexities that enactment in social life present to us.

### *Cogenerative Dialogues*

Cogenerative dialogues are set up as safe spaces, fields, where researchers can talk about, view, listen and plan in a non-threatening environment. The structures in these fields allow participants to appropriate social and cultural capital in ways that they may not be able to in other aspects of their life. Cogenerative dialogues as an approach to research meet the authenticity criteria (Guba and Lincoln 1989) of research to be ontological, educative, catalytic and tactical. This means that through participation in this research, each of us should be able to grow and learn from each other, share our understandings and develop new understandings. For research to be catalytic and tactical, it should propel participants to new ways of thinking, acting and doing, not just for the sake of Self, but also for Others.

The co-researchers and I are not being researched by an outside entity nor am I researching them. Rather we are researching each other's practices with the intent to learn from each other's perspectives. These spaces are also designed to invite contradictions. Contradictions exist in social life, and by acknowledging and working through them, we each grow from them. In this research, cogenerative dialogues are times when each of us selects and brings a recently taped interaction to the meeting and shares an aspect of that interaction as aligned with the goals of self-improvement and the motives of the group meeting. Although I am in a position of power, by bringing my own vignettes to the meetings and inviting feedback, I try to reduce power imbalances. These meetings become sites for the emergence of different people's ontologies and worldviews through the dialogues that occur. Participants become aware of and develop collective understandings and resolutions to enact and transform social life. Cogenerative dialogues become a theory behind the method, a methodology and also the method from which data emerges.

### *Cultural Historical Activity Theory*

A theoretical approach that illuminates social life in chapters 3 and 4 of this dissertation is Cultural Historical Activity Theory (CHAT). Anna Stetsenko (in press) writes that the activity is one that is social, collaborative and mediated by the collectively created cultural tools and artifacts such as language, writing, technology, rules, norms, and constructs such as patterns of acting and thinking. These activities are motivated by social contexts and directed at social goals (p. 17). The activities aim to transform the world and oneself along with the world.

The dialectical relationship of Self and Other and individual and collective become the foundation for CHAT. Using the Scheffer mark, |, we can denote this relationship. The Self presupposes the Other and as such, thoughts, experiences and enactments by the Self profoundly mediate the thoughts, experiences and enactments of the Other. For this reason, use of auto biography/ethnography is essential to this research. Lynn Dierking (2007), when describing her use of autobiography in research, feels that:

through the very act of discussing the isolated parts of the system I have changed them and certainly the act of thinking of my experiences as a science education student, researcher and educator, has sparked my memory and influenced the meaning I have drawn from these memories (p. 249).

These words reverberate for me and when grounded in CHAT, become key when considering authenticity criteria. In the very act of leading this research, I am transformed by this research. Wolff-Michael Roth (2005b) writes, “we are products of the world we attempt to describe” (p. 23). Individuals have goals and the collective has motives. The motives of the collective include the individual’s goals and serves as an umbrella for them. Similarly, goals presuppose the motives of the collective. I (an individual) am part of the collective (the group of pre-service science teachers, fellow museum staff, and me) and my goals and the collective’s motives presuppose each other. Each moment we live, we are producing|reproducing and transforming culture. As a part of the collective, I contribute to and am mediated by this production|reproduction and transformation. My autobiographical accounts become important in contributing my standpoint, my socio-cultural, political, historical situatedness and subsequently my actions. While my autobiographical accounts weave their way into this dissertation, so do the stories of the co-researchers as they present their vignettes, interpret social life, and contribute to each other’s (and my) development as educators.

### Data Collected

I used audio taping devices, the Olympus DS -2 Digital Voice Recorders and video taping devices, Flip Video Cameras. Both of these are small, USB-ready devices where the user can easily download the files and share them as necessary. In the research we all tape our interactions with visitors on a weekly basis and select key interactions based on our personal interests. Later our experiences are shared in the cogenerative dialogue. Each cogenerative dialogue meeting is also videotaped. Transcripts of the audio and video vignettes of the interactions between Explainers and visitors, and the videotapes of the cogenerative dialogues serve as data sources for this study. Thick descriptions of the culture enacted during the meetings contribute as evidence. Narrative from a social networking site set up for CLUSTER Explainers to share their ideas across three meeting groups serves as another data source. While the cogenerative dialogues continue during Spring 2009, the data analyzed in the dissertation research are from meetings occurring between Sept 2008-March 2009. Pseudonyms are used to protect the identities of all participants, except me.

### Data Analysis

Roth (2005) warns us about creating codes and a coding protocol before we actually participate in activities. Codes cannot be written and decided before we have collected some data and gained some understandings of what is happening at the exhibits and in the cogenerative dialogues. I downloaded and viewed all of the cogenerative dialogue videos as they occurred. After eight sessions, I extracted vignettes that served as turning points for one of us co-researchers in the group or demonstrated a pattern of conversation

emerging from the group. My fellow researchers could not participate in selecting vignettes because of their school or work schedule and time constraints. After I had selected 25 vignettes, I wrote short descriptions of what was happening in them. I then created a code based on patterns that emerged from the vignettes and grouped the vignettes according to that coding protocol. Next, I transcribed the selected vignettes and wrote interpretative text on each, weaving in theory as necessary to illuminate social life. Afterwards, I grouped vignettes into themes that would allow me to tell a story in each of the chapters presented below. In some cases, the co-researcher presented in the vignette offered an interpretation and where possible, especially when it was not in alignment with my interpretation, I wove it into the text. Each chapter was member-checked by the student researchers before submission.

### Overview of the Chapters

Since this dissertation is manuscript style, chapters 2-5 stand-alone and can potentially be submitted as articles for journals at a future date. Basic background information about the CLUSTER project, my study, the participants, and the theoretical foundations are repeated in each chapter for this reason. While each chapter illuminates a different aspect of social life, two main ideas run through chapters 2, 3 and 4 –the epistemological and ontological shifts in each of us as educators as a result of becoming aware of the unaware and the development of a field trip museum worksheet, an activity that emerged from the cogenerative dialogue. The authenticity criteria become evident through the narrative that describes our epistemological and ontological shifts and the emergence of the worksheet project across each of the chapters.

**Chapter 1** –In this chapter, I describe my standpoint and situate myself as an educator and researcher on learning to teach. I discuss the challenge we face in preparing science teachers especially related to providing opportunities to practice teaching. I begin with an exploration of how Informal Science Institutions (ISI) can serve as partners to colleges and universities in serving as innovative and necessary sites for teaching in low-stakes settings. I review my theoretical approach to research with a focus on authenticity criteria. Finally, I provide a brief introduction to the rest of the chapters in my dissertation. I reveal issues of power, positionality and limitations to the research.

**Chapter 2** – In this chapter, I describe how cogenerative dialogues are used as a research methodology in an ISI setting. I argue that these dialogues serve as a methodology that matches my epistemological, ontological and axiological stance as an educator and document how these conversations evolve over time. I investigate key ideas that emerged for us in the group as a result of cogenerative dialogues. I conclude by describing the limitations to my study and offer solutions for ongoing work.

**Chapter 3** –In this chapter, I explain how identity development is mediated by interactions with visitors and then with each other during the cogenerative dialogues. Using Cultural Historical Activity Theory, I theorize how identity development is a construct that emerges from purposeful participation in an activity with the Other and with the intent to transform culture.

**Chapter 4** –Focusing on the theoretical framework of interaction ritual chains offered by Randall Collins (2004), I describe how emotions serve as an input and output of participation in activity. Over time, positive emotional energies lead to an affiliation with

the profession of teaching and solidarity with others who teach. Increased social capital through being the role of a teacher mediates identity development as a teacher.

**Chapter 5** – This chapter is co-authored with Jennifer Adams, assistant professor of science education at Brooklyn College, City University of New York. This chapter focuses on the role that Informal Science Institutions (ISIs) play in partnership with higher education institutions for teacher education; specifically partnerships in the United States, Canada and Israel, where pre-service science teachers are able to learn and practice teaching in informal science institutions. Using a sociocultural lens, we review both patterns and contradictions emerging across these sites and discuss how working in ISIs provides pre-service teachers with opportunities to teach in low-stakes settings, repeat lessons to diverse audiences and develop their skills and dispositions for teaching science.

**Chapter 6** – With this chapter, I synthesize what I have learned from chapters 2-5 and make claims that emerge from the research. I review my contributions to science teaching and learning as a result of this research and I describe implications of this research for informal science institutions, and college teacher preparation programs, I discuss the areas of future research that have emerged for me as a result of this dissertation. I also discuss my own development as an educator and researcher and document key ideas that advance my understanding of teaching and learning.

### Ethical Considerations

As Senior Vice President for Education and Family Programs, I am confronted with great responsibility, amazing opportunities, and interesting challenges. The Belmont Report

(1979) reminds us that when launching any type of research, the three tenets that must be attended to are respect for persons, beneficence and justice. The Institutional Review Board protocols ensure that any researcher takes strong consideration for these three tenets when designing the research program. In my case, I supervise all employees who fall under the division of Education and Family programs. The Explainer Program, consisting of two hundred high school and college students, falls under the category of Education. While not directly supervising all of those Explainers, they are fully aware of who I am and the authority I have as head of the department. As such, it is especially important that I tend to the tenets of the Belmont Report in the research design process.

Positionality and power become key structures to contend with in this research. The participants of this research are already cognizant that they are part of a larger research project through their involvement with CLUSTER and are aware that, as research evolves new approaches to research are explored. I face a challenge both serving as a supervisor in the museum and as a Co-PI on the CLUSTER project. I am concerned that students might feel coerced into working with me because they may think they owe me something in exchange for being part of the CLUSTER project. In order to reduce the risk of coercion, I am clear with my intent for research and my invitation. Yet, even with great awareness on my part, my position as a vice president becomes an inevitable resource for me, which can't be ignored. It contributes to my agency and possibly inhibits the agency of others. I made great efforts to reduce power imbalances, but I risk the creation of such structures unconsciously. I sense a great deal of respect from the Explainers generally. I attribute this not only to my general demeanor, but also because they know that I am a former Explainer and that I understand and respect the work they do. Choosing to employ

cogenerative dialogues as a methodology allows me to account for power structures at play. By positioning myself as a co-researcher and bringing my own vignettes to meetings, I seek to develop solidarity with the others and learn from them. In some cases such as the worksheet project, my power as an administrator becomes a resource for the group as will be described in the forthcoming chapters.

### Limitations

The knowledge produced in my research will have theoretical and empirical implications for action and transformation in many ways and through multiple fields. However, as with all research, there are limitations in understandings. My choices of frameworks foreground certain events and phenomena, but obscure others. I am also aware that this research suffers from a crisis of representation. Norman Denzin and Yvonna Lincoln (2003) ask researchers to consider, “Can we ever hope to speak authentically of the experience of the Other” (p. 616)? Although I have member-checked my writing, and where possible, I include perspectives from co-researchers who are present in the transcripts, I maintain a certain privilege and powerful vantage point as author of this dissertation. I hope that the co-researchers of this study, my fellow researchers in the CLUSTER project and my colleagues in both formal and informal science education will read this text and contribute their ideas, understandings and voices to extend this work. With excitement, I present you with the chapters in this dissertation, each of which tells a different, but related story and together documents how working in an informal science institution, interacting with visitors, and then having opportunities to reflectively and

reflexively discuss those interactions mediates the development of a person's identity as a science educator.

## **Chapter 2: I Am Not The Expert: Using Cogenerative Dialogues in Informal Science Institutions to Support Teaching and Learning**

In this chapter, I document and advocate for the use of cogenerative dialogues as both a methodology and method to be employed for the purposes of improving teaching and learning in an Informal Science Institution (ISI) setting. Cogenerative dialogues are meetings where critical discourse can occur, power imbalances can be minimized and all involved have the potential to become aware of practices and schema that they were unaware of, thereby catalyzing their own actions and influencing the actions of others. In what follows, I review the role of ISIs in teacher professional development, and describe an ISI-based teacher preparation program that serves as the context for the study presented in this chapter. I describe how the need for cogenerative dialogues arose and the outcomes of implementing them in an ISI setting by providing evidence of how they served as structures for supporting the growth of pre-service teachers and conclude with claims for why cogenerative dialogues should be employed as methods for training floor facilitators.

### **ISI as Sites for Professional Development**

ISIs are free-choice learning institutions which means that people learn through self-paced, voluntary, non-sequential ways. These institutions recognize learning to be socially constructed, where an interchange occurs between an individual and her sociocultural and physical environments (Falk 2001). ISIs are specifically designed to demonstrate or display real-world phenomena where people can pursue and develop science interests, engage in science exploration and reflect on their experiences through

dialogue (Bell, Lewenstein, Shouse and Feder 2009) and broadly include places such as science centers, zoos, aquaria, nature centers arboreta and natural history museums. A potential role for an ISI is to serve as a partner to schools and universities for reform-minded science teaching, promote student-centered learning, and provide access to exhibits. Doreen Finkelstein (2005) found that teachers perceive ISIs as places of expertise for science content, support for development of pedagogical skills and access to resources. She stated that they view ISIs as places to expose them to ideas and activities they can take back in the classroom and that professional development through ISIs become a venue for meeting other teachers, science experts, and scientists. Her study also describes that teachers feel that ISIs are sites where both teachers and students can be exposed to activities and experiences not possible in a formal classroom. More recently, a set of studies conducted by Michelle Phillips, Doreen Finkelstein and Sandra Wever-Frerichs (2007) found that even though more than half of the nation's ISIs provide professional development programs, they tend to serve experienced teachers at the elementary grade level and furthermore claim that ISIs may be missing a key opportunity to serve an audience in need, new secondary science teachers.

The New York Hall of Science (NYHS) is an ISI located in New York City and serves as a partner and resource to teachers locally and nationally. In 2008, 4500 teachers participated in the professional development programs offered through NYHS. Pre-service teachers are an area of focus, especially through the Science Career Ladder (SCL) Program. The SCL is a twenty-two year old youth employment and engagement program where high school and college students are hired to work as floor staff called Explainers. SCL is named such because Explainers have opportunities to move "up a ladder" and into

positions of leadership both at NYHS, in other informal institutions and quite often in teaching careers. As such the SCL has become an unexpected pipeline for producing teachers.

*CLUSTER – A Teacher Preparation Program*

The Collaboration for Leadership in Urban Science Teaching Evaluation and Research (CLUSTER) is an National Foundation of Science (NSF) funded program where a local urban college, City College of New York of City University of New York (CCNY of CUNY) and NYHS partnered to develop and implement a pre-service secondary science teacher program where undergraduate science students take state-mandated education courses and work as Explainers at NYHS. CLUSTER began in 2005, and the project allowed NYHS to formally document and collect data on the Explainers who are interested in teaching and generate knowledge on how the Explainer experience serves as a valuable and unique opportunity to actually teach while learning how to teach. As Explainers, the pre-service teachers interact with visitors by engaging them in dialogues about science using exhibits as conversation starters. They also conduct twenty-minute science demonstrations, facilitate discovery labs and assist with after-school programs. They work as Explainers at least seven hours per week while they are in the CLUSTER program and their education coursework is coordinated to take advantage of their Explainer experiences through homework assignments and group projects. These Explainers attend weekly exhibit training and receive all of the support and mentoring that is offered to the rest of the Explainers corps (about hundred students) employed by NYHS. The Center for Advanced Studies in Education (CASE) at the CUNY Graduate Center serves as the research partner to document the growth of these CLUSTER

Explainers as reform-minded science teachers. Jian Wang and Sandra Odell (2002) define reform-minded teachers as ones who understand learners as unique, shaped by and dialectically shaping socio-cultural elements, politics, and ideologies. Such teachers appreciate the diversity of students and regard teaching and learning as socially constructed. They promote collaborative inquiry and collective making of meaning. They view themselves as facilitators and knowledge transformers rather than as transmission agents. CLUSTER, as a partnership idea, was conceived to support teachers in developing reform-minded principles at a central objective because the team feels that teachers need to develop an understanding of teaching and learning as socio-culturally situated, and cogenerated through dialogue and discussion rather than transmitted through chalk and talk methods of teaching.

The guiding premise for the CLUSTER Project is that in order to support students in becoming science teachers, we have to provide them with opportunities to practice teaching in low-stakes settings. April Lynn Luehmann (2007) advocates for such an approach to science teacher preparation and reminds us that pre-service teachers face great challenges in becoming reform-minded teachers. Their experiences as students and memories of their own teachers do not always mirror reform-minded teaching so they don't have experience or buy-in for such approaches. Their experiences during student teaching are often counter to what they have learned on constructivist theory. Luehmann invites us to design opportunities for pre-service teachers where they are in low-risk, low-stakes environments with a continuum of experiences and claims that traditional classrooms don't always offer such opportunities. Kenneth Tobin and Wolff Michael Roth (2007) argue for the praxeology of teaching and claim that talking about practice is

very different from actually being in the act of teaching and we need to address the “rift between descriptions of teaching practice and enacted teaching practice” (p.2). In this case, praxeology is not defined as talking about practice as the etymology of the word may imply, but rather as a “way of theorizing each instance as a concrete realization of the general. Each action is both *singular*, concretely enacted by this person in this situation, and *plural*, a possibility for acting in this culture generally” (Tobin and Roth 2007, p31). Explainers’ experiences with visitors are individual acts of cultural enactment, and with each act comes their ability to embody the role of a teacher and develop theory about what techniques work or don’t work. Roth and Tobin also remind us that, “practice unfolds in time, irreversibly, with its own rhythm, tempo, and directionality”(p.7). Michael Wolff Roth, Daniel Lawless and Demonico Masciotra (2001) describe the concept of Spielraum, the ability to maneuver, or to develop practices that are anticipatory, timely and appropriate to given situations. Spielraum can be thought of as schemas and practices for a teacher to be prepared to the best extent possible to take advantage of teachable moments, contradictory events and re/produce and transform culture in real time without needing or even having the time to step back and reflect on the next step to take in that moment and this can not be taught in a course, it is based on experience. Working as an explainer supports the development of spielraum in a pre-service teacher.

A teaching space, the exhibit floor, can be described as a field where fields are defined as sites for cultural production with specific structures and porous boundaries (Tobin and Roth 2006). Fields have structures composed of schema (ideas, beliefs), practices and resources. Resources in this field consist of exhibits and fellow staff. ISIs,

by definition, are places where all kinds of people (both school groups and families) visit for different reasons. Their motivations for the visit become a factor into how they experience the museum and its resources (Falk 2006). By interacting with different and unique visitors one day a week over the course of one to three years, Explainers have ample opportunity to develop, test and refine their approaches to teaching. They learn what works, what doesn't work, how to employ different strategies for different types of visitors and how to engage them in conversations that lead to successful interactions. CLUSTER aims to take their experiences and link them to formal education ideas and structures (composed of its own schemas, practices, resources) so that students can apply their understandings to a formal classroom.

#### The Need Arises for Cogenerative Dialogues

My role in the CLUSTER project as Co-Principal Investigator situates me to work closely with the project teams from the university, but also have regular interactions with CLUSTER Explainers. As time has progressed in the project, I have noticed that certain markers of identity development as a teacher emerge as these Explainers work at NYHS. My own personal experiences as a former explainer remind me how being on the exhibit floor and regularly working with visitors helped shape my interests in teaching and learning as a career choice and my own identity as an educator. In response, I have launched an inquiry in the form of my doctoral research to document the ways in which our identities as science teacher educators develop as we work as Explainers. Anna Sfard and Anna Prusak (2005) remind us that documenting identity development is a complex task, but is more useful for supporting pre-service teachers because it does not separate

one's report about her attitudes and confidence about teaching from the actual act of teaching.

As I struggled to begin this documentation of identity development in Spring 2008, a need arose in the research agenda for the CLUSTER program where we needed to provide more consistent and explicit support to CLUSTER Explainers. One aspect of data collection in CLUSTER is to audiotape each CLUSTER explainer interacting with visitors at a given exhibit, *Light Island*, at the time of entry into the program and then every six months. *Light Island* is a hands-on exhibit that is designed to demonstrate a number of phenomena related to light and offer multiple entry points for a visitor. It also has the potential to allow for visitor-centered investigations on light without prescribing a formulaic protocol. This exhibit is ideal to measure the potential shift in a CLUSTER explainer towards more visitor-centered reform-minded teaching.

In Spring 2008, the CLUSTER research team felt that more support and mentoring were necessary for the CLUSTER Explainers beyond the coordinated coursework to the explainer experience and the weekly training they received as Explainers. While there were documented changes in their growth as Explainers employing inquiry-based methods in their interactions with visitors, the team felt that a more explicit approach through small group coaching meetings might be useful. I offered aspects of a cogenerative dialogue as an approach to the design of these meetings. I felt that the CLUSTER explainer interactions with visitors needed to be taped, shared and reviewed more regularly than every six-months, the protocol in place at that time. I also felt that from an identity development perspective and as a critical epistemological stance, the Explainers themselves needed to review these tapes, reflect on their actions and make

plans for personal change. By having a voice in selecting their audio and video vignettes, and articulating and explaining personal experiences in a shared space and without concerns for assessment, I felt that CLUSTER Explainers would find it safe and useful to examine and improve their practices. Ontologically, I advocated for this protocol because I knew from my explainer days that during interaction with visitors, many thoughts and ideas flowed in my mind which could not be captured on tape, but would serve as an important data source for understanding the act. If my taped interactions were the object of discussion, I would want to narrate what happened just before, and after and the thoughts in my mind that afforded or constrained my activity in real time.

Using methods consistent with design study (Brown 1992), where the protocol unfolds as related to the needs of the research, the CLUSTER team decided to experiment by setting up three CLUSTER groups. These groups were based on the schedule of work for all of the CLUSTER Explainers for summer and fall 2008. I elected to be one of the three coaches. The other two coaches are the explainer manager and a program youth specialist, both employees of NYHS and both involved in administering the CLUSTER project in different capacities. A fourth coach, also a NYHS employee who served as an administrator for the explainer program and also used to be an explainer, was available to lead a group, but since a fourth group didn't exist, she joined the group I led and became a co-leader with me. Although we called ourselves coaches, the structure of these meetings as cogenerative dialogues placed me as part of a team that together learns to teach. Epistemologically, ontologically and axiologically, I felt that we, the CLUSTER project team, would never effectively be able to support the Explainers in becoming more aware of their teaching practices by simply modeling for them. These understandings

would need to emerge from within themselves and could in fact, emerge from them because they are culturally and historically situated students with vast experiences both outside of the program, but also through the program. As Tobin and Roth (2007) write, cogenerative dialogues are “an alternative to interviewing teachers about their experiences. First data are generated (by listening to tapes and talking about them) and then when we make sense of what happened, we evolve our understandings, and it provides a concrete situation in which to generate theory as part of research (p. 85)” and this supported my decision to use this method as a structure for the meetings.

### Cogenerative Dialogues

Cogenerative dialogues are conversations about “shared experiences of participating in a field” (Tobin and Roth 2006, p. 91). In this case the exhibit floor is Field 1. However, a second field, Field 2, is produced in the cogenerative dialogues, where stakeholders (student researchers, me, Explainer administrators) have a shared focus of improving teaching and learning by using “current understandings to describe what has happened, identify problems, articulate problems in terms of contradictions (generalization), and frame options that provide us new and increased choices for enacting teaching and learning. That is, these sessions can be understood as a new learning environment that take the classroom learning environment (Field 1) as its object of inquiry” (Roth, Tobin and Zimmerman 2002, p. 9). In this research, we bring the experiences of Field 1 (the exhibit floor) into Field 2 (the cogenerative dialogue) and then back into Field 1.

Functioning as seedbeds for producing, reproducing and transforming culture (Tobin and Roth 2008), cogenerative dialogues serve as a “methodological framework for engaging classroom participants to generate understanding (local theory) about teaching

and learning – from *being-in* a particular situation *with* other teachers and students” (Martin and Scantlebury 2008, p. 2). Cogenerative dialogues become more than just a conversation when they are conceptualized as meeting the authenticity criteria proposed by Guba and Lincoln (1989) which state that the approach to research incorporate ontological, educative, catalytic and tactical authenticity. When a conversation includes each of these tenets, it becomes a cogenerative dialogue and we can consider this framework as a methodology. Roth, et al (2002) describe a heuristic that describes attributes which are present in such conversations which allow them to meet the authenticity criteria. This includes having respect and rapport between participants, inclusion of all stakeholders, setting up multiple ways to participate such as coordinating discussion, listening attentively, suggesting alternates for actions, offering multiple opportunities to participate, and encouraging diverse, but focused discussion topics on teaching and learning in the field.

### *The Study*

This chapter addresses the following question; *in what ways do cogenerative dialogues serve as a useful methodology for ISI facilitators’ growth as a teacher?* I choose to structure the question with the words “ISI facilitators” because while this study documents CLUSTER Explainers specifically, these students all serve in the role of ISI facilitators on the exhibit floor.

Sonya Martin and Kate Scantlebury (2008) remind us that in the last decade at least forty-five university teachers and student researchers have published articles in over fifty journals internationally, at least four books being written and there are several

unpublished doctoral dissertations and on-going studies underway. “These studies detail the theoretical and methodological frameworks supporting cogenerative dialogues and provide useful insights into how teachers and researchers can use cogenerative dialogues to catalyze positive change in the classroom, and transform social interactions between teachers and students” (p. 2). However, all of these studies are in formal classrooms across K-12 education. Employing this method in an ISI setting required me to describe it to museum colleagues, but also provided me with an opportunity to review the theory behind this method.

The cogenerative dialogue for this study took shape in late August 2008. We meet weekly for one-two hours and during those meetings, we review taped interactions between one of us and visitors. The nature of the meetings evolved from the first day into its current structure over a eight-month period as will be described below.

### *The Participants*

The cogenerative dialogues are in operation at the time of writing this article and include approximately nine people. I am the educator researcher, Jan is the administrator researcher (also fourth CLUSTER coach), and seven people are CLUSTER Explainers serving as student researchers. On average, four out of the seven students, not always the same people, attend the meetings. If less than five total people were available, we do not meet because too many people would be left out of that day’s conversation.

All nine of us are first generation or immigrant students and our ethnic backgrounds are all South Asian, except for Jan who is Latin American and one student who is half South Asian and half Puerto Rican. Having similar ethnic backgrounds was coincidental

and not planned for this study. However, having similar ethnic backgrounds created a shared identity and contributed to conversations. Two students are male, the rest are female. All seven students are undergraduate science majors (four biology, one chemistry, one earth science, and one engineering) at a CUNY college, Jan is currently not enrolled in a college but expects to finish her undergraduate degree in Computer Science and pursue a Masters in Education in the near future. I am a doctoral candidate at the CUNY Graduate Center, have a Masters in Education and a Bachelors in Engineering. At the time of the writing of this chapter, two students have dropped out of the CLUSTER program, but have participated in many of the cogenerative dialogues presented as data sources for this chapter.

#### *Data Sources*

Transcripts of the audio and video vignettes of the interactions between Explainers and visitors, and the videotapes of the cogenerative dialogues serve as data sources for this study. Thick field descriptions of the meetings contribute as evidence. Narrative from a social networking site was set up for CLUSTER Explainers to share their ideas across the three meeting groups serve as another data source. Olympus audio recorders and flip video cameras are used for taping. While the cogenerative dialogues continue to happen into Spring 2009, the data presented here represent meetings between Sept 2008-January 2009. Pseudonyms are used to protect the identity of all participants, except myself.

#### *The First Day of Dialogue*

Since I was planning to use these meetings for data collection, I explained my interests as a researcher and invited the group to become student researchers. After completing IRB

consent forms, I described the nature of cogenerative dialogues and the tenets of such meetings. I never actually used the words, “cogenerative dialogues” because I struggled so much in effectively explaining it to my peers in the CLUSTER team that I was afraid to share it with the student researchers and scare them off with a technical-sounding word. Instead, I described the need for equal stakeholder status, and stated that I was hoping to leave my executive position “hat” at the door and be in the role of researcher/learner/teacher along with them. I described that we would be audio or video taping our interactions with visitors and playing selected vignettes for each other during the meetings for the purposes of improving our ability to effectively interact with visitors. I discussed that I would not always lead the meetings and invited everyone to think about different topics we wanted to discuss and focus on together. While everything I said was listened to attentively, I was convinced that none of these things would actually happen because of the power issues associated with my status as an administrator.

On shaky grounds I presented a vignette of my taping where I interacted with visitors at an exhibit, *Bubbles*, in order to break the ice and make everyone comfortable with the idea of watching themselves on video. The group was interested in the vignette and when it came time to discuss, they offered positive comments about how I conducted the interaction. I took that opportunity to point out my own views of what I did well, but also described where I felt frustrated and where I thought I didn’t successfully complete an interaction. My goal was to show them that I could criticize myself and tried to open the doors for them to criticize me. While they agreed with my self-analysis, they did not offer more in the way of critical feedback.

### *As Time Progressed*

After approximately four meetings, I noticed that we were getting comfortable with each other and by meeting consistently each week, we had formed a routine. In this routine, we all were used to tapings ourselves earlier in the day or in the week and selecting a vignette to share. We also knew that we would start with blogging about our Explainer experiences on a shared social networking site.

In general, there was talk about teaching and learning either triggered by the vignettes presented or because of a recent experience with a visitor. We often talked about other issues that arose such as family structures, our own education, our experiences as students, what we thought was effective or ineffective pedagogy in our teachers and professors (current and past). Talking about these topics and using stories from our past helped to minimize power differences, and create solidarity. Evidence of this shift from strained to more comfortable was documented through physical structures such as seating arrangements, levels of emotional energy, and the general chatter that existed as we all piled into our room. In what follows, I review these three shifts in detail.

### Seating Arrangements



*Cogenerative Dialogue, September 5, 2008*



*Cogenerative Dialogue, December 5, 2008*

The two photos above demonstrate how seating and to some extent, body posture has evolved after a few meetings. The first photo is from the first meeting and the second photo is from the sixth meeting. In the earlier meetings, students who are friends with each other and go to the same college seemed to sit near each other. Jan was less involved and in the role of administrator or assistant to me, tended to sit slightly away (isn't even visible in photo 1), participate less, and placed herself in a support role as per the duty of an administrator. Over time, there is a change in seating arrangements and people mix more with each other. Jan also has more central to the group, and has begun to take her turn her talk. She has been invited to bring her own clips to the meeting even though she is not an Explainer. Since she was once an Explainer like me, she is trained for the job. After approximately five meetings, Jan is able to facilitate the meeting without me (as I missed two sessions due to work schedule). In the first photo above, I am on one side of the table with one CLUSTER Explainer who has been in CLUSTER for one year and the rest of the group is on the other side and they have been in CLUSTER for six months. In the second photo, our seating arrangements have changed. While I may appear in the center, I am somewhat off to the side and everyone is evenly distributed around the table leaning in for a focused conversation.

### Levels of Emotional Energy

A change occurred in the emotional energy that is produced in this field. In earlier dialogues, there was a timid, unsure feeling in the air where everyone was unsure about how these meetings would affect practice. There were often looks of boredom, acts of people checking their schedules to see what was on their agenda after this meeting and an occasional glance at the cell phone to check the time. There were some longer pauses in

between questions and statements increasing the tension of meeting. After a few meetings, I noticed a shift towards more involvement, more interest and equal turns of talk. Now, I am not the only one who initiates a dialogue, others do as well. The video and audio vignettes became the object of mutual focus and remains that object of focus well beyond the actual replaying of the exhibit interaction as can be seen by the second photo. In each meeting, there are times of solidarity represented by mutual focus, collective effervescence and high emotional energy, but there are times when the group is not focused. This is natural because when documenting social life, contradictions will exist for each pattern that we see. With cogenerative dialogues, as time progresses, the frequency of experiencing solidarity is greater than the frequency of experiencing lack of solidarity.

#### General Chatter

In earlier meetings, when all members entered, there was a formality to each other and comments and chatter were softly spoken so that others could not hear. As time progressed and comfort increased, all members would enter the room without changing their tone or pitch of voice. However the topic of chatter would not be the same as when they entered the room. Now, entering the room and seeing the members of the cogenerative dialogue often prompts conversations about professors, a recent exam they took, or some event related to their Explainer experience that has happened in just the past few hours. The routine of blogging on the shared social networking site for five to ten minutes has also become a resource for conversation starters related to teaching and learning.

### Emergence of Key Ideas as a Result of Cogenerative Dialogues

Generating local theory is an epistemological quality of cogenerative dialogues because participants construct knowledge based on their experiences rather than accepting it from an authority figure. In this case, knowledge that came from books and coursework contribute to our understandings of the social world, but discussing our experiences in a structured setting with the intent for improving our own actions allows us to theorize our experiences and praxis. A number of key ideas have emerged as a result of the dialogues that I think may not have been possible had we not talked about them in the cogenerative dialogues. Student researchers have begun to view me as a peer and trust that I am truly interested in co-researching, teaching and learning with them rather than acting as an expert or assessing them. While my designation as a senior vice president for the institution is not forgotten, it has become less important and has faded into the background as my identity as fellow educator and a researcher has become prominent. This allows all of us to become more comfortable and reveal our ontological and epistemological understandings about learning and teaching. In addition to their growth as a teacher, the structures allow me to examine my own epistemological and ontological stances and growth as a teacher. We are able to share ideas and strategies and be reflexive about aspects of teaching and learning. Most interestingly, we are able to be catalytic with our understandings.

*I Am Not the Expert*

As part of the research group, I regularly bring vignettes of my own interactions of visitors. This is a way for me to examine my own practices and also use the vignettes as resources for launching conversations that would link theory to practice. In one particular instance, I taped my interaction with a small group of seventh grade girls who were on a field trip to NYHS and needed to complete a worksheet assignment. I approached these girls and asked if they needed assistance. They needed to find the exhibit, *Hot Light* in order to answer a question. I directed them to it and asked if they would like me to work with them in investigating their exhibit. Together we explored that exhibit for approximately ten minutes and then I asked them to look at their worksheet question. We then attempted to answer their question. After I thought we had successfully found an answer to the question, one student blurted out, "I don't get it." I felt a sudden sense of panic and frustration at that moment. The episode below describes the conversation in the cogenerative dialogue where we have just finished listening to this interaction and I was describing the frustration I felt at that moment:

- 01 Preeti:** (chuckling embarrassingly) I was like (chuckle) I was like what do you mean you ...I felt like saying what do you mean you don't get it.(laughter in group) What do you mean you don't get it? (repeated in conversation with tone of disbelief)
- 02 Samantha:** Did this person just come in?
- 03 Preeti:** No, she was there the whole time (hand gesture demonstrating disbelief)
- 04 Samantha:** You sound like you were going to attack her.
- 05 Preeti:** ↑What don't you get? (repeated for emphasis of disbelief)  
 ↓ Yeah (in response to line 4) I was like ok, in myself, calm down. Think about how you are gonna do this. (Group laughter)

The feeling of frustration I experience in this interaction is commonplace for an educator who discovers her student is confused despite the educator's best efforts at teaching. During the meeting, I reveal the emotion I felt in the moment and then describe how I moved forward to the best of my ability to deal with that frustration and simultaneously work towards helping that student understand. My frustration was based on my belief that I did an excellent job of teaching yet, this one student didn't understand. I didn't know how to modify my approach and get through to this student. Selecting and then presenting this vignette during the cogenerative dialogue revealed to me this feeling of frustration and illuminated for me a need to improve my ability to facilitate that exhibit as well as be prepared to re-word and re-facilitate exhibits for different learners. It also made me realize that I was overconfident in my general approach to facilitation. I could not fathom that after my best attempt to facilitate this exhibit, someone could not understand the concept. It was humbling and reminded me that teaching is not like riding a bicycle. While practice has the potential to make one comfortable with the skills to teach, gives one confidence and self-efficacy, one can be out of practice with how to

teach certain scientific concepts that are not part of the everyday repertoire of experiences. Beyond the opportunity to expand my praxis as an educator, I currently hold the role of the administrator and lead proposal development projects related to teaching and learning. Often, people in my position are experienced, veteran educators who don't have time to continue to teach. Rather they develop projects and base their understandings of this field and its needs on their past experiences. These experiences are culturally and historically situated and may or may not represent current needs of the field. Also, because we are basing our understandings on the memories we have of our lived experiences, we may choose to remember certain events, but forget others. Participating in the cogenerative dialogues has allowed me to renew my understandings and build new memories. I feel more attuned to certain issues of teaching and learning because of my recent experiences, which existed for me 15 years ago when I was an Explainer, but I had forgotten about them as time progressed. When I now discuss the state of field trip visits to NYHS and the role of Explainers, I represent the issues differently than I might have a year ago. My identity as an educator and an administrator is changed through experiences like this because I learned that people who have climbed a career ladder do have expertise in certain areas, but have a lot to learn by examining their own practices and sharing their emotions and understandings with Others.

### *Power*

The vignette above describes how I am able to reveal my own struggles with teaching and learning. Cogenerative dialogues also set up structures where my fellow student researchers can be comfortable with providing me with advice and offering their own experiences to guide my development as a teacher. The following episode continues the

dialogue described above. After discussing my frustration, I am describing my struggle with wanting to help this student who did not understand the exhibit, *Hot Light*.

- 01 Preeti:** How do I help this person get it in a different way ↑ on the spot ↓ like I have to be quick because I didn't want her to become uninterested.  
I was like uh...ok...come [on over]
- 02 Naina:** [Did you read] the question [first?]
- 03 Preeti:** I] didn't ↑ [read] it. [No]
- 04 Naina:** [maybe you should] have read the [question]
- 05 Preeti:** could have directed it [yeah] so I

Naina is a shy person, and comments less than others. She takes her turns of talk especially in the meetings in the latter part of the semester, but often is not the first to offer her opinion. Here, Naina is completely comfortable with questioning me and asking me if I inquired about the worksheet question before engaging the students in an investigation of the exhibit. This demonstrates how she is comfortable giving me advice. Hearing her tell me that I should have read the question first bothers me because I don't like to facilitate exhibits that way. I don't want students to experience exhibits because they have to answer a question. However, I didn't disagree with her or offer my perspective in that moment for two reasons. First, I didn't want to over-ride her comment by stating my philosophy and risk a power imbalance. If I had offered my standpoint that students should experience the exhibit for the joy of it rather than to answer a question, it is possible that Naina would have allowed me to speak and not returned with a comment to defend her point. Second, in a practical way, Naina is correct. In line 05, I agree with her that I should have read the question and later on in the event with the field trip

students, I do use the strategy of asking them to state their worksheet question before engaging them in a facilitated discussion at the exhibit. Power imbalances can create situations that prevent cogenerative dialogues from being transformational. Had I imposed my epistemologies about how exhibits should be facilitated at that moment, I may have caused Naina to shut down and I also would have been dishonest with myself. In fact, reading the question first may be a more useful approach to working with field trip students, even if I axiologically feel that worksheet questions should not lead the exhibit experience. I did consider my stance important for sharing and wove it into other conversations to mediate the Explainer's thinking.

As we discuss our praxis through these dialogues, we have to negotiate our beliefs about how students should learn. The constraints of schooling are such that teachers have to design worksheet experiences to justify a field trip to the science center. The Explainers feel that having worksheet questions focuses the student and it is important to interact with the student with the intent to facilitate completion of their assignment. I feel that experiencing the exhibits is priority and a successful engagement with the exhibit will lead to understanding and eventually the answers necessary for the worksheet questions. As co-researchers, we listen to each other's perspective and over time, we negotiate, we develop and shift our understandings of how to interact with students on a field trip thereby mediating our identity development as educators.

### *Sharing Strategies*

We see in the vignettes presented thus far how cogenerative dialogues are fields where culture is enacted. Members who participate in this field—the collective—have a motive, a shared focus of improving teaching and learning techniques. Each individual member

has her own goals for how to increase her own ability to effectively interact with a visitor. There exists a dialectical relationship between the collective and the individual and as such there is a dialectical relationship between the motives of the collective and the goals of the individual. Through sharing strategies, each of us work towards our personal goals, but that presupposes that we are then working towards the motive of the collective, to improve teaching and learning as a whole. In this system, the idea is not to become like the other at the risk of losing one's own style and identity, but rather to "retain diverse perspectives, value differences and promote solidarity and cohesiveness around shared schema and practices" (LaVan and Beers 2005, p. 152). Using audio and video taped interactions as resources for learning about and discussing each other's styles of interactions, we see evidence of why the Explainers choose to approach an interaction in a certain way and how they negotiate other people's perspectives into their approach.

In the following vignette, we had just finished listening to an audio-taped interaction between Seema and some visitors at the *Biosphere* exhibit. This exhibit is a self-contained ecosystem—an enclosed glass structure filled with water, algae and dwarf shrimp. It was placed in NYHS in the late 1990s and continues to sustain life with ceiling light as the only input. It is a popular exhibit for facilitation because it demonstrates a unique phenomenon. Seema deconstructed her interactions with visitors and we all took turns and comment on it. Rhonda (another member of our group) stated in this conversation that she learned how to facilitate that exhibit from Seema. All of us have just described the main idea that we try to get across to our visitors with this exhibit. Some of are interested in describing sustainability of life in a biosphere and others are interested in discussing the main idea of gas exchanges among two or more living beings

in a system. Seema and Rhonda both tend to focus on gas exchanges, especially because Rhonda learned the exhibit from Seema, but Rhonda had just mentioned that she uses words like “how do plants grow” instead of “photosynthesis.”

- Seema:** That works too. How do plants grow. (as a statement)
- Preeti:** How do plants grow. (Rhonda nodding her head in agreement)
- Seema:** I don't know, first thing I think of is photosynthesis. I think too complicated I think. All these bio classes (in audible) so how does photosynthesis occur.
- Preeti:** yeah so you think of the fancy way of saying and you forget the everyday way of thinking about it.
- Seema:** But that is a good idea, I should use that.

Seema describes her affinity for wanting to use the bigger science words and claims that it is all of the biology classes that she has been taking that force her to use fancier words. Rhonda who learned the exhibit from Seema describes that she gets the same concept across using everyday words, and prefers to do that compared to the science word as an engagement strategy. This sharing of strategies among all of us who have a preferred way of facilitating an exhibit contributes to our growth as teachers of this concept. Cogenerative dialogues become a structure where the stakes are low and collectively, we all know that learning new approaches with support for our individual goals are the motives of the collective. In addition, by definition, these dialogues are structured such that there is an acknowledgement and invitation for each person's right to be different and bring different perspectives to the meeting. While Rhonda learned the exhibit from Seema, she does not mind sharing her strategy with the person who taught her the exhibit. There isn't a sense of expert or master and apprentice. Power struggles do not seem to be evident to hinder sharing. Rather, cogenerative dialogues allow for

multiple voices and reveal multiple ways of thinking. While Rhonda learned the exhibit from Seema, her way of thinking about it and owning it as knowledge become apparent in the way she teaches the concept back to the visitors. A different way of conceptualizing this knowledge becomes visible to Seema and the rest of the group. In this way, sharing strategies becomes a way to bring to the surface multiple ways of knowing, of teaching and of co-generating a plan for improved facilitation at exhibits. It expands our repertoire, supports our *spielraum* or ability to maneuver in timely, anticipatory and appropriate ways. We increase our ability to engage in more successful interactions than before mediating our identities as successful educators.

### *Reflexivity*

In all of the ideas discussed above, the underlying premise is that of becoming aware of the unaware, or experiencing reflexivity. Our work as teachers can often become a routine and while we realize that each activity is a historical act and no two moments repeat, often what becomes habit for us blinds us from reflexivity. LaVan and Beers (2005) maintain that, “the power of this type of [cogenerative] dialogue also lies in the opportunity for participants to identify and review practices that are unintended and habitual, while discussing the power relationships, roles and agency of all of the stakeholders. The associated redistribution of power (vertically and horizontally) allows all stakeholders to discuss future actions and activities as well as aid in the planning for improvements to the quality of teaching and learning” (p. 152). The following monologue from Rhonda exemplifies how it is easy to develop practices that are routine once you are comfortable with it, but become aware of these practices through structures of a cogenerative dialogue.

During one meeting, an Explainer, Neel had just finished presenting his interaction with a group of eleventh graders at an exhibit called *Cheshire Cat*. This exhibit is structured so that our two eyes are focused on two different images. The exhibit demonstrates that even if our two eyes are seeing different things, our brain focuses our attention to the object that is moving and more interesting, causing us to overlap the images in our brain and produce an illusion. In discussing this interaction, a very small comment was made regarding making assumptions. At this point, Rhonda launched into a monologue about her interaction earlier that day at the cow's eye dissection demonstration with the same group of eleventh graders. This is a twenty-minute demonstration where Explainers dissect a real cow's eye for the audience and review the function of each part of the eye and discuss related disorders. Rhonda is certified to conduct this demonstration and has performed it many times. Certification is a rigorous process of demonstrating content knowledge, presentation of material and active engagement with visitors.

**Rhonda:** When I was asking them questions about uh.. in the beginning it was just things like uh..normal things like uh..inversion, involuntary and stuff that I kind of thought you should know because you are gonna take your SAT's, you are gonna go to college and I assumed because I knew it, that they would know too, and normal things like rods and cones and you've sort of heard about them. You might not know exactly what they do ... so at one point I asked them "do you guys know what rods and cones are?" and this one kid kind of shouted out from the back, "Ms, you think we are so smart, but we don't know what you are talking a:bou::t (laughter from all in the cogenerative dialogue). And that's when I realized I shouldn't assume that just because I knew when I was their age, .. I mean a couple of them knew what I was talking about but I kind of assumed that just because a couple knew that I didn't have to say it over because it was a big crowd. I didn't ask what inversion is or when if the image gets inverted, this one girl kept answering but I figured if she knew it, others would kind of know, but I was wrong, and I felt really bad. "Ms, you think we are so smart, but we don't know what you are talking about" I said oh and I said, "I'm sorry"...it is my fault I should have realized that I shouldn't have

assumed, so after that, I was sort of careful about explaining everything.

Rhonda reveals how she made assumptions and based it on her own experiences as a student. However, one statement from one of the students in her audience triggered her to realize that she was making assumptions and this was unacceptable to her. Cogenerative dialogues are places for making visible different ontologies (Tobin and Roth 2007). For Rhonda, the cow's eye dissection coupled with a discussion about her emotion and sudden awareness of her act of making assumptions allowed her and us to understand her ontologies about schooling and students. She believed that eleventh graders are preparing for college entrance exams and are only a few years away from college and should have a working knowledge of science words such as inversion and involuntary. Her reflexivity about making assumptions triggered the rest of group to recall and discuss their own experiences with making assumptions. Each of us took turns during that meeting and revealed moments when we made assumptions, which affected our ability to successfully complete our interactions. The conversation about assumptions became a blog post on the social networking site and other CLUSTER Explainers posted their opinions and stories about making assumptions. The posting below demonstrates how another CLUSTER Explainer added to the conversation by writing on the blog, offered his own examples and then revealed his struggle with another issue, that of, differentiated instruction.

Assumptions are ubiquitous everywhere we go. People are always assuming different things about different people. However, at here in NY Hall of Science this could lead us to a bad explaining experience when we assume certain things about our visitor's prior knowledge. SIMPLEST examples of these are that we often speculate on whether to interact with certain visitors, because we may fear that they may already know about the exhibitions or get irritated for disturbing them. These are some of the chances we take and there are very few alternatives. But, most important, assumptions that we make as an Explainer is about our visitor's prior knowledge, believe it or not, this is where we start losing

our visitors. Let me give you a scenario: say you are explaining an exhibition to a group of people, say its the optical lens.. and there is this visitor who seems to be ahead of others and talks about focal points before you get the time to fill in others with the basic principles about the lens and refraction....what do we do? Just engage the person who is smart and lose others or ask the gentleman to hold on till others catch up with the discussion???.this often happens to me and i loose one or the other....(Harry, October 10, 2008, 2:24pm)

While Harry was talking about visitors and not students in a classroom, he is met with a challenge that new teachers often struggle with, differentiated instruction. Harry used the opportunity of talking about assumptions to bring up a whole new issue, which then led to a new set of conversations. Cogenerative dialogues, by design and structure, allow for such conversations to emerge and then trigger reflexivities in unexpected ways, all the while related to the motives of the collective. Elizabeth Davis, Debra Petish and Julie Smithey (2006) conducted a metastudy of 121 papers to describe the landscape of issues that new teachers face. They found that a key theme that emerges is that new teachers do not tend to consider students and their learning very extensively or in sophisticated ways (p. 618). They are often surprised about what students do or don't know as they begin to teach them. Rhonda was able to experience such contradictions because she could teach in low stakes settings and through participation in cogenerative dialogues, share those experiences and plan for the next time. Teaching in a science center with diverse visitors affords an Explainer the chance to produce an experience that is modified and based on understandings of Self and Other. Over time, an Explainer can describe a change in her ontologies and can articulate her shifts as an educator.

### *Let's Develop Worksheets*

Cogenerative dialogues afford opportunities for catalytic work which emerges from the group and becomes a symbol of solidarity and group identity. Since our meetings are on

Friday afternoons, it is commonplace for many of the audio and video clips to be related to interactions with school children who are on a field trip to NYHS and filling out worksheets as part of their assignment. Earlier vignettes presented allude to such interactions. In some of the earliest meetings when such clips were selected for discussion, not only would we discuss our praxis, we would discuss the length of the worksheet, the quality of questions, the purpose of worksheets or even if the worksheet was effective at meeting learning goals assuming that was the intention of the designer. Explainers in the cogenerative dialogues would recount worksheets they had to fill out as youngsters and on one occasion during the period of these meetings, two people reported that they had to go to another ISI assigned by their ecology professor and complete a worksheet! Over time, Explainers themselves brought the worksheet discussion to the table even without having clips to view. As part of that general chatter when they entered the room, they would ask each other if anyone had seen the worksheets that kids were walking around with that day. A few times they even brought a copy of the worksheet to the meeting because it would be left behind on the floor and it became an artifact that the explainer wanted to bring to the meeting. In those cases, we examined many of the questions and discussed their merit as good worksheet questions.

In one meeting, I asked them, “If you were a teacher now, and you had to design a worksheet, how well do you think...”. Before I had a chance to finish my statement, there was a collective high pitched response with a variety of words such “Awesome” and “we would be so good!”. My response was, “so why don’t you?” After a few minutes of deliberation, we collectively decided that we were going to design a worksheet and we would actually test it on some students on a Friday field trip.

Cogenerative dialogues become a way for stakeholders to deal with contradiction and conflict and to design changes themselves rather than waiting for policies and recommendations from teachers. They serve as sites for potential catalytic activities especially if they reduce oppression, and lead to more equitable classrooms (Tobin and Roth 2007). This story exemplifies how an idea emerged from the meetings to design a worksheet that the group felt would be better and more effective than ones they may have encountered. The group felt that we had enough experience at not just seeing all different worksheets, but helping students work through them to know how to recognize a quality question. Coupled with this was our comfort with the museum exhibits and the science content behind the exhibits.

In meetings that followed, we negotiated what age group to design the worksheet for, agreed that it should have fewer questions than what we had seen, approximately ten to twelve at most. However, we didn't necessarily have agreement on the style of the questions and the goal of the worksheet. Were we testing for knowledge? Should the question be such that the answer can only be found at one particular exhibit? Should it be a group oriented activity or an individual activity? Should it consume the entire field visit time or allow time for free exploration?

The following vignette demonstrates how one Explainer uses her awareness of a free-choice learning environment such as NYHS and its benefit as a field trip site.

- 01 Preeti:** so are we testing knowledge? (inaudible murmur and chatter from everyone)
- 02 Seema:** I don't think...the Hall of Science is a more.. well we place ourselves as an inter<sup>active</sup>, fun museum. I mean if we are testing knowledge, we are not (inaudible). The classroom teacher teaches facts, like that is what we learn in college, learn random facts, you don't keep them in your head, you read and write it. I guess we should figure out a way to test retention(?) if possible, I don't know yet. (negative murmurs from the group) I don't mean

retaining information like studying like when you see something interesting, you try to automatically to

[retain it].

**03 Rhonda:** [But] how do you [test it?]

**04 Seema:** [I don't] know. That is why I put it out.  
(nervous laughter)

**05 Preeti:** well retention, another word might be testing, um, looking for evidence for thinking'. How bout that? Because retention is hard because we only see the kids once, but we could ..what you said is right, like, when they interact with an exhibit, it is not like they are blank slates, they have ideas in them already. (head nods) And the exhibit hopefully triggers some of the [same ideas].

**Seema:** [some type] of thought  
[process].

**Preeti:** [Exactly] some type of thought process. So does our question . is our question well designed so the answer demonstrates some type of ...

**Seema:** understanding. (completing sentence)

**Preeti:** understanding, thinking, critical thinking, some type of problem solving (tone of listing items) so does our question . is our question well designed so the answer demonstrates some type of ...

**Seema:** An example of a question is for Colored Shadows. What would happen if only the red and green light was pointed towards the wall and the blue light was faced away? The only way you would figure that out is if you understand the exhibit and what would happen. I don't think it is something you can look at or someone could tell you. You have to stand there. Ok, you know what. You block the red light and you get a black space and that's a shadow from the red light and then the green light fills in the black space.

**Naina:** yeah, we should have questions like that where to test it out, you have to work it out and not just have straight answers.

Seema is describing that the worksheet question should not test knowledge, but thought process. She struggles with the description of her ideas and is met with negativity from the group. I help her by rewording her interest and giving some new words for people to consider such as critical thinking and problem solving. That time while I am speaking as well as what I say becomes a resource for Seema to then pose an example of

the *Colored Shadows* exhibit, one that she has experienced in her work as an Explainer and has successfully used to elicit student thinking. This allows Naina to see the point and extend the idea in line 15 by stating that we should create questions where students “have to work it out.”

One of the key tenets of the authenticity criteria is to do catalytic work. Cogenerative dialogues become a field where such catalytic work can emerge from within the group. The decision to design and test worksheets for the purposes of providing field trip students a stronger tool for museum exploration demonstrates an interest for action and for improving circumstances. Tired of seeing students suffer through poorly designed worksheets, they question how to develop a worksheet that doesn't just test facts and figures, but encourages students to think. They discuss whether the questions should encourage collaborative inquiry or individual investigation. They are concerned with allowing time for free-exploration. These are ideas that reform-minded teachers consider and these pre-service teachers are not just thinking about the worksheets they would design once they are a teacher, rather, making a difference now for students who visit NYHS. They are ascribing themselves the role of a teacher, one who is concerned about student learning. In being in this role, they are forced to address many issues that practicing teachers face related to curriculum design, student and learning and assessment. In essence, their identity as an educator is shaped by the activity of doing what educators do; design a worksheet.

#### A Missing Stakeholder

Cogenerative dialogues are spaces where different stakeholders are present and bring voice to the focus of the meetings. One limitation of this research is that the voice of the

visitor is not present except in so far as existing in the audio and video taped interactions. While they are free to act and react in the interactions with Explainers and in that way, their voice, emotions and conversations are represented and present in the room, it is difficult to actually have them participate in the dialogues as an ongoing and long-term member of the group. The nature of ISI visitors is to be transient and interactions to be one-time events. Therefore, that stakeholder is not present. If the taped interactions were with a group of visitors such as students in the ISI's after-school program, then there would be some ability to include those voices. As designed, this research does not offer such opportunity for inclusion.

#### Catalytic and Tactical Authenticity

Cogenerative dialogues are an approach to critical research with the intent of giving voice and disrupting power imbalances and structures that replicate hegemonic practices. Christopher Emdin and Ed Lehner (2006) caution us to think about those Explainers who have not been invited to our meetings. Is our work continuing to produce inequities if some Explainers are still not able to voice their ideas and are not afforded opportunities to meet, view and reflect on their practice due to schedules and staff time? To address this issue, Emdin and Lehner extend the idea of cosmopolitanism to cogenerative dialogues. Cosmopolitanism states that all of human kind is bound by shared morals and ideals. Emdin and Lehner invoke us to develop practices where “enactment of communal practice” can exist in multiple fields with a given structure (p. 12). They invite us to consider ways of producing ongoing and continual praxis that reduces the impact of working with a select group of people over a prolonged period of time to the detriment of the others. In response to this concern, this research has a few activities in place. The first

is the social networking site that allows Explainers across the different CLUSTER meeting groups to discuss ideas, share understandings and deal with contradictions. This site serves as a way to extend conversations that occur in one field to multiple fields. Second, when I am unavailable to participate in the cogenerative dialogues, Jan gets the group together and facilitates the meeting. The videos of the meetings indicate that the cogenerative dialogues are able to maintain their structures even in my absence. There is a ripple effect in play for maintaining the structures of the cogenerative dialogues and using that time to produce|reproduce and transform culture. In addition, the other two coaching groups have moved in the direction of creating structures that would define their meetings as cogenerative dialogues. Another catalytic activity that addresses the potential limitations posed by cogenerative dialogues is that the Explainer supervisory staff at NYHS has begun using audiotapes as a means for assessing an Explainer's progress through the program. In this activity, an Explainer audiotapes her interactions with visitors and together with the supervisor, reviews the tape. The conversation is structured to be reflexive, to bring to consciousness what is in the subconscious as related to interactions for the purposes of improved facilitation with visitors. These are one-on-one cogenerative dialogues because the structures are set up to cogenerate a plan for growth.

### Implications for Informal Science Institutions

This chapter provides evidence for how and why cogenerative dialogues should be used as a method for how ISIs conduct meetings for the purpose of planning, learning and transforming practices. In this study the structures of a meeting intended to support the development of all involved as learners and teachers, and led to activities that are

educative and catalytic. Researching our own practice and sharing our changing epistemologies and ontologies about social life through conversations with each other and then with those beyond our group by means of a social networking site, we are educative. By examining existing practices, making a plan to address and improve practices in the form of worksheets and inviting those beyond our group to participate and cogenerate with us, we are catalytic. The data presented demonstrates that by dealing with issues of power, authority and claim to expertise, we can collectively advance teaching and learning in ways that support our individual goals but also the motives of the collective.

ISIs pride themselves on giving their education staff the ability to work collaboratively, plan and learn strategies and techniques towards reform minded teaching. Often, the meetings aim to support staff is developing awareness of self as a teacher and learner, but curriculum planning and sharing of new activities become the focus. Employing cogenerative dialogues allows for education staff to take a step back and develop reflexivity of their own practices as well as those of others. In those ISIs where there is a vibrant floor staff (youth or adults), much time and money is invested in developing training programs where people can learn how to interact with a visitor – engage them in conversation and use reform-minded approaches to support visitors in their own discoveries about science. Bringing the method of cogenerative dialogues into the training plan can support these efforts in profound ways. Both for education and floor staff, taking the role of researcher and developing local theories about teaching and learning have great implications for improvement of practice and advancing science education as a whole.

### **Chapter 3: There Is No “Off Button” to Explaining: Identity Development in Pre-service Teachers in a Museum Setting**

In this chapter, I explain how identity as an educator develops and is mediated by interactions with learners in a low-stakes informal educational setting. I focus on one pre-service teacher and describe her developing schemas, especially an awareness of her standpoint on what counts as knowledge and her beliefs and values about the nature of knowledge. I theorize identity development from the perspective that teaching and learning are dynamically and relationally always emergent, and mediated by many factors such as race, class, gender, which are socioculturally and historically situated. My stance is that identity development emerges through purposeful participation in activity with others. First I review why identity development is a useful lens for documenting growth as an educator by using selected autobiographical accounts that have informed my standpoint, and then I delve into cultural historical activity theory as a lens through which I analyze selected vignettes from my study.

#### **Identity as a Lens**

As a construct, identity “can be regarded as one of the outcomes of a person’s participation in ongoing activity” (Roth and Tobin 2007, p. 14). Aspects of our identity are fluid and are evolving as we experience life. As teachers, we cannot separate this activity from who we are, who our students are, and all of our histories, experiences and ideologies. Teaching as an activity mediates our own identity development. Through interactions with others, we transform our own understandings of the world just as much as we contribute to the development of identities of those we teach. As a result, “learning to teach is inextricably bound with identity formation” (ten Dam and Blom 2006, p. 651).

It implies envisioning oneself as a teacher, not just as having knowledge, but also as, one who has the ability to facilitate learning, and believes that all people can learn. This type of teacher views learning as a social act, and not as an activity bound by classroom walls.

Operationalizing identity is difficult, but I embrace this challenge because of my own experiences past and present. Geert tenDam and Sarah Blom (2006) remind us that developing a deeper personalized meaning of the teaching profession is what is referred to as a professional identity. Development of professional identity does not have to be situated only in formal classroom settings. In fact April Luehmann (2007) invites us to set up low-stakes settings where people can teach and grow as reform-minded teachers; can learn to value student-centered learning, can see the benefits of collaborative work, and can begin to agree that learning is a social and emotional act. One such low stakes setting is an informal science institution and it is broadly defined as a free-choice learning environment. Examples are science centers, zoos, aquaria, nature centers and similar organizations (Falk 2001). In this study, the research site is the New York Hall of Science (NYHS), a hands-on science center in Queens, New York. The New York Hall of Science consists of over 450 hands-on exhibits, approximately 10 daily demonstrations and a variety of discovery labs and activity carts. Visitors to NYHS can encounter an Explainer, a high school or college student who is paid and trained to facilitate exhibit experiences and conduct demonstrations.

The New York Hall of Science has a program to employ and train approximately 150 high school and college students as Explainers. In 2002, the Institute for Learning Innovation conducted an evaluation of the impact of the NYHS program on Explainers who had graduated from the program. Of the many ideas that researchers were interested

in, such as leisure time choices, perceptions of scientists, critical thinking and problem solving skills as attributed to their work as an Explainer, of importance for this chapter, they documented the choice of career as influenced by their experiences as an Explainer. One hundred and five alumni out of six hundred responded to the request for participation. All of these alumni completed a survey and then a subset was interviewed. Identity development was not measured; instead, we assessed self-confidence, an attribute that contributes to identity development. The report states,

An important impact of the Program was creating self-confidence in its participants. Self-confidence did not arise from “just doing the work,” it developed when participants had a sense of doing their work competently. In other words, any aspect of the Program that allowed participants to engage with the public in a competent and knowledgeable fashion also boosted the participants’ self-confidence and self-assuredness. Another aspect that contributed to the self-confidence boosting ability of the Program was the fact that participants were out to practice their skills, even skills that participants believed to have had before they joined the Program.

One of the respondents provided the following description of an event that is exemplary of the types of experiences that support development of self-confidence.

I may have often started out not knowing much about a concept and people would ask questions I could not answer. But after a while I was so pleased with myself that I truly, fully understood a concept and was able to just rattle off things to kids. That was great, and a real confidence booster. I remember one group of important people came in all dressed up in suits, looking very official. I did the mirror demonstration and they walked away looking very impressed. They came in serious and walked away smiling. That gave me a huge boost. [Female Caucasian, under 20, high school student] (Institute for Learning Innovation 2002, p. 11)

The report also demonstrated that presenting in front of a crowd of visitors, approaching visitors to allow them to ask questions, explaining complex issues to children, simplifying science while keeping it interesting and correct were all tasks that

allowed Explainers to grow and develop, no matter where they wanted to go later on in life. In addition, the Program also allowed participants to practice inquiry-based teaching methods. The repetitive nature of the teaching situation allowed participants to learn quickly. They were able to modify and apply newly learned strategies to the interactions, gauge their effectiveness and adjust their strategy quickly thereafter. While this study provides a foundation from which to begin my documentation, we need to delve deeper into how an explainer experience contributes to one's ability to see herself as a teacher. Documenting identity development offers us that window.

Anna Sfard and Anna Prusak (2005) urge us to consider why there is a sudden interest in identity development when we have been able to measure constructs such as personality, character, nature, attitudes, conceptions and beliefs. They remind us that notions of personality, character, and nature, are “tainted with connotations of natural givens and biological determinants” (p. 15). These ideas do not mesh within a socio-cultural frame. Instead, identity as theorized to be made and remade through social activity fits more appropriately. The fundamental problem with attitudes, conceptions and beliefs is that those constructs are being measured in separation from the actual activity being discussed. Attitudes towards reform-minded teaching are different than actually being a reform-minded teacher. One can believe to be a certain type of person, but not actually manifest those qualities in the activity. Therefore identity development becomes the preferred construct of study because it is a naturally occurring phenomenon that is not separate from cultural enactment in a social world. In order to describe why identity development works as a suitable lens for examining teacher growth, I provide a brief autobiographical account of my time as an explainer.

*My time as an Explainer*

I am a first generation Indian American. I have worked at NYHS for twenty years at the time of writing this chapter and currently hold the position of Senior Vice President for Education and Family Programs. I began my tenure at NYHS as an Explainer at age fifteen and slowly developed my identity as a science educator. I experienced an awakening in understanding the social and cultural nature of science. My belief that science is about facts and figures changed to beliefs that science is about process as well as content. I recognized that learning science was a very personal construction, but one that needed to be embedded socioculturally. I was also exposed to the teaching profession in a much different light than I experienced growing up. For me, the Explainer experience created opportunities for successful interactions in science teaching. I was intrinsically motivated to create positive learning experiences for visitors and perfect my craft whenever possible.

As a teenage Explainer, this semi-social workplace was something I began looking forward to every Sunday. My job was to approach people and engage them with hundreds of science exhibits and conduct the different daily demonstrations, 20 minutes scripted experiences performed on the museum floor for approximately 15-20 people. I was trained to use the exhibits, and I was given time to learn one of the demonstrations. It was scary to approach visitors and I lagged behind the others in learning a demonstration. Being naturally shy, feelings of insecurity fueled my discomfort, but I still liked being in the museum setting.

One day, my supervisor, Carlos Lopez, someone who became a great mentor and friend to me, approached me and said that I needed to pick a demonstration and learn it or

I would not be allowed to keep my job. In order to get certified in the demonstration, I had to perform it in front of a live audience. The demonstration assessment rubric measured science content proficiency, presentation skills, and flow of concepts. I panicked and picked the laser demonstration, a twenty-minute experience that taught people about properties of light and applications of a laser. Carlos supported me by setting up peer-training sessions and helped me by reviewing difficult science concepts in accessible ways to me.

Three workdays later, I was up for certification and I performed the demonstration in front of a live audience. After the demonstration, Carlos approached me and said that I did it really well and he was really impressed. That comment from Carlos, who three weeks before had warned me that I might lose my job, affected me in a powerful way. Shortly after that, I became certified in all six of the demonstrations one after the other (at a much faster rate than my fellow Explainers!) The truth was that I was excited to receive praise from Carlos, someone that I viewed as a smart, eloquent mentor who was great at engaging visitors. I also really enjoyed conducting the demonstrations and teaching visitors. I soon realized that in many cases, I knew more science than the families watching my demonstration and became excited to dialogue with them about science. As I continued to perform demonstrations, I became better at gauging my audience and their prior knowledge about topics. I also inspired other Explainers to get certified and provided peer training when necessary.

Having conversations with visitors was fun. Sometimes I approached them and sometimes they approached me. We mostly talked about science, but occasionally they asked about where I went to school and how did I get to know all of “this stuff.” I felt

that I was making a difference to the visitor experience and that these folks talking with me might actually remember the concept we talked about or the demonstration they saw. This created a sense of purpose in me. I felt important and that I was contributing to a higher cause. My world expanded beyond my problems and my issues. Working at the museum was something I looked forward to each week because I was part of a larger mission and my actions would affect not just me, but the museum as well. This experience played a role in the development of my self-confidence, and it transcended the museum. It became visible in my high school life and my family life. My teachers noticed my confidence in class and my friends noticed that I was happier than before. In school, I spoke about topics beyond just the high school. I talked about people I met at the museum and occurrences with visitors that I found interesting. This job allowed me to develop my sense of self and also acknowledge the role others played in this process. My experience as an Explainer reverberates for many people who have been Explainers. The Explainer experience transformed my life, and I believe it has done so for many people. There are Explainers who chose careers in teaching and credit their Explainer experience at NYHS in supporting their decision. In the next section, I describe and apply theory to my experiences as an Explainer.

### Theorizing My Experience

The ISI community is recognizing how youth staff are influenced by their experiences in choosing their career (Diamond, St. John, Clearly and Librero 1987), but in the last decade there hasn't been much focus on specifically documenting youth staff who become interested in teaching. If we view the activity that an Explainer engages in as a floor staff in an ISI as a cultural activity, we can say that each moment is a historical act

where culture is produced, reproduced and transformed. As an Explainer enacts this cultural activity, her identity is dialectically produced, reproduced and transformed. I view the dialectical method as an appropriate approach to viewing social life because as Stetsenko (2009) writes, it

all exists in one moving matter taking various forms and shapes and existing at various levels and dimensions. These levels and dimensions always remain intricately connected with each other – as derivative products and expressions (or incarnations, moments) of one foundational reality that is ultimately unitary (i.e., existing as totality). Within this broad notion of reality as one moving matter, furthermore, all living forms are understood as existing within processes of ever unfolding and continuous relations (p. 14).

A dialectical approach to viewing cultural activity avoids setting up a binary, reductionistic relationship for theorizing social life. The cultural activity is conducted in fields with porous boundaries (Sewell 1999). Fields are sites for cultural production and have particular structures that define them. These structures are dialectically related to agency such that one mediates the production of the other. Agency is dialectically linked to identity such that our power to act within certain structures mediates our identity development. Similarly, as our identity evolves, it mediates our agency and dialectically, the structures of a given field. Using the Scheffer mark, |, we can denote this dialectical relationship as structure|agency|identity. Agency is also dialectically related to passivity and passivity is the willingness or capacity to accept or be receptive to the unintentional acts that occur in cultural production. The dialectical relationship implies that if there is an agency|structure relationship then there is also a passivity|structure relationship. Identity development becomes a function of passivity as well and can be noted as structure|passivity|identity. My autobiographical story illustrates how the structures (schemas, practices and resources) of the field contributed to the development of my

identity as an educator. Visible and invisible schema such as free-choice learning, visitor-centered learning steeped in socio-cultural ideologies, training for exhibits and demonstrations are some of the salient structures. These structures afford the agency of Explainers to be able to mediate a visitor's experience. By earning the certification to conduct demonstrations to support a visitor's understandings of a certain science topic is agentic for an explainer because cultural capital is gained. An explainer gains intellectual capital in the form of new skills and understandings of science concepts and symbolic capital through being recognized as one who is certified to teach others on a given topic and treated as staff, as an expert for that set of ideas. Since agency is dialectically related to passivity, an explainer has to be receptive to both different types of visitors, and the schema they bring to an interaction, and that mediates the activity.

### *Cultural Historical Activity Theory*

The dialectical relationship between the Self and Other is also important for theorizing identity development. Self presupposes Other (i.e., Self|Other) and vice versa. Human activity is not only social, but the actions of an individual mediate the actions of the collective and vice versa. Anna Stetsenko (2008) describes the construct of "spectator stance," and invites us to move past this stance of simply "being" in the world to active participation and engagement with it (p. 479). Otherwise, people respond to the actions of the collective, rather than purposefully contributing to the collective with the intent to transform the world and thus, transforming themselves (Stetsenko 2009, p. 18). Stetsenko writes, "human development, from this perspective, can be conceptualized as a *sociohistorical project* and a *collaborative achievement* – that is, a continuously evolving

process that represents a “work-in-progress” by people as agents who together change the world and in and *through* this process, come to know themselves, while ultimately *becoming* human” (Stetsenko 2008, p. 484). She advocates for us to embrace the work of Lev Vygotsky and Cultural Historical Activity Theory (CHAT) and forge ahead to understand that “there is no gap between changing one’s world, knowing it, and being (or becoming) oneself; all three dimensions simultaneously emerging from this process” (Stetsenko, p. 485). I use CHAT as a lens to illuminate identity development because it gives me an appropriate mechanism for theorizing an activity such as teaching and learning in an alternative setting such as NYHS, extending it first to the agency|structure and agency|passivity dialectic and then to identity development. In CHAT, an activity “denotes societal, culturally historically developed forms of contributing to the satisfaction of collective needs” (Roth 2007, p. 88). The motives for the activity are societal in nature and are met by the people in a given field, the collective. Each individual in that field has goals, which allow for the collective’s motive to be accomplished. The individual and collective are in a dialectical relationship with each other. The structures of the field afford individuals to acting agentially to meet their goals. Roth (2007) argues that the collective’s motives are the structuring constructs that lead to agency or passivity. When the individual’s goals and the collective’s motives are not aligned, it requires tweaking of the structures of the field to accomplish the larger activity. Referring to my autobiographical story of being an Explainer, the institution as a collective needed to conduct demonstrations for the visiting public as part of the mission of the science center. By not proactively pursuing a certification in a demonstration, an agentic act based on the goal of hiding from public speaking experiences, I was changing

the collective's motives to be something that would not accomplish the activity of teaching and learning. Carlos, a structure, in the form of a supportive supervisor, provided me with rules (certification was required for employment) and tools (peer-training and one-on-one tutoring) to support me in modifying my goals to want to get certified in a demonstration. Eventually, when my goal became to get certified in all of the demonstrations, I mediated the actions of other Explainers (part of the collective) and inspired them to get certified.

As individuals enact their roles in an activity, their identities are ascribed to them by Others as well as inscribed by their own Self. Visible actions, acknowledgement or acceptances by others as a certain kind of being contributes to identity and has the potential to be agentic. In Wolff Michael Roth and Yew Jin Lee's (2007) research of an environmental science class in Henderson Creek, Canada, the four female students are ascribed the role of environmentalists with the intent of researching and learning about a local creek. They are ascribed an identity by the motives of the activity. However, Roth and Lee state, from a CHAT perspective, that ascription of identity based on a collective motive actually contributes to the development of one's Self, one's identity. Becoming an environmental scientist becomes a cultural possibility that reproduces and transforms identity. In my case, when Carlos Lopez praised me, he ascribed to me an identity of one who is competent with conducting a demonstration. Over time, I viewed myself as not only competent, but also comfortable and confident at conducting demonstrations. When NYHS hires students and ascribes them the role of a teacher for the visiting public, this is based on the needs of the collective. However the individual/collective dialectic mediates

that individuals see themselves in the role of a teacher and through activity, develop the schema and practices to have success as a teacher.

Anna Stetsenko and Igor Arievitch (2004) write that the development of self is not an additional activity, it is the process of doing an activity. Activities are the real work in which the self is constructed and transformed. They describe this construct of Self as a leading activity “as a process of the real-life activity that most explicitly positions individuals to meaningfully contribute to the ongoing social collaborative practices in the world” (p. 493). Their view of social life pushes the construct of CHAT to a more dynamical, relational, dialectical and motivational theoretical framework.

#### The individual|collective dialectic

The dialectical approach to conceptualizing identity development is important for this research because it allows us to position Explainers as agentic being where the individual goals of improving praxis is not simply to align the museum’s motives. Rather it is to transform the museum’s motives. Stetsenko (2005) points out that in A.N. Leontiev’s conception of CHAT, society is privileged in the construction of self. Leontiev was struggling and combating with dominating paradigms of individualistic notions of self as well as with Soviet ideologies, which disregarded individual contributions to societal processes. She contributes her critique of CHAT when she writes, “ the human mind, in A.N. Leontiev’s interpretation, is actively produced by social practice but is much less involved, as a lawful and active participant, in the production, and even less so in the further expansion and growth of the very social practice that gave rise to it” (p. 76).

Rather, a mediated action approach encourages the idea that self and society co-emerge.

The goals of the individuals are not simply to meet the motives of the collective, but

instead to inform and form the motives. This refreshing approach affords a dialectical relationship between the individual and collective.

Penuel and Wertsch's (1995) description of how an individual expresses agency allows me to extend and describe why participation in an activity is linked to identity development. They write that the cultural tools that an individual uses to participate in activity is what formulates Self. The focus is not on what the Self says that she is, but rather on what she does. How does the Self choose meaningful human action? How does the self appropriate the physical and semiotic tools, artifacts and resources (cultural tools or structures) in the course of her actions? When considering identity development, what is the diversity of tools available and why is one used as opposed to another to carry out or operationalize an action? How often and to what extent is the use of the selected tools conscious or unconscious? Each of these agentic choices for participation with the Other become indicators of identity development. Stetsenko and Arieviditch (2004) comment in describing mediated action as an approach, "these dialogical approaches do not evade self-reflective, conscious dimensions of human subjectivity, while at the same time acknowledging that selves are essentially constructed in the profoundly relational processes of speaking and listening to others" (p. 480). Bringing tenets of CHAT back to the forefront, it is important to remember that the cultural tools are heavily vested with historical, and political processes as well as the socio-cultural processes.

The activity at NYHS is the teaching and learning of science and the motives are to engage and excite visitors about scientific ideas and phenomena. An Explainer's individual goal is to support the motives of this activity. The act of visitor engagement at exhibits is operationalized by the use of resources that exist in the structure of the field.

The field in this case could either be the interaction between the visitor and the Explainer or it could be the overall hands-on science center depending on the analysis of the activity. I designate Field 1 as the exhibit floor where we (the Explainers and me) interact with visitors and Field 2 as the meetings, cogenerative dialogues, where we view videotaped interactions with visitors and discuss ways of improving our ability to facilitate effectively. In both fields, the Self|Other dialectic allows for identity development and because we play a role in both fields, we carry schema, practices and resources back and forth between fields. The cultural tools that form the structures of these fields include objects such as exhibits, understanding of concepts, people and importantly, language. How an Explainer approaches visitors, what she says, how she says it, and interactions of words between the visitor and Explainer are all units of analysis that contribute to the agency and dialectically the identity development of the Explainer.

### Cogenerative Dialogues

Cogenerative dialogues are meetings with a focus goal and where all members in the meeting are given equal stakeholder status. As a collective we have a motive to improve our abilities to facilitate learning experiences more effectively. As individuals in the collective, we have our own goals related to how each of us needs to reflect on what we do well and work towards improving what we are weak on as related to teaching and learning. Cogenerative dialogues become a place to communicate, to relive our experiences both from childhood, but also from the past few hours and describe our thoughts, emotions and ideas surrounding those experiences. Sfard and Prusak (2005) state that in the activity of communicating our life experiences, we are developing our

identity. Harnessing those communications and discussing them in the collective allow for reflexivity (Bourdieu and Wacquant 1992, p. 42) or becoming aware of the unaware, and identity development.

### Opportunities to Practice in Low Stakes Settings

Data presented here is part of an ongoing research study, Collaboration for Leadership in Urban Science Teaching Evaluation and Research (CLUSTER). In CLUSTER, a local urban college, City College of New York and the NYHS partner to develop and implement a pre-service secondary science teacher education program where undergraduate science students take state-mandated education courses and work as Explainers at the NYHS. These students work as Explainers at least seven hours per week while they are in the CLUSTER program and their education coursework is coordinated to take advantage of their explainer experiences through homework assignments and group projects. The Center for Advanced Study in Education (CASE) at the CUNY Graduate Center serves as the research partner and documents the growth of these CLUSTER Explainers as reform-minded science teachers. Supporting the development of reform-minded teaching is key for teacher retention issues. Elizabeth Davis, Debra Petish and Julie Smithey (2006) conducted a meta-analysis of 121 unique papers to document the current research on challenges teachers face. They found that teacher's experiences affect their perceptions of science and their interest and motivation to remain in science teaching (p. 614) and that a number of studies in social science in the last decade have found evidence that pre-service teachers need to engage in reform-minded practices as learners in order for them to assume roles as teachers who espouse such practices (p. 634). Working as an explainer allows students to be both in the role of a learner and a

teacher. As a learner, an Explainer guides her own inquiry, works collaboratively and experiences hands-on activities to generate knowledge and cognition, and then in the role of a teacher, she help others do the same.

In the CLUSTER project, through practice, we bring activity from Field 1 into Field 2. Interactions that are taped between an Explainer and visitors in Field 1 are brought and relived in Field 2, the cogenerative dialogue. These interactions are the mediated actions as theorized by Penuel and Wertsch and become units of analysis in the cogenerative dialogues. Through reflexivity, we develop local theories about teaching and learning and apply them back into Field 1, the exhibit floor. In doing so, we are constantly developing our identities as teachers. Through cogenerative dialogues, patterns of key ideas emerge as topics of conversation as triggered by social acts in Field 1. Over time, these patterns become indicators (or new units of analysis) and evidence of identity development.

### *Participants*

The cogenerative dialogues include approximately nine people. I am the educator researcher, Jan is the Explainer administrator researcher, and seven people are CLUSTER Explainers serving as student researchers. On average, four out of the seven students, not always the same people, are in attendance for the meetings. Jan is present for almost all of them, and I am there as well with the exception of two dates when I was pulled away for working related reasons. If less than five total people are available, we do not meet because too many people would be left out of that day's conversation.

All nine of us either immigrated to the U.S. as a child or are the first generation in our family to be born in the U.S. In addition, our ethnic backgrounds are from the South Asian diaspora, except for Jan who is Latin American and one student who is half South

Asian and half Puerto Rican. The similarities in our ethnic background contribute to our solidarity as a group but do not become a focus for the thesis of this chapter. Two students are male, the rest are female. All seven students are undergraduate science majors (four biology, one chemistry, one earth science, and one engineering) at a CUNY college. Jan is currently not enrolled in a college but expects to eventually finish her undergraduate degree in Computer Science and pursue a Master's in Education. I am a doctoral candidate at the CUNY Graduate Center, have a Master's in Education and a Bachelor's in Engineering. At the time of the writing of this article, two students have dropped out of the CLUSTER program, but have participated in many of the cogenerative dialogues and are included in the data sources for this chapter.

#### *Data Sources*

Transcripts of the audio and video vignettes of the interactions between Explainers and visitors, and the videotapes of the cogenerative dialogues serve as data sources for this study. Thick descriptions of the culture enacted during the meetings contribute as evidence. Narrative from a social networking site set up for CLUSTER Explainers to share their ideas across three meeting groups serves as another data source. Olympus audio recorders and flip video cameras are used for taping. While the cogenerative dialogues continue during Spring 2009, the data presented here are from meetings occurring between Sept 2008-January 2009. Pseudonyms are used to protect the identities of all participants, except me.

### Key Indicators of Identity Development

Over the course of weekly conversations in a four-month period, a number of topics have emerged as themes that demonstrate that all of us in the research group are constantly making|remaking our identities as educators. Identity development is linked to where we believe knowledge comes from, how we understand knowledge to be constructed and whom we think has the ability and right to learn – our epistemologies, ontologies and axiologies. Using selected vignettes that involve one member of our group, Rhonda, I describe how her epistemologies and ontologies become visible and evolve through the activity of interacting with visitors in the museum, and how the cultural tools afforded by an ISI allow her to consider effective teaching practices. For this chapter, I have selected vignettes that describe Rhonda’s growth as an educator. I selected these vignettes because they are representative of what many of us in the research have experienced in our growth as educators. In doing so, I acknowledge that I am using my power as a researcher to determine what are salient moments for the Other. From a hermeneutic phenomenological perspective, I chose vignettes that felt familiar to my own experiences, both past and current, and were rich sources of discussion in the cogenerative dialogues. David Jardine (2006) describes that such interpretative research “begins (and remains) with the evocative living familiarity” with events in our lives (p. 280). I felt that the vignettes presented below capture the essence of long, deep conversations that have reverberated with my experiences as an Explainer and have become thought objects for our meetings. These vignettes also allow me to theorize the dialectical relationship between individual and collective in considering the endeavor of teaching and learning. While the constructs of epistemology, ontology and axiology are interconnected, I

separate them for the sake of deconstructing and interpreting the vignettes. The idea of Self|Other is key to my methodology and therefore, Rhonda's co-researchers (me and the other Explainers) become integral to the story. Additionally, I aim to provide snapshots into a developing narrative so, while analysis is based on presented vignettes, these vignettes are part of social life in action, not the end of the story.

### *Epistemologies*

As Explainers we encounter all types of visitors and develop a sense of ourselves as learners and teachers, which mediates our approach to teaching. I present two vignettes where we discuss the roles of teachers and our ontologies of how children learn best. Through the activity of being an explainer, we reveal our existing epistemologies and reflexivity then mediates shifts in our identity. In the first vignette, we, the researchers, are discussing a group of school children that were at the exhibits that day, and were considered by the research group as "knowing everything." These children knew the canonical knowledge and facts and figures behind a set of exhibits. I probed the student researchers to ascertain if we, as facilitators, have a role to play in the case of such visitors.

**01 Preeti:** For those people who pretty much know everything about that exhibit, do we not have a role to play?

**02 Rhonda:** Well sometimes, kids probably don't know that they know stuff and in cases that they do know, our role is that we help them know that they know. Like you know something but then someone else asks you questions and then you answer it yourself and work around answering even though, like, I don't think any of us sits down and says, like I know this, this, this, (gesture of making a list), but then if someone asks you about it, you start answering and you realize that you yourself know and that could be a very good confidence booster.

- 03 Preeti:** So what I hear you saying is that we are people who um, initiate conversation.
- 04 Rhonda:** Yeah (collective head nods)
- 05 Preeti:** So a person, a visitor might know everything they need to know about that particular exhibit, and that's ok, but by interacting with us, it's getting drawn out.
- 06 Rhonda:** yeah, its like since we know about it, we know what kind of questions to like ask them and navigate them towards the right answer cuz I am pretty sure that most kids at high school level would know stuff about what we have on our floors, but they can't piece all of the information together to understand and complete the exhibit by themselves.

In the way I phrase the opening question, line 01, my own epistemologies of our roles as Explainers is evident. By saying, “do we not have a role to play,” I am sharing my beliefs about the situation, but I am asking others to confirm it for the group. Rhonda’s view of learning becomes visible in line 02. She claims that students may know facts and figures, but a teacher’s role is to help draw it out, make sense of it, and make it applicable. Her epistemological stance is that teachers are facilitators even for those students who appear to know it all. Because of the mediated action where an explainer interacts with such students, and selects tools for cultural enactment, we as a group have a topic to discuss that allows us to develop reflexivities in relation to working with students who are over-achieving or who surpass our expectations of what we think they know.

In the second vignette, we witness conversation of Rhonda’s experiences as a young learner and how they mediate her understanding of how children learn best. In this cogenerative dialogue, we had delved into a conversation about how certain science topics can best be learned when done hands-on such as anatomy and related biology

topics. The conversation had evolved to the macro issues of funding in schools and how teachers want to do hands-on work, but don't always have funding.

**01 Rhonda:** I like bio in grammar school because my [teacher]

**02 Seema:** [you] went to a private school and I went to a public [school]

**03 Rhonda:** [my teacher], we didn't have like actual things to look at, but she would instead of saying ok you have a test, she would make us do projects. So instead of going home and studying for a test and learn about the parts of a cell, she would tell us ok go home and construct a cell and that's your project and I am grading you on it, but don't just draw it, actually

**04 Seema:** =build it.

**05 Rhonda** =yeah, build it. And this way, when you're building it, I remember sitting with my mom and she was, like, so frustrated, because she hates anything to do with art, she's like "I don't know what to do here" and I am like, "this part goes here" and "this is like the ribosome", it doesn't have to be fancy, you don't necessarily need a lot of props, you can use things that you have.

In lines 01 and 02, we see that Seema implies that private schools would normally have funding and can afford science materials, but Rhonda goes on to describe how the simplest materials can be used and students can participate in projects rather than a test. Macro issues of funding and access to equipment in private versus public schools weave their way into the conversation. Yet Rhonda does not let the macro issues defeat her point. She describes that as a learner, she preferred the project-based way and "liked bio" because she was able to remember the parts of a cell in the act of constructing the cell. April Lynn Luehmann (2006) states that one of the biggest challenges to implementing inquiry based teaching is that people who have not experienced reform-based science experiences are less likely to buy-in and have confidence with it. In Rhonda's case, she recalls her positive learning experiences as triggered by the conversations in the meeting

and it becomes a thought object for discussion, even for those who may not have experienced reform-minded teaching, but are part of the activity system of working in the science center and participating in the cogenerative dialogues.

These vignettes are a great example of why working as an Explainer mediates our identity development as educators. From an activity theory standpoint, our motives as a collective are to teach people science. In a science center setting, each of us has the opportunity to encounter different types of students. Sometimes we encounter students who know less than we assume they would as I described in chapter 2 and other times, we encounter students who know a lot about a particular topic. As Explainers, the role we play as a facilitator supports a variety of learners, but epistemologically and ontologically, it is not our first instinct to play that role. In discussing our roles as facilitators, we remind ourselves of the purpose for why we are part of this collective. When Rhonda makes the point about the value of reform-minded teaching, she mediates shifting of schema that each of us carry as individuals, in turn mediating the shifts in epistemologies of how people learn. Grounded in actual experiences through activity in a science center, our identities as educators change as we shift our understandings of effective teaching and learning.

### *Shifting Ontologies*

Preparing future teachers means to support people in developing their dispositions for teaching and learning. Adam Urbanski (2004) offers a useful mechanism for thinking about developing such dispositions and states, “any teacher who knows his or her subject well and knows pedagogy well but does not care about students as much as he or she would about their own son or daughter is not a professional” (p. 7). He believes that

without developing positive dispositions towards children and their ability to learn and prosper, all other attributes are useless for a teacher. In the following pair of vignettes, we see how being in a position to teach in low stakes settings allows a person's ontologies to shift towards believing and experiencing that all students are capable of learning.

In the vignettes, the research group had been watching a cow's eye dissection that Rhonda was doing for a group of students who attend a weekly after-school program at NYHS. Rhonda works in the program every week, but normally, she doesn't work with the set of kids she is dissecting for even though she is familiar with them. In the video of the dissection, Rhonda was on the center of the screen and the kids surrounded her. Presented below are two short vignettes from the same cogenerative dialogue but separated by a few minutes. Rhonda described her surprise that a student with autism knew a particular answer, the word *nocturnal*, and further surprised that he knew a word that she didn't even know, the word *diurnal*.

#### **Episode 1**

(All group members are watching and listening to the video.  
3 seconds later)

01 **Rhonda:** Autistic kid knew!

(4 seconds later) The autistic kid knew! (collective wows and smiles) because he loves owls! Nobody knew what nocturnal was besides him, he goes "they stay awake at night like owls," like he loved owls. (collective murmuring inquiring about grade level, and more wows) I did not expect him to know what nocturnal was, but he did. (with a tone of pride and achievement from Rhonda for her student)

#### **Episode 2**

01 **Rhonda:** Autistic kid again! He gave me a new word.

02 **Seema:** was that a real word?

03 **Jan:** Is that right?, because I don't even know

04 **Seema:** wait, rewind, rewind [it.]

- 05 Rhonda:** [diurnal]
- 06 Samantha:** yeah it is (referring to the idea that it is a real word)  
(Everyone practices saying it.) Just right the word down.  
  
(Overlapping talk as people say the word and try to write it.)

I presented this vignette as transcribed above to Rhonda and stated that it was salient to me in documenting identity development as a teacher. I asked her opinion and an excerpt of what she said is provided below. In Rhonda's own words, we see her describe her developing awareness about her ideas of people with disabilities.

**Rhonda:** When I did the cow's eye and talking about nocturnal and stuff like that, and I was seeing what he was doing, and he was jumping around and when I asked another question, some kids knew the answer and some didn't and he says, "oh it's the opposite of this word" and I was just like, "you weren't even paying attention, how do you know." So, it's really bad to associate kids who have problems, disabilities, that they might not know, that, even though we live in this day and age and anything is possible, it's so bad that I would still associate a kid, even an autistic kid to not know, but this is one of the few instances that totally changed my opinion of everything. I am never gonna think a kid or person with a disability isn't capable of knowing stuff because other than the fact that he has autism, he's very normal, he wants to read and stuff. So yeah, this (referring to vignette) does demonstrate it (identity development) because it changes the way you think, because you think the kid who is smart is stable and definitely has no disabilities because he has to be able to comprehend, and here is a kid who is totally the opposite. He's very hyper, very jumpy, very all over the place, doesn't pay attention half the time, he's doing his own thing, but he was able wow me with a word that I didn't even know.

Rhonda experienced an ontological shift at this time when she saw that a student with autism could actually know the right answer and furthermore, know a word that she didn't know. The entire research group shared this excitement with Rhonda and was surprised by the autistic student's responses as well. I added that I experience such moments when I teach and although I have had such experiences in years past, I continue to be reminded of my developing ontologies every time I am in such situations and gain

an awareness of my own beliefs and actions. The video becomes a structural resource to initiate a conversation. Rhonda is agentic enough to be reflexive and say that she did not expect the student to know what a word meant because he is autistic. Having Rhonda pick out that event during the cow's eye dissection makes it a thought object for discussion in the cogenerative dialogue. This same topic is posted onto our project social networking site and continues to be a thought object across the different groups in CLUSTER. For Rhonda and possibly others, this series of events contributes to her identity development as a teacher in profound ways. The activity of conducting a cow's eye dissection spurs this ontological shift. Having opportunities to conduct this demonstration repeatedly over time affords and improve praxis. Identity development requires purposeful participation in activity. If Rhonda were not in a situation where she had to conduct this demonstration week after week, she may not be able to harness her reflexive thinking. It is through the act of teaching that she and others can develop a dhift ontologically.

### *Teaching effectively*

As part of an activity system, Explainers have to position themselves as educators with the goal of helping our visitors learn science concepts. Teaching and learning are complex and through the following vignette, I demonstrate how Rhonda struggles with her role in the activity. She describes her goals as necessary for the activity of teaching science and contradictions that she faces based on her experiences by revealing her fear of scaring students away from science by providing too much content.

In a cogenerative dialogue, we had just finished watching an interaction between Neel, one of the student researchers, and some students. He had described that he

considered the interaction to be only somewhat successful and was unable to state why he didn't have the feeling of full success. Expecting it was because he didn't go into the science behind the exhibit in a deeper way, I asked if that is the reason. He stated that he didn't want to go into deep science after the students interacted with the exhibit because he didn't want to scare them. The vignette below continues the conversation.

- 01 Rhonda:** Sometimes I feel like I am scared to fully explain to them because science, I think, most of the reason, why kids don't like science is that there is no fun in it for them, like you take away the fun of science by teaching it so much, sometimes things shouldn't be explained so fully.
- 02 Preeti:** from a like a content [perspective]
- 03 Rhonda:** [but like], especially children, you don't wanna make them feel like, oh my god (implying it is too hard), you want them to be interested in it, sometimes I feel it is kind of difficult for me to understand where to draw the line between boring them and turning them off from science completely, but still trying to keep them engaged in a way. ( collective head nods)...so I have difficulties with that.

Those of us who have ever taught have experienced a struggle in a given situation and don't always have the opportunities to pinpoint and discuss them. Through cogenerative dialogues where we can review our videotapes, we are able to relive the experience. We are able to narrate why we chose our actions. The cultural tools selected by us, the agent, and the rationale for the selection become the unit of analysis for identity development. Being able to work in an ISI context, a low-stakes setting, where these pre-service teachers can have multiple experiences allows them the ability to make comparisons and predict actions. They have experienced failures and over time learn how to create successful encounters. Rhonda is struggling with the fine line between too much content, which may make it boring and too little content, which may not communicate the

appropriate science concepts. To her, this is important because as she has described on many occasions, that science can be presented poorly and students can be turned off from it. This vignette illustrates how she does not want to contribute to that. She wants to teach science, but not at the expense of having students lose interest. Later in that meeting, she goes on to state that if we, Explainers, don't do our job right, "kids might feel like science is the worst thing ever." To Rhonda, her job is high stakes even though the CLUSTER program is designed to provide low-stakes environments to practice teaching. Rhonda believes that her role in this field, that of NYHS, is an important one and if she doesn't do it well, it will not align with the motives of the collective. Therefore, developing a strategy for teaching effectively is an important goal for her.

### *Catalytic Work*

As a group, we continued to work on strategies to improve our interactions with visitors, but over time, a project emerged out of the cogenerative dialogues to collectively develop a worksheet for students visiting on a field trip. The group felt that they encountered a variety of worksheets developed by schoolteachers and most times the questions were lacking and didn't contribute to learning. Together, the group chose to collect questions and design a worksheet that we could test with middle school students. During a meeting where these questions were being generated and tweaked, we felt a sense of frustration as evidenced by the comments each of us made about how hard it was to actually develop a good question. We had contradictory understandings of the main ideas described by certain exhibits and in some cases, contradictory experiences as to how students respond to a set of opening questions for facilitation. Cogenerative dialogues are meant to highlight these contradictions and use them for advancing the conversation. As such, it

was clear that our experiences of having conversations with visitors at exhibits contributed largely to creating an ability to determine the big ideas of an exhibit and strategies to reach our goal of getting visitors to engage with those main ideas. We also had stories, actual experiences, which we could narrate about the nature of the dialogue that took place at the exhibit. As we discussed a strategy, we could predict the direction of the conversation that might take place. We could predict the transitions we needed to build on to connect ideas because we had failed at doing so in the past.

One vignette of such a conversation is presented below. In this meeting, we were trying to create questions for a certain exhibition area and we were struggling to phrase the worksheet question in a way that students can reason through an answer. However, we couldn't assume any prior knowledge in the students because they are on a field trip and we couldn't agree on one big idea. As we go through different ideas of questions, I am writing them on my computer.

### **Episode 1**

- 01 Preeti:** ok, so we would ask, "what are the differences you notice between the planets" and then they can list all of the differences, but then, what's the main understanding [that we]
- 02 Naina:** [in parenthesis we could] put like temperature, size, they usually get the size
- 03 Rhonda:** yeah, well, I usually, they usually get the size because when I ask them like "what do you notice about it?", they won't tell me what they notice about the size immediately, but when I make them touch and feel and ask them "why do you think this planet is so like cold?", they'll be like because its small, automatically, I think that, they say, oh "because it is small and maybe because it is far away from the sun, its so cold." That's like a lot of answers that I get.
- 04 Naina:** Yeah, I wouldn't get that answer. (Samantha, nodding her head in disagreement murmuring that she doesn't get that response either.

- 05 Rhonda:** Oh I always get that. "Oh it's small so it has less heat." And stuff like that. A lot of kids would end up, maybe not the less heat part immediately, but they'll tell me "it's really small" and that why they think it is cold.
- 06 Preeti:** That's interesting that you all get such different responses to your facilitations.
- 07 Samantha:** probably the way we pose the question (collective head nods and simultaneous responses of agreement)

I guided them to refocus to the question for the worksheet even though this discussion was interesting. I probed them to settle on one big idea so that we could finalize this part of the worksheet. In what follows, you see how Rhonda describes her contradictions and how that influences the development of the question for the worksheet.

## Episode 2

- 01 Rhonda:** Well the point of that exhibit is to get to the idea that the atmosphere of Earth is more dense. I use blanket to talk about it as if Earth has a blanket, cuz, I don't know how to explain dense to them (collective laughter) so I'll use blanket. And I'll say, "Mars doesn't have a very thick blanket" and I'll relate to "if you are cold, do you wanna be under a thicker blanket or not so thick blanket?" And kind of get the answers from that.
- 02 Preeti:** So do we need a transition question to get them from the differences between the planets to the atmosphere idea?
- 03 Rhonda:** (with high pitched excitement) Well, one thing I do that is wrong is that I ask them "why do you think Mars is cold and Earth is warm?"=
- 04 Preeti:** =And why is that bad?=  
=
- 05 Rhonda:** =Because if someone asked me that, I would not think, like I never get a straightforward answer for that, that's where I get the funny answers from, about it being small and far and I always tell myself that I am going to change that question, because no one ever tells me, "its because of the atmosphere." I'll always get its because Earth is bigger and closer to the Sun so it is warmer and I'll be like then why is the top cooler and...I get funny answers

The members of this group were working collectively to share their experiences with this one exhibit and use that to develop a great question. The contradictory experiences

lead to a rich discussion about the necessity to have a good starting question to guide students towards a particular idea. Following this vignette, I ask Samantha to offer her approach to facilitating this exhibit and help Rhonda avoid her self-identified pitfall in the opening line with students. Elizabeth Davis, Debra Petish and Julie Smithey (2006) remind us that many studies have documented that new teachers have “more sophisticated ideas about instruction than they are able to put into practice. Developing the ability to put one’s beliefs into practice – to identify which of one’s beliefs are more productive – is hard for teachers” (p. 627). These pre-service teachers are able to develop their *spielraum*, the ability to enact culture in anticipatory, timely and appropriate ways to handle different situations in real time (Roth, Lawless and Masciotra 2001). This is rare for a new teacher, and what one expects from veteran teachers. Furthermore, they are able to use that *spielraum* to conduct a different activity of creating effective and well designed worksheets for NYHS, a complex task for a pre-service teacher. These Explainers, pre-service teachers, were being ascribed the role of a teacher. As a teacher, their self-realized task was to develop a worksheet so that students learn key ideas from the exhibits. Their identity as an Explainer provided them with the repertoire of experiences to inform the task at hand. Zooming in, I theorize this task as an activity where the motives of the collective are to design this worksheet. Each person brings her goals, her resources and cultural tools to the system and mediates the development of the worksheet. In doing so, contradictions arise and are dealt with accordingly to progress with the activity. Through this shared activity, we all develop an awareness of ourselves as teachers, and our abilities to consider the pedagogical issues of teaching science to diverse learners. Working as Explainers contributes to our cultural capital as educators.

We feel that we have knowledge about how students can best experience an exhibit, have content knowledge of the exhibition areas, and have experience with how students actually use an exhibit. This cultural capital contributes to our agency. Due to the dialectical relationship of agency and structure, in designing worksheets that might actually be used by teachers, we are aiming to contribute to the cultural tools that exist in the field and affect the structures.

### Studying Social Life

Identity development is life's work, not something that happens just when one is learning to be a teacher. The title of this chapter, *There is no off button to Explaining*, is inspired by one NYHS Explainer, Victor. He said these words in the context of describing what it means to him to be an Explainer and what he was referring to is that the schema and practices that one learns and embodies as an Explainer move from one field to another, whether it is in school, with friends and family or at another job. Aspects of the Explainer job have become part of Victor's identity represented through his views and actions in social life.

In this chapter, I contribute knowledge to the field of science teaching and learning about purposeful participation in a teaching activity in a science center. This activity mediates our identity development by shifting our epistemologies and ontologies. It affords us the opportunity to practice effective teaching techniques and even design new resources for teaching and learning. Many opportunities exist for pre-service teachers to practice in low-stakes settings, each with its own merit. Working as floor staff in ISIs where it is one's job to facilitate learning experiences for those who visit situates a pre-service teacher as part of a larger endeavor and places her in the role of being an

educator. Working as an Explainer is different from traditional fieldwork and student teaching experiences because an Explainer has an integral role in the ISI and is held accountable. Without Explainers reporting to work and being in the role of an ISI teacher, the experience at the ISI would not be complete. As Explainers, pre-service teachers gain capital as teachers and learners. In the act of teaching, having agency to select and use specific cultural tools, and appropriate them gives one the ability to experience and contribute to cultural production and transformation.

One limitation in this research is that the experiences and indicators of identity development described here do not happen for all Explainers. When examining social life, we have to expect contradictions to the patterns we discover. Patterns exist in a dialectical relationship to contradictions. While there are opportunities for identity development, there are equally the same opportunities for one not to participate in reflexive actions. Identity development is an activity linked to enacting social life, but becoming aware of it is a conscious action. The structures of an ISI alone cannot mediate this reflexivity. The agent, the Explainer, has to co-contribute to the structures in experiencing the act of reflexivity. The structure|agency dialectic is what accounts for the possibilities for identity development of a reform minded teacher. It is true that these experiences may not reverberate for all Explainers, but the idea of this research is to demonstrate that given certain structures, such opportunities exist for Explainers.

This research is about developing local theory, which can mediate practice, rather than developing a grand theory that can be replicated in other settings. I agree with Kenneth Tobin who embraces the idea that research outcomes can serve as kernels of thought and actions for Self as well as Others. Like him, I focus on making a compelling

case about activity in a science center as the site for cultural production|reproduction and transformation (Tobin 2009). The goal of my research is not to create generalizable understandings. It is to demonstrate the viability of ISIs as partners to university teacher preparation programs to support pre-service teachers in developing their identity as reform-minded teachers. Science centers and universities interested in pre-service education can learn from the claims I make in this chapter about how participation in purposeful activity such as working in a science center coupled with cogenerative dialogues changes identity as an educator for all involved.

#### **Chapter 4: Applying Interaction Rituals Chain Theory to the Explainer Experience**

In this chapter, I use interaction ritual chain theory to make claims about how purposeful activity working as an Explainer at a science center mediates identity development in pre-service teachers. Explainers are required to facilitate learning experiences for visitors aim to create successful interactions. Emotions, intricately linked to teaching and learning, serve as inputs and outputs in an interaction. Activity that mediates successful interactions leads Explainers to feel an affiliation with the profession of teaching. James Paul Gee (2001) writes that a big part of our identity is our affinity with a certain group and in this case, if pre-service teachers can be in the role of having to create successful teaching experiences, it can mediate how they view themselves as teachers. Second cogenerative dialogues allow those of us in shared work experiences to also share cultural tools such as language, schema including strategies for engaging visitors and even physical resources such as our uniforms. We develop a sense of belonging to a group of people who share interests and experience the same challenges leading to solidarity with Others. All this leads to increased social capital, which supports us to identify with being an educator. Specifically, I examine two inter-related fields of social life by documenting how a pre-service teacher who works as an educator on the exhibit floor of an informal science institution structures and is structured by emotions and then how those emotions are brought into structured meetings called cogenerative dialogues (Tobin and Roth 2006) generating new conversations and activities mediating the development of solidarity with teaching.

The first two vignettes demonstrate how Explainers struggle with the emotions that are produced in an interaction. Grounded in the notion of the individual|collective

dialectic, I describe when Explainer's goals and the visitor's goals are misaligned and how an Explainer negotiates her approach and actions to produce successful interactions. Through autobiographical accounts, I review how that constant act of modifying an interaction leads to successful interactions which recursively leads to positive emotions. Over time, the chain of interactions produces an affiliation to teaching. The next vignette is used to demonstrate how shared work experiences create solidarity during cogenerative dialogues. This solidarity produces an object of mutual focus, which positions us in the role of teachers and invites us to espouse an activity of producing a worksheet, the job of a teacher. I review how social capital is produced through working as an Explainer at a science center and make claims about the role of emotions in face to face interactions in a science center leading to solidarity with the profession of teaching.

#### The role of emotions in teaching and learning

As a learner, teacher and teacher educator, I think about how often we associate our science learning experiences with emotions. It is common to hear, "I had the best science teacher," "I hate math" or even, "science is boring." Teaching and learning is an emotional activity. Andy Hargreaves (2000) reminds us that "teaching, learning and leading may not be solely emotional practices, but they are always *irretrievably* emotional in character, in a good way or a bad way, by design or default" (p. 812). Embracing a socio-cultural approach, I agree with Jennifer Nias (1996) who writes, "as an occupation teaching is highly charged with feeling, aroused by and directed towards not just people but also values and ideas" (p. 1). Nias goes on to describe that the reason teaching is closely linked to emotions is because as teachers, we feel passionately about our students, and about the structures related to schooling and curriculum which can

afford or constrain our ability to teach. We, teachers, cannot separate our feelings from our perceptions and the affect of experiences from making judgments about those experiences thereby rooting emotions into cognition. My standpoint is that cognition and emotion are in a dialectical relationship to each other (Stetsenko 2008). Teaching and learning are not simply cognitive activities, but emotional ones also. Also, neither cognition nor emotion can be separated from social and cultural forces, which help to form them and are shaped by them. The production of emotions are mediated by how we view ourselves, and others, the activity we participate in, and how we mediate tools and resources in that activity and that contributes to our identity development as a teacher.

#### The Contextual Nature of Informal Science Institutions

Informal Science Institutions (ISIs) are free-choice learning environments that are outside of school, but provide intentional learning experiences (Eshach 2007). People who enter these institutions can experience it on their own or choose to participate in a planned activity. Learning is usually not evaluated and typically is non-sequential. John Falk and Lynn Dierking (2000) offer us a framework to consider the structures that mediate learning in an ISI. This framework, the contextual model of learning, states that learning is dependent on personal, socio-cultural and physical contexts and as these contexts dynamically change, so do the opportunities for learning. Embedded in this framework are the motivations for why one visits an ISI. John Falk and Martin Storksdieck (2005) theorize that there are 5 categories that visitors can be grouped into based upon their identity-related motivations when visiting a cultural institution. These identity-related motivation groups are explorers, facilitators, professional/hobbyists, experience seekers and spiritual pilgrims. Explorers are those visitors who are curious about what an ISI has

to offer. Facilitators are those people who are supporting the learning in a group such as a teacher who brings a field trip or a parent who visits because her child is interested in visiting. Professional/hobbyists are those who feel excited by or close to the material being presented at an exhibit. Experience seekers are interested in engaging with the institution in some way. Finally, spiritual pilgrims are those whose primary motivation is to be *affected* by the experience, possibly learn something new, and have time for reflection and contemplation. Each of these groups visits with a particular outcome in mind. Jan Packer (2008) confirmed and expanded patterns in satisfying visitor experiences as described by Andrew Pekarik, Zahava Doering and David Karns (1999). Visitors aim to either see the “real thing” or a valuable object that can only be experienced at the museum, grow cognitively in their understanding of a certain subject, have an experience that allows them to imagine, reflect, reminisce or connect to what they know, or have a social experience with their friends, family and others.

In regards to both, the motivation for visiting or the intended outcome of the visit, face-to-face encounters with floor staff in an ISI are common place and these encounters not only presuppose emotions but also produce them. People tend to interact with each other with the expectation of certain payoffs and those expectations are bound by the identities through which people enter an interaction and the emotions they carry with them. As such, encounters that floor staff has in the interactions with people mediate the development of new emotions and using interaction ritual theory, I illuminate how that has implications for identity development.

### Interaction Ritual Theory

Randall Collins (2004) writes that interaction ritual theory gives the most fine-grained picture of how emotions are transformed in the process of interaction. Interactions begin with emotions (starting ingredients) and as one goes through an interaction, certain emotions intensify. In the case of an ISI, some emotions can lead into a shared excitement – the Durkheimian notion called collective effervescence. Examining chains of interactions allows us to see the flow of emotions across situations, each moment being a new point of cultural production. If we trace human bodies moving from one encounter to the next, we see the history of their chains – carried along in emotions and emotion-laden cognitions that become the ingredients for the upcoming encounter. As the interaction rituals do their work, they intensify, transform, and diminish those emotional ingredients that humans brought into a situation and produce a new set of emotions as the interaction concludes. These emotions don't have to be dramatic, but rather they are underlying tones and moods, have long-lasting effects and therefore contribute to identity development. As such, I am led to the following research question: *in what ways do interaction ritual chains allow me to document identity development in pre-service teachers?* To begin this documentation, I first present the context of the study.

### The Context of the Study

Whether you take the number 7 train to 111th street or drive along one of the many highways in Queens, you must pass through the streets of Corona, Queens to get to the New York Hall of Science (NYHS). Examples of what you might hear are music from homes pouring into the streets (Latin from one, Indian from the next), cars and bikes

honking, the Long Island Railroad passing on the overhead track, or even screaming kids being released at 3PM from the local school. The savory smell of garlic from the local pizzeria, or arroz con pollo from the nearby Peruvian restaurant, invites you to purchase a snack. You may see ice cream cone vendors, people playing soccer at the end of the NYHS parking lot, and a mom wearing a salwar kameez, the traditional dress for a country such as Pakistan, and her children walking home from school as her excited children tell her all about their day. The sensory experiences allow you to realize the diversity of people who live in the neighborhoods surrounding NYHS. The lives and histories of the different people are apparent by their dress, their language and their mannerisms.

Approach 111th street and 47<sup>th</sup> Avenue and you stare at shiny rockets overshadowing a strangely shaped building, the New York Hall of Science. Somewhat out of place, this structure was built in 1965 for the World's Fair. After the World's Fair, the building was to remain open as a science center. Financial hardships and lack of leadership led to turbulent times until 1986, when the Board of Trustees put a new team in place to launch the science center of New York as the New York Hall of Science with the intention of serving as a science center for New York City, a place to galvanize science curiosity and expose people to topics in science and technology. Since then, the center has been renovated and has expanded in 1996 and then again in 2004.

The New York Hall of Science feels like a different place depending on if you come on a weekday or a weekend day. On weekdays, close to a thousand field trip students fill the halls of the different exhibitions. At first, they appear to be running around aimlessly. Closer examination shows that although initially running around, after a few minutes of

trying to touch and see every exhibit in the area, students return back to one that interested them the most. Kids show their friends what they find interesting evidenced by the gesture of excited pointing and looks of delight or interest by what they see. You still witness running, but now the running is from one exhibit to another with the intention of simply moving between them faster.

On weekends, the mornings are slow and then by noon, families start to pour in. Some come in with their strollers and their big family bags with packed lunches and snacks, ready to spend the day at the museum. Some families go right to their favorite areas evidenced by how they communicate with each other. “Let’s go to the Sports exhibit first and then we can spend time at the microscopes,” is what one Dad says to his elementary age son indicating familiarity with the exhibits and a plan for the day. Other families move past the admissions area with a map in their hand looking somewhat confused and disoriented. Upon being approached by a staff member, such as me, to help direct them to begin their visit, they show great appreciation and excitement.

Regardless of weekdays or weekends, first-time visitors or return visitors, as they walk inside, past the admissions area, they notice people in red aprons floating around in the exhibitions, the Explainers. Explainers are responsible for approaching visitors or helping visitors who approach them and engaging them in conversations about science at the exhibits. They also conduct short science demonstrations, work in the discovery labs and assist with workshops.

#### Pre-service Teachers as Explainers

A project, the Collaboration for Leadership in Urban Science Teaching Evaluation and Research (CLUSTER), is a research study with the intent to document how a university-

science center collaboration supports pre-service teachers develop reform minded teaching practices. In this project, pre-service teachers work as Explainers. Pre-service teachers take required education courses at City College of New York while working as Explainers, a paid, part-time job which also contributes to their understanding of teaching and learning. They are aware that they are part of a National Science Foundation funded project that is researching the role that science centers play in supporting teacher preparation in secondary science. They identify as a CLUSTER Explainer, a name that distinguishes them from other Explainers. All of the CLUSTER Explainers audiotape or videotape themselves interacting with visitors and they discuss their interactions during cogenerative dialogues, meetings designed for the purpose of discussing a shared activity with the intent to improve praxis. Cogenerative dialogues are meeting spaces where participants have a shared focus and work together to describe social actions, deal with contradictions and collectively decide the strategy for moving forward (Tobin and Roth 2006). These dialogues develop over time to maintain structures where each participant is an equal stakeholder, where each respects the similarities and differences as they arise and where each contributes to the advancement of the conversation.

I am the Vice President for Education at NYHS and a co-principal investigator in the CLUSTER project. I am also a former Explainer and a member of one of the cogenerative dialogue groups. As such, the CLUSTER Explainers are co-researchers with me. As a former Explainer, I share the knowledge and skills for interacting with the public and therefore bring my own vignettes to the cogenerative dialogues so that I can work towards improving my own practice. I share a group identity of having been an

Explainer and can also acknowledge the types of cultural capital (Bourdieu 2001) that develops from being an Explainer.

### Being an Explainer: Getting Right Back on the Horse

Working as an Explainer, one experiences many different emotions and learns to navigate through them to produce successful interactions. As a high school Explainer, I remember wanting to go to work every Sunday because it made me feel good. In reflecting why it felt good, I realize that it was the feeling of interacting with visitors and seeing them excited about an idea, or seeing them learning something new or simply showing them something cool. In contrast, I also experienced times when I would approach a visitor and ask, “Would you like to see how this exhibit works?” and the response would be, “No, thank you.” It was difficult to hear these words and similar phrases that might be characterized as negative responses. Since I did not have control over when those times would occur, I could only develop my ability to create an environment that had a higher chance of getting positive responses. Without realizing it, I was adapting my opening line to be more inviting. Instead of saying, “Can I help you?” I would say, “Wanna see something cool?” I was looking for body language and gestures that signaled that a visitor might be amenable to a social interaction. When I had negative experiences, I didn’t have the choice of halting my interactions with visitors because then I would not be doing my job. As an Explainer, I was required to interact with visitors and for me, this meant developing a thick skin with those visitors who were not interested in chatting with me about the exhibits. I had to learn to develop strategies that led to more positive interactions as opposed to negative ones. Over time, successful interactions with visitors led me to build confidence in teaching science. I believed I was good at it, enjoyed this

work and identified as being an educator. I miss being an Explainer and I have had the opportunity to be in that role because of my research agenda.

Explainers work at least one day per week over many years and have the opportunity to have multiple interactions a day. Therefore, an Explainer engages in hundreds of face-to-face interactions over time. My personal experience is testimony to the idea that in that time, an Explainer experiences many more positive interactions than negative ones and those interactions influence how she identifies with herself as a teacher of science. An Explainer develops her ability to structure a situation that has a higher potential to lead to a positive interaction. While she may not label herself as a traditional teacher, she gains the cultural capital as an effective teacher and develops *spielraum*, the ability to maneuver in timely, anticipatory, and appropriate ways (Roth, Lawless and Masciotra 2001). Just as I described that I developed effective engagement strategies by trying techniques and gauging their success, Explainers develop techniques for assessing a visitor's prior knowledge, introducing new ideas and when possible, assessing if the visitor learned the idea by asking the person to try an advanced task at an exhibit. Repeat experiences coupled with peer training and support leads to increased capital production (i.e. learning). Specifically, as an Explainer becomes competent at the science of the exhibits, how to operate them and how to engage visitors to interact with them using both scientific and colloquial language, she develops linguistic and intellectual capital.

Emotions that are produced through these face-to-face interactions are a key component of developing cultural capital. Negative emotions such as anger, frustration, and sadness can lead to an Explainer becoming afraid to approach a visitor. However, emotions of excitement, satisfaction, happiness, and delight can lead to an increased

interest in recreating such interactions with visitors. As an Explainer, we face both.

Repeat experiences with visitors mediate our personal understandings of rituals enacted by different types of visitors in social settings such as a teacher on a field trip, or a parent with children.

During one cogenerative dialogue, the Explainers and I had just finished listening to a recorded interaction with one of the Explainers, which led into a conversation about visitors who are not interested in learning about the exhibit; they are visiting the museum just to have fun. Triggered by this conversation, Marina, one of the Explainers, offered a recent experience with a group of boys at an exhibit called *Celestial Mechanics*. This exhibit is designed as a gravity well where a visitor can push a button, which releases a ball with force onto a circular platform that has a hole in the middle. The ball begins to roll on the platform in an elliptical fashion, gaining speed as it gets closer to the central hole and eventually enters the hole.

Marina had just finished describing how she had tried to help this group of boys, but the parent stopped her and told her to just let them push the button. The following transcript demonstrates how a negative interaction triggers a set of emotions and actions:

#### Episode 1

Speaker	Dialogue	Gesture and Tone
01 Marina	<p>I was standing there trying to talk to them. I am trying to explain to them, "Oh so what happens when, what kind of energy do you need," whatever and then the ↑mom just completely cut me off and one point she goes, "oh let them just push the button." And I was like, ↑are you serious?</p> <p>The mom cut me off just to tell the kids that they could push the</p>	<p>Excited frustrated tone</p> <p>The words "are you serious" were not actually said to the visitor but are used by Marina to express</p>

	<p>button for the ball. And I am like, "ok, so have fun pushing the ball. ↓I am gonna go now."</p>	<p>an emotion of disbelief.</p> <p>Tone of defeat</p>
<p><b>02 Jay</b></p>	<p>You could kind of like do it like have some fun and then learn and then have some fun, for example, <i>Anti Gravity Mirror</i>, I just go up and start doing crazy tricks and then I sort of explain it a little bit and then more crazy tricks, and they have fun with it, because at the end of the day, you wanna have some fun while learning. What's the main goal, you want them to learn something and have fun at the same time</p>	<p>Hand gesture of interweaving</p> <p>Collective comments of "right" or positive head nods</p>
<p><b>03 All</b></p>	<p>But a lot of the exhibits don't have that.</p>	<p>Overlapping talk with the louder Explainer being caught on audio.</p>
<p><b>04 Seema</b></p>	<p>That exhibit is a very entertaining exhibit. Think about <i>Celestial Mechanics</i>.</p>	
<p><b>05 Preeti</b></p>	<p>Yeah, do you have a strategy for that one?</p>	
<p><b>06 Jay</b></p>	<p>Take it easy. You know, let them press the button and let it go around a little bit and then say, "what did you notice?" because all you do at that exhibit is push the button and watch the spheres go around. Could be like, "Could you guys relate this to something?"</p>	
<p><b>07 Marina</b></p>	<p>Yeah, I was saying that. I had used that exhibit just before and it went fine. It was just that group which I found, I don't know. I shouldn't get offended by it because I shouldn't take these things personally, but I took it personally. I was so m:a::d. I was like, I can't believe it.</p>	<p>Rest of group smiling or chuckling</p>
<p><b>08 Preeti:</b></p>	<p>Group discusses the degree to which certain exhibits are fun or are not fun.</p>	
<p><b>08 Preeti:</b></p>	<p>Marina when you got so mad, what</p>	

	<p>were your next five to ten minutes like?</p>	
<b>09 Marina:</b>	<p>Well after I got mad, I was fuming right, so I was walking back and forth, I was trying to figure out why they wouldn't listen to me, I was like, you know what, screw it, I'll find another visitor, but first I ↓told another Explainer about the incident</p>	<p>Collective laughter</p>
<b>10 Preeti:</b>	<p>Oh so you had to vent it out</p>	<p>Great collective laughter</p>
<b>11 Marina:</b>	<p>I had to tell them and they were like, oh, its gonna be fine. And then I found another visitor and then I explained <i>Light Island</i>, so then I felt a little better, I was comforted by, kind of, explaining to another visitor.</p>	<p>Overlapping talk of rest of group</p> <p>Smiling collectively</p>

For this chapter, I presented Marina with the transcript of the vignette and invited her to interpret it in relation to the role of emotions for both, doing her job and in the broader endeavor of teaching and learning. We each interpreted the transcript independently of each other. Marina describes her interpretation of the transcript in the white box. I describe my interpretation in the grey box.

Looking back at the interaction, I believe that I acted more on my emotions than my senses. I should have not taken the interaction with the visitor so personally. I cannot force people to learn or listen in this case. I think that I find the situation unusual because it is usually kids that do not listen to Explainers, not adults. As mentioned in our last meeting, adults tend to stay long after they are bored because they do not want to be rude. And I believe that I pre-judged that the adult would "force" the children to stay and listen to me. Through similar interactions it becomes more evident that the Hall of Science is much different from a classroom. In a classroom, students have to listen to the teacher but at the Hall it is different. the visitor chooses if he/she wants to

Marina described her anger with this interaction knowing that she had just had a positive interaction at the same exhibit earlier that day. Jay offered her strategies, but in this case, she did not find it useful because she was using similar strategies in this interaction to what she had used in the past, which had proven successful with a different group of visitors. Marina, especially after venting to another Explainer, accepted that while she is angry, she was unable to control whether visitors will want to learn or not. She decided that she would find another group of visitors at a different exhibit and aim for a successful interaction. The emotional energy of one interaction carries into the next interaction

In interpreting both Marina and my own understandings of what happened in that transcript, I believe that Marina has developed an expanded agency that encourages her to deal with her emotions and immerse into another interaction. She may be rejected again, but she has had enough experiences to know that it could also be successful. She knows that she has to get back on the horse, and for her own sake (individual) and for the sake of the job (the collective) she has to try again and risk another defeat that she may take

personally. Randall Collins (2004) reminds us that when people make a choice to join certain interaction rituals, they consider the structures, the symbols, the resources and their own identities. “One’s identity, which includes self-perceptions, group affiliations, and others’ perception of self, can be considered one of the many structures that both enables and constrains these choices” (p. 51). Marina has developed the confidence to approach another visitor and engage them in a ritual with her although she has very little control over the visitor’s reaction to her approach. While there is the risk of another negative interaction, she knows it is her job to approach visitors, and her collection of positive experiences give her the motivation and confidence to pursue this action. In Marina’s interpretation, her statement about making judgments about certain ritualistic practices that are socially acceptable such as it being okay for students to run away from an Explainer, but it is considered rude if an adult does so, is intriguing. She has developed a local theory on rituals people follow in a museum setting and that theory mediates her agency as well as her receptivity to cultural enactments. If we theorize social life as existing in fields, then fields are sites for cultural production, reproduction and transformation with porous boundaries and structured by the schema and practices of the people in it. Emotions are a key aspect of the schema produced in fields. The ISI exhibit floor is called Field 1 and the cogenerative dialogues are called Field 2. Emotions from one field are carried into another. Bringing an emotion-laden experience from Field 1, the exhibit floor, as a thought object into Field 2, the cogenerative dialogue, allows us to develop awareness about visitors, their motivations, our roles as Explainers and as teachers. By examining the vignette of our discussion, and interpreting it through our own lenses, Marina and I continue to make this topic a thought object as we each give

meaning to what happened. This polysemic approach mediates the emergence of key ideas for of the two of us. Marina reveals that having many other similar interactions reinforces her understandings of the differences in structures between a formal and non-formal learning institution. Production of positive and negative emotions becomes part of the schema for an Explainer's developing identity as an educator. Due to the dialectical relationship of schema to practices, emotions mediate the development of practices that potentially lead to an increased frequency of successful interactions. I use Jonathan Turner's ideas of transactional needs (2002) to demonstrate how successful interactions contribute to identity development. Turner states that in addition to socio-cultural and historical constructs that structure each situation, each person's needs fuels the flow of interaction. As such,

If a person attributes the verification of self to the corporate unit in which an encounter is embedded, then positive sentiments toward this corporate unit and the institutional system in which it is embedded will be evident. The more salient is self in the encounter and the more this attribution continues over iterated encounters, the greater will be the positive feelings and the level of commitment to the corporate units and the broader institutional system in which the encounter is embedded" (p. 105).

As an Explainer becomes aware of negative or positive emotions through encounters of teaching and learning over chains of interactions and uses them to develop an awareness and schema that lead to successful interactions, she attributes those sentiments towards the corporate unit and the broader institutional system –learning and teaching science and being a teacher of science. Marina has hundreds of interactions through her work as an Explainer. Although she will have some unsuccessful experiences, the schema and practices she develops will lead to increased positive interactions and over time she will identify herself as someone who can successfully teach. At the time of writing this

chapter, Marina continues her activities as part of the project and we can not know if she will pursue a career in education for sure. However, my own experiences as an Explainer serve as evidence because, similar to Marina, successful teaching experiences over time mediated my identity as a teacher.

### Is It Our Public?

At NYHS, Explainers conduct demonstrations and these are 20-minute interactive, scripted presentations on a particular topic conducted on the museum floor amongst the exhibits.

Explainers go through a rigorous certification process that assesses their presentation skills, understanding of science content, transitions between ideas, and ability to effectively communicate to mixed audiences. Each demonstration is a unique cultural activity structured by the physical, yet temporal characteristics of the ISI on a given day such as crowdedness, ages of the visitors, composition of the visitor groups, the location of the demonstration, the time of day, the temperature of the space or any variety of factors that can influence the setting. An Explainer can be agentic with some factors such as crowdedness or location of a demonstration. However, some factors are not controllable for an Explainer such as the age of the visitors or the temperature of the room. Different audience members bring different schema mediated by many of these uncontrollable factors such as temperature, location, and crowdedness and contribute to the cultural production of the science demonstration. Emotional energies of the audience become part of the schema. For example, some might approach the demonstration excitedly. Others might be skeptical. Others might be apathetical or just looking for a comfortable activity where they can sit for twenty minutes without having any emotional

expectations of the demonstration. How does an Explainer cope with such uncertainty in each demonstration? How does she do her job of teaching the demonstration if possibly, the emotional energies create an unsupportive structure?

During another cogenerative dialogue, we had been discussing how sometimes it is difficult to be excited about coming to work especially when you are tired because of school and overwhelmed with many responsibilities. A conversation that emerged was that sometimes, an Explainer comes to work ready to interact with visitors and then encounters apathy from an audience. The following set of vignettes describes two instances where different Explainers experienced such apathy.

Episode 1

Speaker	Dialogue	Gesture and Tone
01 Rhonda	I was doing a cow's eye about two weeks ago and there was a group of 13-14 year olds. And it's like a basic question, "why do you think we use cow's eyes?" I got nothing, I think anything would work at this point, just give me anything why, why you think we use a cow's eye for this demo, but then what got me was kind of was that they were older kids, they were 13-14 year olds, they would at least be able to come up with anything, like "its big" or "it looks funny" or anything, but I didn't get anything so I had to like give them every answer, but I tried to get it out of them, and they would just look at you and you don't wanna waste time since you only have about twenty minutes for the demo and sometimes there is just nothing you can do to get them hyped [or]	laughter and collective nods  Tone of frustration
02 Seema	[its] really hard, especially in a demo, if you get discouraged, its [like]	
03 Preeti	[its] all downhill.	
04 Seema	yeah (group laughter)	

Episode 2 (later in the same meeting)

Speaker	Dialogue	Gesture and Tone
01 Neel	Believe it or not, it happened to me. It didn't happen on those kinds of questions, it happened with, "hey, how are you doing today?"  That is the worst thing, that just knocked me out. I started off and nobody says anything and from that moment on, I knew that this demo was not really gonna be interactive.	Tone of disbelief  Group laughter  Tone of defeat
02 Preeti	Is it our public? They are just so jaded, that they [don't]	
03 Seema	[it's not] really our public, it's the way you say things. The first time I went for the chem cert, I didn't get it because I was nervous, the second time I went, the first thing I was like, "so hey guys,"  I just took on this sunny, sunshine persona, I am sure that people who were depressed were probably like, "I hate you." But I was like, "so how are you?"  I mean like, you have to respond to someone if they are asking you like that, so forceful, I usually, like with higher pitch, just start talking, I don't know, for some reason, it gets to people, instead of if I just talk like this, it is more boring.	(referring to chemistry demonstration certification),  High pitched tone of excitement  High pitched sound switching to normal monotone for emphasis

In this vignette, these Explainers experience apathy and feeling conflicted because they need to do their job as a teacher, but the students are not interested in learning. Once again, I presented the transcript to Seema, one of the Explainers in the dialogue. We each interpreted independently. Her interpretations of the transcript are in the white box and mine are in the grey box.

I think that our emotions while conducting a demonstration, has a large impact upon our audience. If an audience is bored and the demonstrator takes on a positive upbeat attitude then it will engage the audience. No one wants to be sad or bored so they will respond to someone with a positive attitude. Teaching not only depends on content but how this content is presented. A teacher may use Power Point presentations and this will discourage a lot of students because it is not interactive. The teacher could just be using a laser pointer and reading monotonically through the slides. Whereas if the same teacher using the same slides engaged the students by asking several questions, they could instead of reading the slides exactly as is, present a summary of each slide while maintaining eye contact with the class. The most difficult part of teaching is to have your students comprehend the content. Some of the few ways to engage unresponsive students would be to have eye contact, activities, and

While it is easy to blame the students, in line 03, we see Seema taking the responsibility for the apathy student's display. She believes that a positive emotional disposition will force students to want to participate. Her disposition is such that she is willing to take responsibility even for a crowd that may not bring positive emotional energy and is willing to change her mode of presentations to affect the emotional energy of the whole situation. As with the vignette presented above, she has had positive experiences and believes that a new situation with slight modifications such as a high-pitched tone to launch a demonstration can make a difference. Seema has experienced success by trying a revised approach to initiating a demonstration with an increased pitch. This situation demonstrates that in social life, there are many things that we can't control and by embracing passivity, we can accept this lack of power to act in certain instances.

Seema's interpretations bring to the forefront her epistemologies about teaching and learning. We can use such situations to theorize about the importance for the individual goals and the collective's motives to be aligned for an activity such as teaching and learning to occur. If we think about the science center as a collective which has the motives of igniting the curiosity of science in visitors, then we have to consider the individuals who compose the collective, each of whom bring their own goals to the activity of experiencing NYHS. Individuals and the collective they comprise are in a dialectical relationship to each other and as such the goals of the individuals and the motives of the collective are also dialectically related. In this vignette, we learn that the Explainer and the audience do not have aligned goals. Explainers want to do their job of teaching the demonstration and engaging the public in a conversation on the topic, and the public is not interested in participating in the dialogue. There is a misalignment between the goals of the Explainer and the goals of the visitors. An Explainer may be creating a student-centered environment for learning but the visitor may not be interested in having the agency to direct her learning. An Explainer may want to teach certain scientific concepts, but the visitor may be interested in learning different concepts or not learning anything at all. In the field of NYHS, the structures may allow for Explainers to be agentic and to appropriate resources as needed to accomplish their goal. Yet, because of the dialectical relationship between agency and passivity, an Explainer's agency will be mediated by the passivity or lack of control she will experience. If the public is not interested or is apathetical to an experience, it may be that the Explainer cannot control that. In this activity system where there is a misalignment of goals and motives, most often, it is the Explainer who attempts to identify the visitor's goals and adapt her actions

to create positive emotional energies in the interaction rituals as described by Seema. In doing so, she develops *spielraum* and grows her repertoire of actions that may lead to successful interactions. She also strengthens her confidence and self-efficacy as a successful educator.

### Worksheets as Symbols for Solidarity

Interaction rituals have four ingredients: group assembly, boundary to outsiders, mutual focus on a common object, and a common mood (Collins 2004, p. 48). Cogenerative dialogues become an interaction ritual. When these meetings create positive emotional energy, mutual focus, synchrony and entrainment, there is solidarity and the emergence of group identity (Tobin 2009, p. 29). Collins reminds us that solidarity becomes possible when people have a shared activity (p. 82). Our shared activity of learning to improve our practice has grown strong to maintain positive emotional energy.

Over a number of cogenerative dialogues earlier in the year, we developed a focus on the fieldtrip worksheets that teachers asked students to use while visiting NYHS. Often we would feel frustrated by the quality of the field trip worksheet questions and this led us to conversations about designing a high quality worksheet. During one meeting, after having a lively conversation about the nature of worksheets, we decided to create our own worksheet for use by teachers who visit NYHS. In the episode presented in the vignette below, we see how one statement by me mediates the development of new activity for our group and leads to increased positive emotional energy and a strengthening of our group solidarity.

Speaker	Dialogue	Gesture and Tone
01: Preeti	The other thing we could is just, um, it would be very easy for me, to call up a school that is already coming on one of the future Fridays and say, we are testing out an instrument for worksheets. Can we hand it to your kids and, no [pressure],	
02: Rhonda	[yeah?]=	Everyone looks surprised
03: Preeti	=yeah, we could do that.	And me and Jan are nodding yes
	Then it will be <i>real</i> kids, not Kids Club kids.	Group laughter
04: Jan	Kids Club kids are not real.	Higher pitched group laughter
05: Preeti	They aren't real. They already know the place.	Group laughter
06: Samantha	Well, they are going to hand it back to us, right=	Referring to worksheet
07: Preeti	=Yeah, we'll collect it and take responsibility=	
08: Rhonda	=Are we, are we, helping the kids with their worksheets, like how we would normally help them?	Inquisitive tone
09: Preeti	Yeah, I think we would um, well, what we'll do is, we won't the kids=	Tone of thinking through the idea
10: Rhonda	=We'll get others to help the kids	
11: Preeti	We'll get other Explainers to help the kids. But we won't t:e::ll the other Explainers that it is our worksheet	Tone of having a brilliant idea
12: Group	Whoa!!	Tone confirming that the idea is a good one.
13: Jan	Then we can get feedback from those Explainers	

<b>14: Preeti</b>	Yeah, yeah, that way they won't like, [extra help them.]	
<b>15: Samantha</b>	[This is so funny]. We are like testing like two groups, wow!	
<b>16: Preeti</b>	All right, ok, so this is fun, ok	
<b>17: Rhonda</b>	I feel so devious right now.	
<b>18: Samantha</b>	Yeah, this is great. I am really interested in it.	Excited tone

As Vice President of Education, I have the authority and agency to invite a school to prototype a worksheet that we create. This was surprising for the group and led to excitement. As we together decided how this would be enacted, there was an increased interest in this project. Samantha said in line 18, “I am really interested in it”. She has always been an active participant in the cogenerative dialogues and the CLUSTER program in general. However, this statement demonstrates a renewed personal excitement about development of a worksheet –the object of mutual focus as described by Randall Collins (2004, p. 48). In Chapter 2, I describe how the structure of cogenerative dialogues support teaching and learning for identity development. With this transcript, we can also see that have senior administrators, as part of the dialogue is important for such meetings to work because senior administrators can bring their own cultural capital necessary for informed praxis.

While this episode occurred almost two months before the writing of this chapter, the activity of designing the worksheet and preparing for it to be prototyped with a field trip group continues to bind us together. One Explainer, Seema, has shifted to a cogenerative dialogue that meets on a different day and therefore does not attend the same group meeting where this idea was generated. She brought the worksheet project idea into that other group and has garnered that CLUSTER group’s interest in the project which

Kenneth Tobin and Wolff-Michael Roth (2006) regards as signs of ripple effects. On the project blog, Samantha, one of the CLUSTER Explainers who initiated the worksheet development idea wrote,

I can't wait to see what our results are for the worksheets and if anything, how we could revise it to make it even better. I want to know what questions went wrong and which ones are successes. That could help us change things around a bit. We still got so much to do in such little time! I hope we could get it all done by then. (March 6, 2009 at 3:50pm)

Interaction rituals lead to four main outcomes: feelings of membership, emotional energy, symbols or objects that people feel the closeness of the group with, and feeling of morality with respect to sense of rightness in adhering to group (Collins, 2004, p. 49). In this case the Explainers are excited to meet each week and continue developing questions for the worksheet. The worksheet has become an object that everyone is excited about and creates a mutual focus for our continued work not only by improving praxis, but also for developing our identity as producers of knowledge (in the form of a worksheet), not just consumers. Just as Randall Collins describes how football players become a symbol for positive emotional energy for a crowd of people who have attended a football game, these worksheets have much the same effect. While at the game the football players ignite a positive emotional energy in the public. Later on, discussing the players in an office setting or school setting, positive emotional energies are produced. Developing worksheets creates a similar effect.

Focusing on the development of positive emotional energies is important for identity development because emotional energies can be strong steady emotions, lasting over a period of time, not a short-term disruption of a situation. A general characteristic of emotional energies is that it “gives the ability to act with initiative and resolve, to set the

direction of social situations rather than to be dominated by others in the micro-details of interaction. It is an emotion that allows individuals to be self-directed when alone, following a smooth flow of thoughts, rather than a jerky or distracted inner conversation” (Collins 2004, p. 134). Emotional energies produced can mediate production of agency in an Explainer. In the last month, there have been a number of meetings that were canceled because of scheduling difficulties. However, the worksheet project has continued and Explainers have tested their questions on each other. I have downloaded articles of empirical studies of field trip worksheets, created annotations to share with the group and even shared our project with the authors of those articles<sup>4</sup>. Even if we are not able to meet, the positive emotional energies towards the worksheet project have mediated each of us to do our part to move the project forward. In a recent conversation, we discussed the final questions and layout for the worksheet in preparation for the prototype day. A general sentiment that filled the room was a feeling that anytime students have to fill out a worksheet, it makes the trip less fun and exciting. We were concerned about the downward turn in emotion that students could feel as soon as they are handed the worksheet. When I questioned why we were going through the effort of making a worksheet if it was doomed to deflate a student’s excitement about the trip and possibly science, the group commented that the whole goal of this project was to create an effective, but fun sheet. At this point, one Explainer chimed in, “Why do we call it a worksheet? Let’s call it Funsheet.” The entire group was silent for a second, looked at each other, and synchronously agreed with nodding heads, and loud pitched cries of

---

<sup>4</sup> For example, I contacted James Kisiel because we referred to his article on worksheets from 2007 in *Journal of Science Teacher Education* and shared our project with him.

“yeah,” and “right.” The excitement of the entire group rose to a new level and a collective effervescence resonated from the group. The worksheet project positions all of us in the role of thinking like a teacher, dealing with issues of differentiated instruction, constraints of schooling and opportunities for curriculum design. In this role, we identify with being a teacher and through the process, change and grow as educators.

### Developing Social Capital

Being employed as an Explainer, having the same responsibilities towards the motives of the collective, following the same rules, using similar tools and having a particular identity as an floor facilitator in the guise of a uniform contributes to feeling of group membership. The cogenerative dialogues in place where Explainers can discuss praxis offer another modality for experiencing group membership. Membership into a certain profession mediates increased social capital. The following excerpt from the CLUSTER project Ning site describes how one Explainer, Samantha, feels about the cogenerative dialogues and the worksheet project. Samantha writes,

Well, I love these meetings because they actually help us in many ways. I mean you don't notice or think about it at first but it does help us. I feel comfortable speaking in these meetings because it's people that I know and I know others probably have similar situations like I do. And the situations we all having involving teaching is something we could all share. I don't think we would talk about our teaching problems with other friends outside of school so we have the Cluster group to share our views and thoughts. Other comments and advice from others would help me see my situation differently or would help me figure out what to do or what my options are. Also, not only that it would help us with our own teaching skills but it also helps us become better Explainers. I hope the worksheet idea would come through because it was a great project for all of us and it would give us a better idea of how to write good worksheets in the future for our own class. Also, I have noticed that I was much more nervous when I started Cluster than now. I felt much more confident at what I'm doing and I now know how to approach people just randomly and start a conversation. (February 20, 2009 at 3:15pm)

Samantha's words illuminate how the individual|collective dialectic is at work in this research. She claims that the solidarity developed through the group not only helps her teaching skills (individual), but also helps her become a better Explainer (collective). She is excited about the worksheet project because she acknowledges it will be useful now and later when she her own classroom. This is an indicator for increased social capital.

### *The Red Apron*

The social capital gained through group membership as an Explainer surfaces in symbolic form as well. I use an autobiographical story to illustrate two points. First how the Explainer uniform, a red apron, serves as a symbol for me in relation to belonging to the Explainer group and two, how my experience reminds me of the nature of social capital that an Explainer develops in this role.

The red apron is a practical uniform because it is one-size-fits-all. It has pockets so that an Explainer can carry a notepad, a pen, the staff schedule and also, small items that can be used to support visitor inquiry, like a flip book that helps describe the ideas of persistence of vision, or a triangular bubble making wand to help visitors realize that that bubbles are always round even if the shape of the wand is not round. The apron carries with it more than just a practical role. It is a reminder of the role we play as informal educators and how visitors view us.

A year ago I decided to put on the red apron, something I have not done in about fifteen years. My goal was to assume the role of an Explainer and re-experience what it feels like to interact with visitors in an official role of floor staff. In my time at NYHS, I was an Explainer for five years and was promoted to the highest level that an Explainer

can earn signifying that I was versed with the exhibitry and demonstrations, highly qualified to interact with visitors and demonstrated leadership with supervision. Now, as an administrator, I interact with visitors as I go from one office to another, but by choice rather than job description. I am identified as staff because I wear a nametag and carry keys and if I see a visitor struggling or interested in an exhibit, I walk over and interact with her. In putting on the apron, my goal was to properly assume the role rather than take action on my way to a meeting.

With a red apron on, I walked towards the microbiology exhibits, one of my favorite areas and as I got closer, I finished tying the apron around my waist. All of a sudden, I felt a sense of panic. In thinking about why I felt this way, it wasn't that I was unsure of the science of the exhibits or how to facilitate the exhibits. Rather, it was a sense of responsibility. If a visitor were to approach me while I was wearing the apron, it was my job to help her and I would be accountable for providing her with as best an experience as I could offer. I knew that visitors viewed the Explainers as smart, knowledgeable people who knew all about the 450 exhibits. Even veteran teachers looked to the Explainers as exhibit experts. Being recognized as that kind of person was what panicked me when I first put on the apron. Two minutes into the facilitation, I felt right at home as I conducted myself as an explainer. The idea of *spielraum* becomes key because I felt that I could recall and use my ability to maneuver with different visitors. I only stayed in the explainer role wearing the red apron for about fifteen minutes. I interacted with three or four groups of children during that time. I returned to my office with a great sense of excitement and renewed energy about teaching and learning.

Being ascribed this role of an educator who has the capital to facilitate science experiences in a place like NYHS is empowering and exciting. Repeat experiences in such settings allow Explainers to feel a group membership within NYHS, not only with being an explainer, but also with the profession of teaching. Positive emotional energies linked with the activities we engage in as Explainers, we develop a sense of belonging and as such, these emotions have a cognitive component. People have “an expectation of being able to dominate particular kinds of situations, or to enact membership in particular groups”(Collins 2004, p. 119). The Explainers at NYHS develop cultural capital as teachers of science and supporting that development are interaction ritual chains that produce positive emotional energy. Increased cultural capital mediates the development of identity as an educator.

### Implications

Emotions are a key input of an interaction ritual, but are transient in nature. However, outcomes of such interaction rituals are long-term emotions such as feelings of attachment and solidarity with a group, a profession, an institution or even a broad endeavor such as teaching and learning (Collins 2004, p. 108). Bobby, an explainer, writes,

The topics we discuss are very interesting and it motivates me to become a teacher. Knowing from my experience, all the horrible teachers out there, it makes me want to be the one to set the example of what a teacher should be. But without actually teaching an actual classroom, I don't know how well I will do. I do feel the "emotional energy" to go out there and teach and it is great to have these meetings to help us lead towards teaching. Sooner or later we will hopefully still have these emotional energies and by that time we will know how to teach classes. (February 20, 2009 at 3:05pm)

In this quote, we read that Bobby experiences positive emotional energy towards interacting with visitors and talking about them during cogenerative dialogues, but is concerned about the outcomes over time. He hopes that he will be able to create and appropriate positive emotional energies by the time he makes it to the formal classroom. My argument is that understanding social life means to accept that there are just as many opportunities for the production of negative emotional energies as there are positive emotional energies. Yet, when people feel enough positive emotions towards certain activities, over time, they embrace those activities even though it is evident that not every experience may be a positive one. Structures of an ISI provide the opportunity for many interactions where Explainers can experience success. Through her study of an eighth grade urban classroom, Stacy Olitsky (2007) described how she set up structures and interaction ritual chains that led to a sustained interest in science beyond the duration of the interaction ritual. By inviting students into interaction ritual chains that promote mutual focus, familiar objects as symbols and opportunities for physical and emotional entrainment, she fostered student engagement with topics that they may not previously have held interest in and even supported each other in peer learning. Similarly, by being in the role of an explainer, experiencing a solidarity with other Explainers, especially those who are interested in science teaching, experiencing ritual chains filled with positive emotional energies and related experiences to teaching, an explainer can envision oneself as a teacher.

As Stetsenko (2008) reminds us, emotion and cognition, the personal and the conceptual, always exist together, and should not be separated just the same way that theory and practice cannot be separated. As Vice President for Education at the New

York Hall of Science, I am responsible for growing and advancing the Explainer program. Part of that responsibility is to consider ways of improving our training and support systems so that Explainers can aim for an increased number of successful interactions with visitors to meet the motives of the science center. I also lead and participate in international conversations with science leaders who are in similar roles grappling with similar issues. Stetsenko's ideas inspire me because I believe that the emotional aspects of being an Explainer are intricately linked with the cognitive aspects of being an Explainer and seeing oneself as an effective educator. Theorizing the role of emotions in informing praxis has implications for my own center and for science centers internationally because in each of these centers, interaction ritual chains are imbued with emotional energies that have great impact on meeting the motives of those centers, engaging people in purposeful transformative activity and simultaneously developing identities as learners, teachers and ultimately, being human.

## **Chapter 5: Museum-University Partnerships for Pre-service Science Education (Co-written with Jennifer Adams)**

In this chapter, we demonstrate the value of informal science institutions to serve as partners to university based teacher preparation program by describing programs in three international contexts. Our standpoint is shaped by our experiences as museum educators, teacher educators and education researchers. The first author (Preeti) developed an interest in science teaching particularly because of her experiences as a student working as floor staff at the New York Hall of Science. The second author (Jennifer) has had experience teaching in multiple contexts—high school classroom, in a museum setting, and in a teacher education program. We believe that learning to teach is a practical activity and is shaped by sociocultural, historical and political processes. Through our personal experiences and research, we've learned that active engagement and participation in low-stakes teaching activities within informal science institutions mediates the development of practices, understandings and local theory about teaching and learning. Both of us firmly believe that the patterns that emerged across the three program described in this chapter are important to understand because traditional university-based teacher preparation programs often lack the time and structure to support teachers in developing their epistemologies and ontologies towards teaching and learning especially to diverse learners. In some cases, traditional programs continue to divorce theory from practice. Partnerships with informal science institutions could strengthen teacher education programs and provide them with an invaluable resource where theories about teaching and learning could be merged with practice in a novel, resource-rich context.

Informal Science Institutions (ISIs) are spaces designed for learning about science and the natural world. Existing within the larger context of museums<sup>5</sup>, science centers, nature centers, natural history museums, zoos, aquaria, botanical garden, or arboreta, are free-choice settings with the overall goal of exciting, engaging and educating the public in science and technology. Although many ISIs include education as a central part of their mission statements, the potential role that ISIs could play in teacher education has yet to be fully realized. However there is growing evidence that suggests that university-ISI partnerships for teacher education could provide a rich context for pre-service teachers to learn about and practice teaching science.

Sally Middlebrooks (1999) learned that both the ISI and college faculty felt that such partnerships allowed pre-service teachers to practice teaching with demographically different audiences, observe different styles of teaching, and make connections with ISI staff as mentors both during their pre-service program and later, during their in-service experiences. Almost a decade later, David Anderson, Bethany Lawson and Jolie Mayer-Smith (2006) investigated how the epistemologies and pedagogies of teaching and learning of pre-service biology teachers enrolled at the University of British Columbia were influenced by a three-week practicum in an aquarium setting. Pre-service teachers had opportunities to lead workshops, facilitate interactions between the visitors and exhibits and develop aquarium-based curricula. They learned that in such practicum experiences, pre-service teachers understood that valuable teaching and learning can

---

<sup>5</sup> International Council of Museums definition of “museum”: a non-profit making, permanent institution in the service of society and its development, and open to the public which acquires, conserves, researches, communicates, and exhibits, for the purposes of study, education, and enjoyment, material evidence of people and their environment (1989)

happen outside of the classroom, appreciated the value of hands-on learning and learned to recognize and react to “teachable moments.” They also gained practical skills such as, teaching diverse learners, doing collaborative group work, and classroom management skills. These patterns in the data set the groundwork for University of British Columbia’s current project where they expand the number and type of institutions that pre-service teachers can select for their practicum experience.

Along with the program at the University of British Columbia, in this chapter we discuss patterns emerging across similar partnerships in two other international contexts. In these three projects, pre-service teachers work as staff in the ISI as a way to practice the art of teaching. We describe how this model is enacted in these international settings, unique to their own requirements and resources. Although the different partnerships present different approaches to the university-museum partnership and the roles of pre-service teachers as staff, certain similarities emerge in the findings for each of the projects that have implications for the prospective role of ISIs as partners to universities/colleges for teacher preparation. We begin by presenting an argument for the need for such partnerships and why ISIs are fertile contexts for pre-service science teacher education.

### The Need For ISI-University Partnerships

According to the National Association for the Council of Teacher Accreditation (NCATE) in the United States, a highly qualified teacher is one who has mastered and is able to demonstrate qualities of strong knowledge, skills, and dispositions. In fact, NCATE requires that when colleges and universities apply for accreditation, evidence of developing and measuring knowledge, skills and dispositions is present and especially

visible in their conceptual framework. However, in spite of these seemingly stringent requirements, many people are graduating from programs without having opportunities to develop their skills and dispositions in practice and especially in working with diverse students (Villegas and Lucas 2002). Linda Darling-Hammond, Karen Hammerness, Pamela Grossman, Frances Rust, and Lee Shulman (2005) argue that many teacher preparation programs are criticized for being “overly theoretical and lacking connections to practice” (p. 392). In most cases, it is assumed that clinical experiences involving fieldwork and student teaching allow teacher candidates to be exposed to students and develop their dispositions towards teaching. They also claim that, too often, clinical practice is divorced from theory because institutions aren’t able to create coherent links between the coursework and student teaching experiences. In other words, pre-service teachers do not have the opportunity to develop *spielraum*, or the ability to maneuver in multiple ways to engage diverse learners. Wolff Michael Roth, Daniel Lawless and Domenico Masciotra (2001) describe *spielraum* as developing practices that are anticipatory, timely, and appropriate to given teaching situations. Then, “...the teacher's readiness for action allows an unfolding of a realm of appropriate possibilities within the immediacy of the student-teacher transaction. Second, this realm of possibilities, in turn, allows the teacher a point of entry to unfold the reality of the students' understanding” (p. 186). Developing *spielraum* is developing fluency in science teaching; that is, where “discrete actions are coordinated and interwoven with practices to constitute a seamless whole as participants appropriate resources” (Tobin 2005, p. 28). In a carefully constructed university-museum partnership, teachers have opportunities to connect their clinical experiences to the theoretical foundations that they receive during coursework;

they can observe, practice and reflect on theory-in-action. Additionally, they learn how to informally assess learning, which could complement the formal measures of student data that are often stressed in formal teaching environments (both in their traditional coursework and in the formal classroom), all factors important in developing spielraum.

### Informal Science Institution Facilitators

Facilitators work in ISIs and create a scaffold between the visitors and exhibits. Paola Rodari and Maria Xanthoudaki (2005) state that by engaging various audiences (families and school groups) in conversations about the complex topics presented in exhibits, facilitators serve as human interfaces between the exhibit's intended purposes and the visitors' interests. Miha Kos (2005) claims they are the direct link between the visitor and the exhibits. Across science centers internationally, these facilitators (referred to by different titles at different sites) have varied levels of responsibility. Some of the tasks of museum facilitators include (but are not limited to) interacting with visitors in the exhibit galleries, conducting demonstrations, facilitating lab activities, working with object carts, leading workshops, and developing activities for school-group use.

In order to prepare floor facilitators for active engagement with diverse visitors, museums put significant amounts of time and effort into training. Current discussions on facilitator training have focused on the need to model diverse teaching approaches, shifting them from transmitters of information to guides who assist visitors with inquiry experiences. The DOTIK<sup>6</sup> (2007) study finds that facilitator training and mentoring is critical to the facilitator's science communication skills, comfort with public speaking

---

<sup>6</sup> DOTIK was a two-year funded project from the European commission aimed at developing and testing methodologies for training museum educators ([www.dotik.eu](http://www.dotik.eu))

and ability to engage with diverse audiences. These skills are a solid foundation for anyone who might consider teaching as a career. As former ISI educators, we are proof that experiences as staff in such settings can alter one's trajectory in life, develop dispositions towards teaching, and build a teaching identity. We argue that ISIs are potentially effective sites for teacher education as they allow aspiring teachers to practice teaching through actively engaging diverse audiences in science activities. With access to a variety of science rich experiences, ISIs are rich learning laboratories for future teachers.

#### Pre-service teacher Education In Museums: Practice and Potential

Kenneth Tobin and Wolff-Michael Roth (2006) theorize that learning to teach is a practical activity. In order to learn how to teach, one has to actively engage in the activity of teaching. Learning can happen across different contexts (Bruner 1996), thus the learning that happens in one context can influence learning and action that happens in another context. Relating this to learning to teach, knowledge, skills and dispositions learned and developed while teaching in a museum context can influence one's ability to teach in formal school contexts. In-service teachers who participated in 60 hours of museum-based professional development were able to introduce practices in their classroom that were more reflective of the museum's inquiry-based and object-based contexts (Adams 2007). Therefore for pre-service teachers, who are in the process of developing an emerging teaching practice, having actual teaching experiences in an ISI context could have the potential of developing skills and dispositions that are more reflective of a free-choice learning environment.

April Lynn Luehmann (2007) reminds us that one of the challenges that we face in pre-service teacher education is the lack of opportunities to be successful at teaching in low-stakes environments. ISIs are low-stakes education environments in that they lack formal assessments of learning and visitors often come for a novel (fun, entertaining) experience. This context presents an increased likelihood of successful teaching interactions with visitors for ISI facilitators. When ISI facilitators feel successful at interactions with visitors, they try it again and again, each time learning how to adjust their interactions to meet the needs of changing visitors and therefore developing *spielraum*.

In the following sections, we provide an overview of the three partnerships, including the central museum teaching activities, description of the patterns emerging from teaching in an ISI setting, allowing us to make assertions about the role of museum-based practice in pre-service teacher education. Each of the partnerships continues to exist and engage in ongoing data collection, including interviews, surveys, focus groups, regular journals or logs and observations. Our analysis is based on research data and evaluation reports from each of the partnerships. Stakeholders in all three partnerships have reviewed the descriptions and claims presented here to ensure their accuracy.

#### *Collaboration for Leadership in Urban Science Teaching Evaluation and Research*

The Collaboration for Leadership in Urban Science Teaching Evaluation and Research (hereafter referred to as the New York program) is an NSF-funded research project awarded to the New York Hall of Science (NYHS) in collaboration with the City College of New York, a four-year college that is part of the City University of New York and the Center for Advanced Study in Education at the Graduate Center at the City University of

New York. In this project, undergraduate students who are enrolled in the required courses for secondary science education at City College work as Explainers at the New York Hall of Science for at least seven hours, weekly, through their third and fourth years of undergraduate work. All Explainers are required to participate in explainer training and work tasks, however, the New York program Explainers are also pre-service teachers, and thus they have the further opportunity to take their museum experiences and reflect on them during their education coursework. As Explainers they learn how to engage visitors of all ages through a variety of interactive exhibits and public demonstrations. They can also assist with after-school programs, field visit workshops and school outreaches. Undergraduate students who apply to the New York program are pursuing a major in one of the sciences: biology, chemistry, physics or earth science and are selected in their third year of study. Because recruitment is conducted through all local New York City colleges, the resulting New York program corps is diverse in socio-economic status, ethnicity and religion, as is true for the rest of the Explainers.

Two mechanisms were developed to enhance the integration between the explainer experience and the formal university coursework. First, project staff co-teach some of the mandated courses with college faculty. That role includes customizing the syllabus so that assignments and discussions can take advantage of the explainer role. In addition, faculty from the college familiarize themselves with both the resources of the science center—the unique environment that exists for teaching and learning—and the New York program’s goals. The museum staff learns about the state approved elements of each course syllabus, and become familiar with state and national standards necessary for secondary science teaching.

Second, a conceptual/pedagogical frame of reference that is applicable to instruction in science education is necessary to assist the pre-service teachers in developing knowledge, skills and dispositions as praxis. The New York program designed a framework to foster a common language about instruction in both the formal college setting and the multiple settings at NYHS. The framework consists of five components that were identified by the project team as being central to instruction and are functional in guiding science education activities in real time. The five components of the framework are: Identifying the Big Idea; Engaging the Learner; Making Student Thinking Visible; Introducing New Science Ideas; and Reflection/Assessment. The framework has been used to inform the various course syllabi and to organize elements of exhibit and demonstration training at the museum.

*The Extended Practicum Beyond the Classroom Option Program*

Extended Practicum Beyond the Classroom Option (hereafter referred to as the Vancouver program) is based on a successful pilot study discussed earlier where pre-service teachers from the University of British Columbia's Teacher Education Program had semester long practicum experiences in the Vancouver Aquarium Marine Science Centre (Anderson, Lawson, and Mayer-Smith 2006). After the pilot, the Vancouver program expanded to include two additional institutions during the 2005-2006 academic year, Science World at the Telus World of Science and Vancouver Art Gallery. Pre-service teachers completed a ten-week classroom-based placement followed by a three-week practicum at one of the aforementioned sites. In this chapter, we focus on data from the two ISIs in the expanded project. All pre-service teachers were in the secondary education program at the University of British Columbia and had majors in biology,

chemistry, physics and art. All pre-service teachers attended orientation at their assigned institutions before their classroom placement began. These sessions allowed them to have an orientation to the facility, become familiar with the educational offerings and meet the staff.

The key objectives for pre-service teachers to participate in the extended practicum through the University of British Columbia was to 1) learn to listen and respond to the K-12 audience in the informal context/milieu, 2) build on their teaching skills in thoughtful interaction in this same context, and 3) apply their developing pedagogical experience and practice helping students connect with the curriculum offered by the relevant informal context/milieu.

At the Vancouver aquarium, pre-service teachers observed activities in the institution's galleries, delivered classroom workshops to K-12 students on field trip visits, and developed new material for K-12 audiences. The three-week practicum began with the pre-service teachers shadowing the institution's staff, then team-teaching with the institution's staff, and then teaching in the programs and exhibits on their own. At Science World, pre-service teachers followed a similar protocol but focused more on exhibit-based teaching and associated programs suitable for facilitating learning in the museum's galleries.

### *Bloomfield Science Museum Jerusalem*

Bloomfield Science Museum Jerusalem (hereafter referred to as the Jerusalem program) has been in partnership with Jerusalem Teachers College for Girls for the past 13 years in a program where undergraduate students that are pre-service teachers from the College

work as Explainers in the science museum once a week for a semester as a required part of their practicum experience. As other Explainers in this museum, they teach workshops, conduct demonstrations and give guided tours for visiting K-8 school groups on their field trip to the museum. Each student leads workshops with up to two classes a day. Before that, the students attend sixty hours of training over an intensive summer course for Explainers, to learn and experience the museum programs, exhibitions and hands on activities as well as to observe museum staff in action. The participants in the program are undergraduate women majoring in science and education and most of them are enrolled to become science teachers in elementary and middle schools. During the semester they are observed and get feedback from the college and the museum staff. Their program at the museum focuses on supporting teaching skills, the informal pedagogical methods that can be adapted for the classroom, and on the potential connections between teaching in traditional class and using non school settings as resources.

### Emerging Evidence

Taken through a Bourdieusian lens, ISIs can be considered as a field or site where culture is produced|reproduced and transformed being experienced as patterns having thin coherence and associated contradictions (Sewell, 1999). These fields are structured around specific schema and resources that different people (staff, teachers and visitors, for example) use to meet their goals. Although the physical setting—building exhibits and objects—usually characterize the structure of an ISI, there are relevant invisible structures, like the founding mission and ideology of an ISI that mediate activity in that

field. For example, since schema can include ideas, beliefs, values and conceptions about how to conduct activity in social life, the ideology of an ISI—whether an interactive science center or a natural history museum—will shape and enable the activity that happens in the museum field. The resources include physical objects, human beings, and symbolic entities such as space and time. William Sewell (1992) theorizes that schema and practices are dialectically related to each other. As a pre-service teacher works within the schemas in ISI settings, she develops *spielraum* and expands the array of practices she can use to teach science. Due to the dialectical relationship of schema to practices, she has the potential to mediate the schema in different fields. That is, she has gained agency—the ability to appropriate schema and resources to change the structures in other fields (i.e., such as a formal classroom).

Although the three museum-university collaborations we discuss in this chapter are different in implementation, they were all transformative in that they enabled pre-service teachers to develop *spielraum* characteristic of teaching in a museum setting, yet beneficial to their future roles as classroom teachers. Four common themes emerged across the three contexts: Pre-service teachers are able to apply and practice different pedagogical techniques on the same topic and refine their teaching practices; teach a select group of topics to diverse learners; experience different teaching styles; and have greater opportunities for self-reflection and adapt their ideas on what it means to teach science. Each of these themes and related challenges is discussed and then illustrated with examples from one or more of the partnerships.

*Same Topic, Different Audiences*

Overwhelmingly, pre-service teachers mentioned that working in an ISI helped them to practice and refine their teaching, especially in using constructivist pedagogy, as this is the guiding philosophy of many ISI program designs and enactments. Pre-service teachers in the Vancouver and in the Jerusalem programs stated that opportunities to repeat the same lesson with different audiences were useful because they were able to feel confident while enacting the lesson as written, but also being able to modify it according to the needs of participants from different grades.

Pre-service teachers reported that teaching the same concepts to different audiences revealed the complexity and difficulties in teaching those concepts and the opportunity to repeat and attempt different strategies for teaching strengthened their ability to teach effectively. One teacher from the Jerusalem program states, "*...to repeat explaining the same subject to different groups in different interactions... enables you to reach different needs of students and levels... in different ways... and to improve your way of teaching and understanding....*" Pre-service teachers felt that this opportunity could only exist in the museum, and not in traditional classroom practicum experiences. Pre-service teachers can review videotapes of the classes they taught in the museum on their own and then review vignettes with the college faculty. They can track their own changes and growth over time.

In the New York program, pre-service teachers work for many months and have chances to work at the same exhibits day after day. Over four semesters of weekly logs completed by the pre-service teachers, there was evidence of a shift from activity-based responses such as "*I explained exhibits on the museum floor,*" and "*I performed a*

*chemistry and laser demonstration*” to responses that reflected a more inquiry-based approach to teaching such as *“I am helping kids understand exhibits by letting them perform the activities instead of me showing it to them.”* Pre-service teachers are encouraged to audiotape their interactions at the exhibits. They record interactions at one particular physical science exhibit upon entry into the program and consistently thereafter. In listening to tapings at the same exhibit six months later, there are several changes from initial taping to the second taping. The most noticeable change is a marked decrease in didactic teaching or simple explaining at the exhibits. In the later tape, there is also more of an attempt to draw the child in (create engagement) and provide positive reinforcement for visitors’ verbalizations with statements like, *“Yes, I agree”* or *“Did I understand you correctly?”* Another change evident between the two tapings is how the pre-service teacher gears the interaction towards certain Big Ideas so that the visitor could “take away” at least one primary concept about the content of the exhibit.

Patterns emerging from all three projects support the potential utility of pre-service teachers assuming the role of museum staff to practice aspects of inquiry-based, constructivist science teaching and allowing aspiring teachers to practice teaching the same concepts multiple times to different people. Since each visitor is different and brings her own schema and practices to the interaction, the pre-service teacher has to approach each experience as a new activity. While the topic and content may be the same, the interaction is structured by both the pre-service teacher and the visitor, thus leading to a different enactment. As such, each act offers a fresh opportunity to develop teaching skills, anticipate and respond to comments and questions, and immediately assess learning and engagement while interacting with visitors. These are necessary skills

for any effective science teacher, but the structures of an ISI allow a *pre-service* teacher to develop such skills.

These same structures can also be limiting in certain ways. Pre-service teachers sometimes felt that the practicum needed more diverse tasks. While being able to teach the same topic over and over to different audiences was useful for developing practice, they sometimes felt bored and wanted to try something different. In the Jerusalem program, the pre-service teachers had a variety of topics to teach, however the program style was the same for each session—a workshop, a demonstration and a guided tour. To address this challenge of providing a diverse set of job responsibilities in the New York program, pre-service teachers were invited to participate in a broader range of work, time permitting. These work/training experiences can be ordered along a continuum that ranged from informal science education activities on the museum floor to science education activities in classrooms such as leading discovery labs, assisting with after-school programs and outreaches to school. Not all pre-service teachers in the New York program take part in all types of work experiences, but all are required to at least engage in floor interactions with visitors. For those who are able to devote more time, the continuum of work experiences affords them the benefit of a deeper, more varied experience.

### *Work with Diverse Learners*

Ana Maria Villegas and Tamara Lucas (2000) advocate for a coherent approach to culturally responsive teaching by redesigning teacher preparation curricula and providing pre-service teachers with opportunities to rethink their own selves in the context of their students. They state

A crucial task of teacher educators in preparing prospective teachers to be responsive to a changing student population is to help them locate themselves along this dysconscious-to-conscious continuum and then to support their movement toward greater consciousness (p. 32).

In response to this statement, we again consider the structures that exist in an ISI. The physical context of the ISI is designed to foster social interactions (Falk and Dierking 2000) between people and between people and exhibits. It is often the role of ISI staff to facilitate interactions between the visitors and the exhibits—many times the ISI staff interacts with multiple visitors at once. ISIs, like the ones described in this chapter, attract economically and ethnically diverse visitors. Thus, pre-service teachers in the role of ISI staff have the opportunity to learn how to interact with and teach a diverse population (where the diversity can even change from moment to moment!). Teachers can observe how culture plays a role in level of engagement. They can think about and practice various ways to work with students who may have various disabilities. They can also develop pedagogical approaches that allow them to successfully interact with students who may speak a different language than that of the host country. In the ISI setting, the pre-service teacher can become more aware of herself as a culturally situated being vis-à-vis the cultural situatedness of her future students. The museum setting has been described as a place for doing “identity work” (Rounds 2006)—a place where one comes to confirm existing identities or expand their identities to include the new resources that they encounter (Adams 2007). Learning also expresses identity, so in learning to teach in a museum setting, a pre-service teacher is developing and expressing an identity at once and this identity includes what she learns in her interactions with visitors. In these interactions, a pre-service teacher can become more aware of how her schema and practices (culture) afford her interactions with diverse people and vice versa. She can

bring this learning, this expanded agency into her classroom practice as she continues her learning to teach diverse students.

When pre-service teachers work as museum staff, they have opportunities to practice teaching a concept, gauge their success, re-evaluate their approach, and immediately engage another visitor. Over time, they become unafraid to approach a new visitor or groups of visitors and venture into science conversations that don't have a predetermined teaching or learning goals. Each experience allows them to build on prior successful interactions and increases their potential of being successful teachers. Each success creates an increased level of confidence and strengthens within them the notion that all people can learn given the right strategies and approaches. For both of us, this ability to practice teaching concepts to diverse audiences strengthened our skills as science educators and our personal experience becomes the reason why we have chosen to focus on this idea across the partnerships.

In all three contexts, pre-service teachers' experiences consistently support the idea that informal learning organizations offer a unique environment for practicing the act of teaching with a variety of audiences who differ in age, race, socioeconomic status and learning abilities. Pre-service teachers in the program credit the exposure they received to working with heterogeneous audiences as important to their development as a teacher. In the Vancouver program, pre-service teachers also valued the opportunity to work with students of all grades even though they were training for secondary school stated,

[I] started out with this great broad view of education as anything that could happen with students and learning. Then through my [classroom] practicum I had teachers go "Oh no, no you can't do that in the classroom... they aren't mature enough for that." I really kind of felt that the ways I could teach were starting to get more and more limited. And then I got to the aquarium and it was great to feel like, OK yeah, I can try all these different ways of teaching again and I can really

experiment with what ways are going to be the best ways for these kids to learn. All these things that I would have liked to have done on my [classroom] practicum with my grade elevens, some of them I was able to try doing in the wet lab [at the aquarium] and worked out really well. – Andrea (Anderson, et al. 2006, p. 349)

This quote demonstrates this pre-service teacher's excitement at being able to try different strategies with learners in different grades. Pre-service teachers increased their confidence to teach all different kinds of students, and strengthened their pedagogical skills. The experience helped them expand or confirm the grade levels they were interested to teach. They directly attributed their ability to quickly establish pedagogical relationships with visiting groups of students to their extended practicum experience. They increased their ability to gauge the audience, draw out their prior knowledge and engage them with the new ideas in a short amount of time. These teachers felt that they would not have developed those skills in only a traditional classroom-based practicum.

We believe that for a museum practicum to be effective, pre-service teachers need to participate in a variety of pedagogical experiences over an extended period of time. Each of the three partnerships described engage pre-service teachers for different time intervals. In the Vancouver program, pre-service teachers spend two to three weeks in intensive experiences. At the Jerusalem program, they spend one day a week for one semester after a ten-day intensive summer orientation course. In the New York program, they spend one or two days a week for approximately two years. We have learned that over time, pre-service teachers are moving beyond their comfort zones in their attempts to engage children with the big ideas behind the exhibits and to help them construct their own understandings about the exhibit. However, we need to document how much

practicum time—on the museum floor with visitors—is sufficient to allow teachers to develop spielraum in this setting with diverse audiences.

### *Learning Alongside Many Museum Staff*

In ISI settings, the full-time museum staff have different approaches to teaching the same content and/or corresponding exhibit. Each person develops a particular repertoire over time that is personalized to her teaching style. In all three settings, the pre-service teachers worked with experienced museum staff that effectively modeled science teaching and learning in the museum setting. The pre-service teachers were able to observe different staff members teaching the same content and base their own practice on what they observed. Since pre-service teachers had opportunities to teach the same content to different visitors, they could attempt different strategies. They were able to learn and practice at once. Seeing different styles and different approaches to working with students exposed pre-service teachers to constructivist pedagogies that they learned about in coursework. In particular, the Vancouver program pre-service teachers state that they expanded their understanding of pedagogy. They also valued opportunities to collaborate with each other and the museum staff and articulated that such opportunities contributed to their sense of worth as an education professional. Once the participants become teachers, the Jerusalem program has learned that some of them continued to visit and even consult with the museum staff on their fieldtrip plans. The teachers have also mentioned that they implemented some of the museum's skills and methods in their teaching career.

However, there were issues with role clarification that emerged across settings. Part of the challenge in such partnerships is to articulate the role of the pre-service teacher—

whether they become staff in already existing roles or retain a separate identity. In each of the three sites we discuss in this chapter, the pre-service teacher had a slightly different role. What the role was and how it fit into the organizational structure of the museum was important for success. For example, pre-service teachers who worked at the Vancouver aquarium felt that they needed more clarification about the difference between the roles and tasks of the permanent museum floor staff and themselves. In both the New York and Jerusalem program, pre-service teachers join the existing staffing structure and are responsible for all tasks that fall under the Explainer role, including group orientation and departure. Often, these tasks detract from their time to practice teaching. When the museum tried to exempt these Explainers from some of the non-pedagogical tasks, there was resentment from other Explainers. Still, there is value to integrating pre-service teachers within the organizational structure because it is much more immersive into the museum culture, which includes social interactions and networking with people from different backgrounds, interests, and majors and it is least disruptive to the museum's own systems. Yet, a separate and special program for pre-service teachers allows the faculty to focus on specific skills and experiences and everyone is clear on their roles for that specific time period.

The need for focused orientation related to the goals of the pre-service programs also arose. In the Vancouver program, the pre-service teachers felt that the museum orientation could have included more observations in the museum, integrated more of the expert staff to model lessons and less of training on logistical issues (i.e., bathroom locations). The New York program experienced a similar challenge where while pre-service teachers did receive the traditional orientation that all Explainers received, it was

focused more on the logistics of working as an Explainer rather than on pedagogy. To address this challenge, a special half-day orientation was added specifically for those Explainers who were part of the New York program. This orientation focused on using the project framework for teaching where experienced staff modeled the use of the framework at exhibits, and pre-service teachers learned about and discussed the different ways they can take advantage of the museum practicum experience. The Jerusalem program also developed a focused orientation just for pre-service teachers beyond the mainstream Explainer training for similar reasons.

### *Opportunities for Self-Reflection*

Julie Monet and Eugenia Etkina (2008) demonstrate that being able to conceptualize how one learns and how to identify strategies through which one learns are key components of one's professional development experiences. The environment of museum practicum program coupled with some form of journaling, online logs or blogs have the potential to elicit such self-reflection. Additionally, exposure to diverse teaching styles, different topics and heterogeneous visitors triggered prompts for self-reflection possibly not available through traditional practicum methods. Working in an extended practicum at an informal institution allowed the Vancouver program teachers to reflect upon their own personal pedagogy. They were able to compare the formal and informal teaching and learning environments and become aware of their own preferences for how they approached teaching and what they liked about formal teaching. These teachers felt that the classroom practicum didn't allow much time for self-reflection and when there was time, it was more advisor-driven while the reflection in the extended museum practicum was more self-driven.

In the Jerusalem program videotapes were used to facilitate self-reflection. Pre-service teachers selected vignettes to show colleagues, professors and museum staff. They used a rubric designed by the museum and college staff to assess and discuss elements of student-centered teaching in their practice.

In the New York program, some pre-service teachers realized when their own teaching needed modification along with the notion that they would have opportunities to practice their modifications at the Hall. For example:

Because of assignments due from the methods course, I have been analyzing almost every lesson I am involved in at the Hall of Science, comparing it to the cluster framework. This has allowed me to streamline my presentations, trying to keep in mind at least one big idea, or question that could bring out a student's thinking as well as be a usable form of assessment. (Center for Advanced Studies in Education 2007, p. 36)

The weekly logs from the pre-service teachers in the New York program suggest that they are not only acquiring concepts central to framework, but are also undergoing a shift in thinking about what it means to teach science:

[observation of another Explainer] The Explainer that was working at the bio lab today, was using formative assessment by asking the kids what were they noticing when doing the experiments. These types of questions are important because the instructor or Explainer would know if kids are learning or not. (Center for Advanced Studies in Education 2007, p. 35)

Evident from this statement from a pre-service teacher, developing the schema and practices to be able to self-reflect in low-stakes settings allows teachers to have agency in guiding their own learning progressions. They begin to recognize when their teaching style needs adjustment (based on feedback and reactions from learners) and are able to be agentic in doing what they need to do to adjust their practice. In the ISI setting, for example, they could observe another colleague teaching a similar lesson to learn a different approach/technique. They also have the opportunity to reflect on how they

themselves learn by trying out different interactive exhibits and transfer their learning about their own learning into practice with visitors. Thus, in the ISI setting pre-service teachers gain the tools to be agentic in their own professional development and growth as teachers.

### Next Steps

In this chapter, we describe the emergence of key ideas that are shared across the programs, in three different contexts, where a partnership with a teacher preparation program and an ISI supports a pre-service teacher's ability to practice teaching content to diverse audiences, have opportunities to observe and interact with staff engaged in student-centered teaching practices, and have opportunities for reflection and building awareness of one's own self as a teacher. The program continues to exist in all three sites and project teams are gathering data to document the longitudinal growth and development in pre-service teachers who have participated in museum-based practicum experiences. In all three programs, pre-service teachers are being tracked so that we can learn how their ISI experience impacts their actual classroom teaching. The following anecdotal vignette demonstrates what we expect to learn.

Researchers from the Jerusalem program interviewed a mentor teacher in a placement school. She described an instance where a principal was short-staffed and needed two different classes to be covered. Two pre-service teachers from the Jerusalem program were present and volunteered to conduct the classes. Each teacher managed to conduct effective lessons without time for preparation and planning. When questioned as to why they felt so comfortable volunteering to conduct the classes, they reported that it was

similar to conducting classes at the Bloomfield Science Museum Jerusalem. Although they did not have time for preparation, they had enough experiences to engage children in learning experiences for a two-hour class. The mentor teacher was surprised that student teachers could have such comfort and confidence in volunteering to teach a class. In an interview two years after this event, one of the pre-service teachers commented, *“Ahh, it was in the beginning of our practicum in that school... there was a need to help and to enter another class with no teacher. So we did it. It was not such a big deal. It was like having one more group of children in the museum. Actually we both behaved as if we were in the museum. We even told them about an activity we loved to do there, and we hooked the children and even could connect it to the class syllabus.”* They did not remember the occasion as a remarkable event because they were able to readily transfer the *spielraum* that they gained in the museum to the classroom. In all three sites, we are working to draw out the long-term impact and strengths that a museum practicum can offer as visible from the experiences of this pre-service teacher.

Although we are learning that ISIs are unique laboratories for learning how to teach, we have also realized that partnerships between museums and universities have to tackle certain challenges, such as institutional cultural differences between the ISI and the college setting. The approach to teacher education can be different from both the university and ISI perspectives, and require time and negotiation to foster the relationship. Gaining familiarity with each other’s contexts is crucial to appreciating what each partner brings as a resource for the partnership. To that end, we expect to continue our research in this area and hope that as we learn more about university-ISI partnerships

for science education, similar projects will emerge around the world thus adding to the body of knowledge around different mechanisms for preparing effective science teachers.

## Chapter 6: Looking Back and Looking Forward

This study is embedded within a larger research project funded by the National Science Foundation called Collaboration for Leadership in Urban Science Teaching Evaluation and Research (CLUSTER). In CLUSTER, pre-service teachers take education courses at a local college while working as Explainers, floor staff who interact with visitors at the New York Hall of Science, a hands-on science center. Explainers engage visitors in a dialogue about science using exhibits as resources and have opportunities to create learning experiences with diverse audiences multiple times in a day. These experiences mediate their identity development as educators. A subset of CLUSTER pre-service teachers are the participants|co-researchers in my study. I have structured this study so that the participants assume the role of co-researcher so that we all theorize our practices with the intent to inform our practice of teaching and learning.

I launched into this research to describe, document and argue that opportunities to practice teaching in low-stakes settings such as informal science institutions mediates a pre-service teacher's identity as an educator. I have used a hermeneutic phenomenological approach to data collection, analysis and writing by weaving theory, autobiographical and auto/ethnographical accounts and key moments of cultural production|reproduction and transformation to theorize the developing identity of as educators as we practice (or enact) science teaching and learning in an informal setting. I embrace critical ethnography as an approach to research because it “goes beyond interpretive and naturalist research and is ultimately concerned with the structural transformation of society and the emancipation of individuals through the revealing of dominant social ideology” (Elmesky and Tobin, 2005, p. 810). In my research, the goal

is to have all of us co-researchers examine our practices, become aware of what we are unaware of so that we can reveal and shift our epistemologies and ontologies about teaching and learning.

Applying a bricolage of theoretical frameworks, I illuminate the different stories, meanings and knowledge that emerge through interactions in social life. Each story allows us as co-researchers to be reflexive with our praxis. In particular, I employ cogenerative dialogues, cultural historical activity theory and interaction ritual chains because with each, I am able to describe my standpoint which is that identity development occurs in purposeful and social activity, is fluid and dynamic and is structured by Others. The dialectical relationships that describe social life such as Individual|Collective and Self|Other are central to this research project as evidenced throughout the chapters. The Bourdieusian construct of fields (sites of cultural production with porous boundaries) extended with the Sewellian idea of the dialectical nature of structures and agency serve as the foundation for my research. I also subscribe to the idea that where there is agency, there is passivity (Roth 2005). Cultural enactment is documented in two fields in this research. The first field is the exhibit floor where an Explainer interacts with visitors and the second field is a cogenerative dialogue where an Explainer interacts with her peers. Those involved in the research bring the schemas, practices and resources from one field to another and back enriching both fields, improving our praxis, and developing our understandings of teaching and learning. In this chapter, I zoom out and discuss the implications of this research in the field of informal science education as well as science teacher preparation.

## Synthesis of Chapters

In chapter 1 I discuss how my experiences working in an informal science institution such as a science center inspired and shaped my interests as an educator and as a researcher. I discuss the definition and nature of informal science institutions and how they can serve as learning laboratories for pre-service teachers to practice and develop their understandings of teaching and learning. I describe how the New York Hall of Science Explorer program offers pre-service teachers opportunities for prolonged engagement with diverse learners, which is a real need for those who want to become teachers. I discuss the bricolage of frameworks I plan to apply to illuminate social life. I also discuss ethical considerations and limitations of my research.

In chapter 2, I describe how cogenerative dialogues are used in an ISI setting and become a place for us to develop local theory. I demonstrate how such dialogues evolve over time and the structures they afford for each of us to share strategies, question our assumptions about teaching and learning and become catalytic with our new understandings. Joe Kincheloe wrote, “teacher empowerment does not occur because we wish it to. Instead, it takes place when teachers develop the knowledge, work skills and pedagogical abilities befitting the calling of teaching” (2003, p. 19). Cogenerative dialogues become a way for pre-service teachers to see themselves as teacher researchers and to learn about Self and Others and apply that knowledge to praxis. As this practice|research becomes a part of the everyday activity for the Explainers, they identify with and see themselves as knowledge producers and develop the schema and practices as such people as well. I also tackle the issues of power and positionality by using my own vignette to reveal the frustrations of teaching and use this narrative to demonstrate

that I am not an expert even though I have twenty years of experience as an educator at the science center. I describe how cogenerative dialogues allow me to meet the authenticity criteria I employ as quality indicators for this study and I review the implications that my methodology and method can have for cultural enactment in ISI settings as well as in use for pre-service teacher preparation.

In chapter 3, I use cultural historical activity theory to describe one Explainer, Rhonda's, shift in identity as an educator. Consistent with the individual|collective dialectic, Rhonda's shift mediates the shifts we all experience. This chapter is important to demonstrate how an ISI setting serves as a productive learning laboratory for pre-service teachers. An Explainer is positioned as an educator for the ISI and is part of an activity system with a particular endeavor. In this case, the endeavor is teaching and learning in a museum setting and an Explainer's job is to engage visitors in a conversation about science. With a very specific role, over time an Explainer appropriates cultural tools to accomplish her goals. Those cultural tools are mediated by an Explainer's experiences and active participation in teaching and learning activities. The structures of the activity afford her agency to appropriate those tools and in turn her agency mediates the shifting of the structures in the activity system. For example, Rhonda describes how she conducted a demonstration in ways that led her to make assumptions about the prior knowledge the visitor might have about the topic. Reflexively, Rhonda discovers that she is making such assumptions and her use of language reflects those assumptions. She decides to use language differently so that through her activity, she has a higher chance of achieving her goal and aligning with the goals of the visitors. Her agency to improve her interactions by appropriating cultural

tools in different ways, mediate structural shifts in the activity system. Epistemological and ontological shifts such as this indicate identity development in Rhonda and dialectically, then, in all of us.

In chapter 4, interaction ritual theory guides me to theorize how emotions serve as inputs and outcomes of face-to-face interactions and over time, the production of positive emotional energies, mutual focus, synchrony and entrainment, which lead to group identity as an educator and solidarity with educators. Group identity supports an Explainer's growth as an educator. I begin by describing how the structures of an informal science institution require an Explainer to have repeat interactions with visitors. Having unique interactions with different visitors at the same exhibits mediates an Explainer's ability to plan for actions that are more likely to produce more successful interactions. An Explainer has agency to select cultural tools and enact an experience with the intent of teaching and learning science. Since agency is dialectically related to passivity (Roth 2007), I also describe how the structures mediate the passivity that an Explainer must contend with, accept and become receptive to during interactions. Successive face-to-face interactions over time lead to positive emotional energies towards the act of teaching and learning. Enacting the role of an educator over time mediates the potential for an Explainer to envision herself as an educator. Second, sharing experiences with each other during cogenerative dialogues leads to solidarity as a floor educator and with each other. The solidarity mediates the development of catalytic projects creating increased positive energies and more solidarity. Social capital gained through face to face interactions at a science center and in belonging to a group of fellow Explainers mediates identity development as an educator.

In chapter 5, I co-write with Jennifer Adams and we review museum-university partnerships in three countries where pre-service teachers are working as staff in ISIs. We document the patterns and contradictions that arise across the three sites and explore the implications for these types of partnerships internationally. Key patterns that emerge are the benefits that pre-service teachers report that they are able to apply and practice different pedagogical techniques on the same topic and refine their approach, teach a select group of topics to diverse learners, experience different teaching styles working at the elbow of ISI teaching staff, and have opportunities for reflection. When an Explainer has an opportunity to interact with different visitors, appropriate language, tools, schemas and other cultural tools over and over, she develops the ability to maneuver, or *Speilraum* (Roth, Lawless and Masciotra 2001). She learns how to act in anticipatory ways, timely and appropriate to different teaching situations. For each pattern, there are contradictions, including that often pre-service teachers who are working in these ISI settings feel the need for a more diversified set of tasks, and need more than a few weeks to feel immersed in the experience. In all three sites, this type of a program is an innovative approach to working with universities and therefore, challenges exist in how to position pre-service teachers and their roles within the existing structures of the staff.

#### Claims Emerging From The Research

As a person with a science background, I entered this study with the intent to look for patterns and make claims to serve as evidence for assertions I would make. I expected to look for thick coherence in the patterns and explain away the contradictions as anomalies, rather than accepting them as realities, dialectically existing with patterns in social life. I

fully expected to research the Other and then write papers about the Other from my beautiful corner office, with the big windows and the large, fancy desk. The past four years of doctoral work have led me to rethink how I approach research and how I situate myself in this activity.

### *Use of Cogenerative Dialogues*

Situating myself as a co-researcher at the elbow of student researchers has been a key feature in this research. I have shifted my thinking from an apprenticeship model where there are experts and novices to a community of learning model where each of us brings our own expertise, values each other's knowledge and works together towards a shared goal. This is the approach that I embrace for new projects that I envision. I have discovered that I am much more interested in research that informs practice, even if it is just for a few of us at a time. Developing local theory and using it to inform praxis has emerged as another salient outcome of this research. Using cogenerative dialogues as sites for cultural production|reproduction and transformation, each of us continues to develop our local theories informed by our own understandings and the understandings of Others. We apply our theory to our practice and we refine our theories. We approach this endeavor as a collective, while maintaining our goals as individuals to tweak our own practice.

This is a major contribution to the field of informal science education where practitioners often feel removed and alienated from research and research outcomes. I have demonstrated through this research that researching our own practices, developing theory and transforming practices is feasible and mediates our identities as educators.

David Tyack and Larry Cuban (1995) write, “Tinkering is one way of preserving what is valuable and reworking what is not” (p. 5). What they mean is that to get to the macro level of change, to make grand sweeping reforms, sometimes tinkering at the local scale is what works.

### *Purposeful Activity as an Explainer*

Through this research, I have shown that working as an Explainer in a science center affords us the opportunity to engage with diverse visitors and teach a variety of concepts. While each interaction is short-lived because of the nature of exhibit interactions, cultured is produced, reproduced and transformed. These interactions make us re-think and re-envision ourselves as educators, each time improving our skills and learning more about our epistemologies and ontologies of teaching and learning. We have grown in key ways discussing issues such as making assumptions in our learners and differentiating instruction. We have shared strategies, and learned new techniques. We have created a worksheet that we think will be useful to teachers and will continue to serve as a tool for us to develop our skills as educators. All of these examples demonstrate how working as an Explainer mediates our development as an educator.

### *Contributing to Theory*

As a theoretician|practitioner, I have evolved to understand that theory is useful insofar as it helps us to make sense of what is going on. Dialectically, what goes on also informs theory. Through participation in this research, I have developed an interest in advancing theoretical conversations among us scholars|practitioners in the field of science education

in a particular strand of thought; how the nature of a participant|co-researcher mediates the emotional energies produced during cogenerative dialogues.

In the cogenerative dialogues that have taken place over the last eight months, an interesting pattern I have noticed is that certain co-researchers who are more outspoken and tend to “think out loud” mediate the dynamics of a meeting and more often than others, offer thought objects that trigger conversation, thereby mediating the structures of cogenerative dialogue for increased opportunities for teaching and learning. An example of a thought object from a recent meeting is the emergent topic of engaging with a visitor who knows more than the Explainer at an exhibit. This is conversation that did not directly emerge from listening to an audiotaping, but was a “think out loud” moment for one co-researcher. James Paul Gee (2001) provides us with a set of perspectives on what it means to be a certain kind of person. One of those perspectives is what he calls a discursive perspective, or D-identity, which is recognized as an ascribed or achieved attribute one has such as being charismatic or funny. In this case, I am ascribing those co-researchers who “think out loud” as being more outspoken. They may not ascribe themselves that identity, but as the writer of this chapter, I feel that such co-researchers support the cogenerative dialogues in healthy ways by mediating conversation. In this research, for example, Rhonda, a co-researcher, is often vocal and discusses her own assumptions about teaching and learning. She contributes thought objects for all of us in the collective so that we can discuss our understandings of social life. On days that Rhonda was not present, the cogenerative dialogues were effective, but had a different energy. As a collective we worked through our planned activities, had interesting discussions and made a plan for the next meeting. We developed lots of positive

emotional energies. Yet, when Rhonda, was there, we created a different level of emotional energy. Rhonda is not the only person who mediated such difference, but not all of us in the group did mediate such changes in emotional energy. Theoretically, I am interested in exploring whether each cogenerative dialogue group has such individuals and if so, how can theorizing their D-identity mediate the structures of and the usefulness of cogenerative dialogues as a methodology and a method for improving teaching and learning.

### *Authenticity Criteria*

By adhering to the authenticity criteria as described by Egon Guba and Yvonna Lincoln (1989) where qualitative research should aim to be fair, allow for different ontologies, educative, catalytic and tactical, I have found research to be much more fulfilling and practical. The data that are emerging from the research are being used immediately in praxis and then continue to inform new research questions. This recursive approach makes this research relevant for the program at NYHS and for the science center community overall. Throughout the chapters, I have described a set of events that address these authenticity criteria.

*Fairness.* Researching social life means that the inquiry will be value-laden and different social constructions of events illuminate new understandings. The criterion of fairness allows me to address this reality and in this research, I have done a few things to bring fairness to the research. In chapter 4 where emotions are theorized to better understand the role they play in creating solidarity and group identity, I provide interpretations from the co-researchers whose voices are present in the transcripts used as evidence. Seema and Marina, each, are presented with the transcript and then offer their

interpretations of the event. I also offer my interpretation. Each of these interpretations is provided in separate text boxes. I then synthesize the two interpretations and review the patterns and contradictions that emerge. For those vignettes, we each read the synthesis and peer-checked it to make sure that it properly represented our understandings of the events.

*Ontological and Educative Authenticity.* Research is ontologically diverse when it transforms the way one views and then produces/reproduces social life. It is educative when those transformed understandings are shared with others for the purposes are supporting each other's endeavors. Use of cogenerative dialogues as a method of improving our practice as floor facilitators is by design both ontologically diverse and educative. By listening to each other's interactions with visitors, learning new strategies that each of us could incorporate into our repertoire, having debates about what works best in a given situation in ways that were respectful and useful, each of us grew in our understandings of how and why we do things and appreciate why others may approach a situation differently. In chapter 2 where I describe why cogenerative dialogues serve us well to develop local theories and understandings about social life so that we can transform praxis, I review how Rhonda ontologically transforms when she realizes that she often makes assumptions about what students know about a certain topic. Because of the dialectical relationship between self and other, as she changes her ontology, we also transform. In a different example also presented in that chapter when I write about our task of developing a worksheet, I present a transcript where we are discussing how to phrase a question related to a particular exhibit. Evident in this transcript is how Rhonda in the midst of her dialogue, realizes that she elicits a particular type of response from

visitors because of the words she uses to introduce the exhibit. At this moment, we all offer our approach to elicit a response at that exhibit. The activity is informing our practice, but is also reflexive in that we become aware of our own and other's practices and therefore meet the criteria of educative authenticity.

Catalytic Authenticity. A variety of outcomes demonstrate how this research meets the catalytic authenticity criteria. The worksheet project serves as the biggest example of how this research has propelled all of us to not only grow and transform as learners and teachers, but also as leaders who aim to improve science education for others. Described throughout this chapters is how the worksheet project emerged as a result of dissatisfaction among us researchers in the quality of questions we encountered as we worked with students visiting on a field trip. Conversations during cogenerative dialogues revolved around the nature of how kids learn, what types of questions work best in a science center setting where students are working with hands-on interactive objects and the goals that teachers may have in designing and implementing worksheets. When we took the local theory generated in our conversations and used it for action (developing a worksheet), then we were not only conducting activity for ourselves, but for the larger endeavor, for improving teaching and learning. Our conversations about worksheets did not just support our growth, but now extends to teachers and students who participate in our pilot testing as they help to develop an improved worksheet. This research is also catalytic in that those of us who participate in the research are part of a larger science center community and mediate transformations in those communities. While the student researchers are part of a larger cadre of Explainers, I am also part of a large cadre of science center professionals internationally. The practices that we researchers examined

through the cogenerative dialogues allowed us to develop theory about teaching and learning. We applied that theory to our practices recursively as we functioned as floor facilitators. Belonging to larger communities further allows us to share our transformed practices through training sessions, workshops and conference presentations.

*Tactical authenticity.* Those participating in the research should have the opportunity to control it as well. Cogenerative dialogues by design are intended to support all those participating to have voice in the dialogue and in the direction of the conversations. The intent is to reduce power inequities by encouraging equal turns of talk, respecting each other's opinions and inviting contradictions. In chapter 2, I discuss how I experience frustration when I am unable to successfully facilitate an exhibit with middle school girls. The vignette presented is used to demonstrate how I show my vulnerability as a teacher, and that I am not an expert so that everyone in the group can realize that I have a lot to learn even if I have a higher designation in the science center. Over time, the structures of the cogenerative dialogue evolve such that everyone in the group owns this time and contributes to the agenda of the meeting. This research has mediated an increased agency in those who have participated so that they have set up and maintained their own cogenerative dialogues. Numerous cogenerative dialogues are in operation at the science center. Others in the Explainer department have set up cogenerative dialogues with small groups of people in order to support improved praxis. While slightly different in each case based on the individuals who comprise each dialogue, there are shared structures across these meetings upholding the heuristics for what a cogenerative dialogue should be. These structures dialectically are shaping the schema and practices for those involved.

Those unable to be involved have the opportunity to participate through social networking sites.

Limitations of this research include the intense amount of time invested in small numbers of people, and a lack of control and predictability to describe to funding sources the expected outcomes of the research. With that said, when the research and praxis barrier blurs so that research and praxis are dialectically related to each other, it requires a paradigm shift from hoping for a large scale, grand theory of everything to a small scale where local theory is generated, informs work and becomes input for generating new theory. This shift does not mean that grand scale work is not occurring, rather, it means that it is happening through a ripple effect where the work is collaborative, cogenerated and informed by those most affected by such work thereby upholding the authenticity criteria.

#### *Producing Kernels of Thought for Others*

Many of my colleagues ask me about the generalizability of my research activities and “findings.” When social life is researched and examined, it is important to note that each moment of activity is a historical act (Tobin and Roth 2006). The schema, resources and the practices that the people bring to the act structure each moment. As Kenneth Tobin (2009) reminds us, “Even when the same individuals are involved, in the same spaces, substitution is not warranted, because as individuals grow older, even by a few seconds, they change” (p. 149). Instead of positioning my research as generalizable, I demonstrate the viability of using ISIs as partners for pre-service teacher preparation. I use Tobin’s inspirational words to address this issue. He writes, “I consider my research outcomes as

kernels for others' actions and focus on making a compelling case about social life, allowing others to apply what they learn to fields in which they conduct their professional practices" (p. 157). With this research, I have learned how co-researching with pre-service teachers who are working as Explainers in an ISI setting supports not only their developing ontologies and epistemologies about teaching and learning, but also mine. Through this research I have set up structures that allow awareness to emerge and mediate practice.

### Implications

My research has implications for informal science institutions and university-based teacher preparation programs. Research in informal science education is stronger than ever. Yet, as Jonathan Osborne and Justin Dillon (2007) describe, "while the study of learning science in formal contexts has at least reached the foothills of knowledge and understanding, researchers working in informal contexts are still in the plains gazing at the mountain in the far distance" (p. 1442). They also feel that researching in informal learning spaces is more difficult than formal contexts because there is less control of the environment, a great deal of unpredictability with audiences and activity, constraints to data collection and increased issues of getting informed consent. I agree with both of those statements, but it is that richness of context, in the real moment, in social life that is most interesting and inspirational for me. I am committed to demonstrating how informal science institutions are unique sites for both practicing and researching teaching and learning and as such are an invaluable resource for those that are either considering careers in teaching or work as teacher educators. Opportunities to share my dissertation

research at recent local, national and international conferences with other informal educators and researchers has led to rich conversations that inform my research and writing, but also demonstrate the interest and excitement that my research is garnering in the informal science learning communities.

Through this research, I have learned that while informal science institutions and universities have a common interest in preparing teachers for science teaching and learning, each has a different culture and therefore carry different schemas, practices and beliefs related to teacher preparation. These two cultures are not contradictory, and more often than not, they are complementary. However, because each is historically, politically, economically and socially situated differently, culture enacted through patterns and constraints within each can lead to complexity. Through their research, Tasmin Astor-Jack, Ellen McCallie and Phyllis Balcerzak (2007) described a series of patterns and contradictions related to how informal science institutions viewed elements of effective professional development as compared to institutes of higher education. They found that there were differences in how the two types of institutions used language and meanings. When institutes of higher education described key features of professional development, they referenced literature and theory and used specific terminology to describe strategies of teaching, learning or curriculum development. For example, while people from higher education stated they used backwards design, ISI professionals used that strategy but did not using the same terminology to identify such practices. ISI practitioners were using backwards design as a principle in their professional development programs but were not labeling it as such. They were more focused on engaging teachers in activity, which was based on sound practice and experience, not

necessarily what theory dictated. Another example of difference was how inquiry was described. While both viewed inquiry as a teaching strategy during professional development, the institutes of higher education described inquiry as what scientists do and the informal science institutions described it as what students and teachers do to learn more about science. As related to looking for growth and change in a teacher, the institute for higher education looked for cognitive change by examining attitudes, and beliefs while the informal science institutions looked for growth by examining change in comfort, and confidence with hands-on teaching. In the CLUSTER project, interestingly, each of these three issues have emerged through the collaboration of faculty from the college and the science center.

My work points to the role that ISIs can play in partnering teaching preparation programs with the intent to provide a rich learning laboratory for pre-service teachers. The complexities described by Astor-Jack, McCallie and Balcerzak (2005) are aspects of developing a CLUSTER-like partnership, it will be important to think about activities that will aim to address the dichotomies that may arise across the cultures of informal and formal institutions of learning. As described in chapter 5, museum-university partnerships where pre-service teachers are working as staff in the science center in Jerusalem and in Vancouver continue their efforts and expect to expand their programs over time. Our three programs become models that others can consider and learn from as they develop their own partnerships. Although I look forward to supporting these emerging partnerships and sharing my work, I caution that difficult conversations need to happen to create a type of third space, a hybridized culture, that respects and values the culture from both the formal and informal realms of learning (Tobin 2009) and only then can we begin

to get away from the dichotomies of formal and informal learning. Sonia Nieto writes: “all of us in education should know by now that it is only through critical reflection, the ethical use of power, collaborative and meaningful relationships and hard work that any idea really works” (2005, p. 201). Dealing with the complexities of museum-university partnerships for pre-service teacher preparation is hard work, but crucial if we expect to support our pre-service teachers in developing understandings of their own selves and Others as teachers and learners.

### *Implications of a Doctoral Program at the CUNY Graduate Center*

Six years ago, when I decided to pursue doctoral education, I was confronted with the dilemma of choosing full-time work or choosing educational endeavors because I was having difficulty finding doctoral programs that were supportive of people who had full-time jobs. Learning about, applying and then being accepted to the City University of New York Graduate Center’s Urban Education program has great implications for where I am today. This program has design features that allow people who choose to continue full-time work to also pursue doctoral education. Courses and seminars are scheduled in the late afternoon and evening and the number of credits that qualify me as a full-time student were such that I only had to take two classes to maintain full-time status. This criterion is important because many of my peers in the program needed to maintain full-time status for scholarship and financial aid reasons. The design features not only made this endeavor feasible, but also allowed me to grow as a researcher *and* as a practitioner.

Doing away with the divide between research and practice is the direction that scholars and practitioners are advocating for as evidenced by 2008 Visitor Studies Association conference theme, *Theory, Practice and Conversations*, at the 2009 National

Association of Research in Science Teaching conference sessions and through the writing of scholars such as Anna Stetsenko (2008), who writes at length about the need to close the gaps between the realms of theory and practice. Too often, practitioners have to sacrifice our day-to-day work to join academic pursuits, thereby separating us from practice. If I was not able to maintain my position at the New York Hall of Science, I would not have been able to conceive and pursue this research. What I have learned in the past four years has mediated my practice, and due to ripple effects, mediated the practices of others. Through my research, I can contribute to my own and other's theoretical growth. Having the flexibility to work and go to school has had profound effects on the outcomes of my research and my developing identity as a scholar|practitioner.

A difficult, but important point to write about is regarding the hegemonic practices that are unintentionally at play through traditional doctoral programs. Too often, doctoral programs structure the courses and commitments in ways that require students to give up their full-time work. Such programs offer fellowships so that they can enter the academic arena, teach foundations classes, and support tenure professors with their research agenda with the intent to learn at the elbow of another. While this is laudable, the fellowship awards are generally half of the salary that a person who is considering doctoral work may be earning in a full-time position. While college tuition is waived or covered by a grant, the student is expected to go to school and work for the college for a lot less money. While this system works for some, it does not necessarily work for those of us who need to earn a full-time salary to survive in New York City. This is predominantly an issue of class rather than race, gender or other social categories and because these

social categories all mediate each other, it becomes an issue of race, ethnicity and gender. Most middle and lower class people in New York City may not be able to give up full-time work in order to pursue doctoral studies. Unless places such as the Urban Education Program at the Graduate Center become prevalent, urban, middle and lower class people may not be able to pursue scholarly endeavors. This would be a disservice to those people who are interested in such work, and also to the field of academia, which is constantly struggling to diversify its constituency and therefore the polysemic views of social life. We aim to create socially just and equitable opportunities for learning for children (Michelli and Keiser 2005), but are we at fault for producing and reproducing the same injustices at the doctoral level? Implications for these hegemonic practices are not noticeable in the day-to-day, but become evident when we look at the attendees at national research conferences. In summary, I advocate for all of us to continue this discussion through writing, presentations and debates so that we can move beyond hegemonic practices and explore new possibilities for both theory and practice.

#### What More Is There?

I have already identified two areas of work that need pursuit, the role of an individual's D-identity in mediating the structures of a cogenerative dialogue and the need for more conversation and subsequent action in the design of doctoral programs. I will also continue research underway at the New York Hall of Science with the expectations that new ideas and knowledge will emerge from our interactions with each other. Tyack and Cuban (1995) claim, "change where it counts most – in the daily interactions of teachers and students – is the hardest to achieve and the most important" p. 10). Keeping this in mind, it is priority for this research|practice to continue and evolve. The lens with which

we examine social life as it is produced will change and illuminate new understandings. In my research, I expect to delve into a polysemic approach to data analysis and writing. By co-authoring articles and book chapters, I want to work collaboratively with the co-researchers in this study to document what is happening through this research.

I also want to investigate frameworks that relate to science talk. The conversations during the cogenerative dialogues often delve into the use of science words and science language as part of the interactions with visitors. When should we use science words and when should we use everyday words? How do we scaffold the experience so that the learner is introduced to the science words but not limited because of them? The seminal work of Jay Lemke (1990), *Talking Science*, lays the foundation for tons of research on this topic. At the 2009 National Association of Research in Science Teaching conference, Bryan Brown and Kihyun Roo's award winning article in the *Journal of Research in Science Teaching*, *Teaching Science as a Language: A "Content-First" Approach to Science Teaching*, provides food for thought because his research documents that teaching urban students science with everyday words and then introducing scientific language supports them their conceptual understanding. Also, in the informal science world, Doris Ash studies conversations between visitors with each other and with staff and interested in nature of these conversations. Each of these scholars are contributing to our knowledge about on the topic of science talk and I expect to become more familiar with their work and apply their understandings to what happens in this research and generate new knowledge.

Each new slice of social life that we examine will reveal new knowledge. One area of focus that has already surfaced and needs to be investigated is the role of laughter in

teaching and learning. Christina Siry (2009) theorizes the role of laughter as structural resonances that are created from social bonds that develop through coteaching and cogenerative dialogues in a field-based science methods course. She explores how laughter supports and acknowledges difference within a classroom interaction. At the 2009 Ethnography Forum, Jennifer Dorsey and Jennifer Weiner from the Harvard School of Education presented a paper, *Why are They Laughing? Pre-service Teachers' Use of Humor in Discussions About Race*, and described how they theorized the role of humor and laughter as ways of negotiating and dealing with conversations about race. I plan to explore how the role of laughter supports the reduction of power and positionality and this mediates the development of solidarity and group identity.

Another area of exploration is to delve into an analysis of gestures and prosody using conversation analysis. Microanalysis reveals a different type of social reality and can potentially inform praxis in profound ways. Wesley Pitts (2007) demonstrates how body gestures coordinated with prosody markers such as pitch, intensity and variation in utterances are resources for tracking emotional energy and solidarity. By exploring activity in a chemistry classroom, Pitts describes how change in students' pitch, intensity, and duration of utterances mediate how students interact with and negotiate with each other and create a new type of culture, an interstitial culture, for enacting chemistry. Students appropriate their resources to create structures that decrease the breaches in interaction across issues of ethnicity, gender, age and role. I look forward to working alongside the student researchers and selecting vignettes that stand out and describe specific moments of high energy and analyzing them using prosody analysis.

### The Immediate Future

The next few months are especially exciting. Although I conclude this dissertation, I am in the midst of significant ongoing work with my co-researchers. Through chapters 2-4, I discuss the evolution of the worksheet project, an activity that emerged from the cogenerative dialogues and was based on a collective interest. It became an object of mutual focus and therefore solidarity. It also has allowed each of us to launch and participate in conversations about how museum exhibits can and cannot successfully engage students to think critically about science topics. We are continuing our worksheet project and have a plan to continue to prototype our field trip questions with different groups of students, each time refining the questions. When we are satisfied with the worksheet, we will be able to place it on the New York Hall of Science website so that other teachers can use it and adapt it to their needs. We also have a plan to co-write a chapter for an edited book on the use of cogenerative dialogues in different settings. Therefore, this research will continue. Dialectically it will mediate our praxis and through this endeavor, we will dynamically and relationally continue to develop our identities as educators, learners, and social beings producing|reproducing and transforming culture one historical act at a time.

## Appendix

### Transcript Conventions

↑	Rising Intonation
↓	Falling Intonation
[ ]	Simultaneous talk by two speakers, with one utterance represented on top of the other in the moment of overlap marked by left brackets
=	Interruptions or next utterance following immediately, or continuous talk represented on separate lines because of the need to represent overlapping comment on intervening line

## References

- Adams, J. (2007). The historical context of science and education at the American Museum of Natural History. *Cultural Studies of Science Education*, 2, 393-440.
- Anderson, D., Lawson, B. & Mayer-Smith, J. (2006). Investigating the impact of a practicum experience in an aquarium on pre-service teachers. *Teaching Education*, 17, 341-353.
- Ash, D. (2009, April). *Re-examining the theory and practice of scaffolding in informal learning settings*. Paper presented at the National Association for Research in Science Teaching. Long Beach, CA.
- Association of Science & Technology Centers. (2007). *ASTC sourcebook of statistics & analysis*. Washington D.C.: Author
- Astor-Jack, T., McCallie, E., & Balcerzak, P. (2007). Academic and informal science education practitioner views about professional development in science education. *Science Education*. 91, 604-628
- Bell, P., Lewenstein, B., Shouse, A.W., & Feder, M.A. (2009). *Learning science in informal environments: People, places and pursuits*. Washington, D.C: National Research Council of the National Academies.
- Belmont Report. (1979). *Ethical principles and guidelines for the protection of human subjects of research*. Washington, DC: The National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. Retrieved April 28, 2009, from <http://ohsr.od.nih.gov/guidelines/belmont.html>
- Berry, K. (2006). Research as bricolage: Embracing relationality, multiplicity and

- complexity. In Tobin, K., & Kincheloe, J. (Eds.). *Doing educational research [pp:87-116]*. Rotterdam: Sense Publishers.
- Brezner, E. (2008). [Pre-service students program in the Bloomfield Science Museum Jerusalem]. The Bloomfield Science Museum Jerusalem. Unpublished raw data.
- Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2, 141-178.
- Bruner, J. (1996). *The culture of education*. Cambridge: Harvard University Press.
- Bourdieu, P. (2001). The forms of capital. In M. Granovetter & R. Swedberg (Eds.) *The sociology of economic life* (pp. 96-111). Boulder: Westview Press.
- Bourdieu, P., & Wacquant, L.J.D. (1992). *An invitation to reflexive sociology*. London: University of Chicago Press.
- Center for Advanced Study in Education. (2007, December). *CLUSTER: Investigating a new model for teacher preparation*. Annual Report for National Science Foundation Award #055426. New York, NY
- Collins, R. (2004). *Interaction ritual chains*. Princeton: Princeton University Press.
- Darling-Hammond, L., Hammerness, K., Grossman, P., Rust, F. & Shulman, L. (2005). The design of teacher education programs. In Darling-Hammond, L., & Bransford, J (Eds.). *Preparing teachers for a changing world [pp:390-441]*. San Francisco: Josey-Bass.
- Davis, E., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, 76, 607-651.

- Denzin, N., & Lincoln, Y.S. (Ed.). (2003). *The Landscape of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.
- Diamond, J., St. John, M., Clearly, B. & Librero, D. (1987). The Exploratorium's Explainer program: The long-term impact on teenagers of teaching science to the public. *Science Education*. 71, 643-656
- Dierking, L. (2007) Understanding the nature of science learning. In Tobin, K., & Roth, W.M. (Eds.). *The Culture of Science Education [pp:239-250]*. Sense Publishers.
- Dorsey, J & Weiner, J. (2009, February). *Why are they laughing? Pre-service teachers' use of humor in discussions about race*. Paper Presented at University of Pennsylvania Ethnography Forum, Philadelphia, PA.
- DOTIK. (2007). *European training for young scientists and museums Explainers*.  
[www.dotik.eu](http://www.dotik.eu)
- Duschl, R., Schweingruber, H., & Shouse, A. (Ed.). (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington D.C.: National Academies Press.
- Elmesky, R., & Tobin K. (2005). Expanding our understandings of urban science education by expanding the roles of students as researchers. *Journal of Research in Science Teaching*, 42, 807-828.
- Emdin, C., & Lehner, E. (2006). Situating cogenerative dialogue in a cosmopolitan ethic. *Forum Qualitative Social Research*, 7, Art. 39, <http://nbn-resolving.de/urn:nbn:de:0114-fqs0602390>.

- Engeström, Y. (1999). Activity theory and individual and social transformation. In Y. Engeström, R. Miettinen, & R-L Punamaki, *Perspectives on activity theory* (pp. 282-297). Cambridge, United Kingdom: Cambridge University Press.
- Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal, and informal education. *Journal of Science, Education and Technology*, 16, 171-190.
- Fazio, X., Melville, W., & Bartley, A. (2008, March). *The role of the practicum experience in supporting secondary pre-service teachers implementing inquiry-based science*. Paper presented at the National Association of Research in Science Teaching.
- Falk, J. H. (Ed.). (2001). *Free-choice science education: How we learn science outside of school*. New York: Teachers College Press.
- Falk, J.H. (2006). Impact of visit motivation on learning: Using identity as a construct to understand the visitor experience. *Curator*, 49, 151-166.
- Falk, J. H., Dierking, L.D. (2000). *Learning from Museums: Visitor Experience and the Making of Meaning*. Walnut Creek, CA: AltaMira Press.
- Falk, J. H., Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education*, 89, 744-778.
- Feldman, P. & Kent, M. (2006). A collaborative effort: bridging theory and practice in pre-service preparation. *The New Educator*, 2, 277-288
- Finkelstein, D. (2005). *Science museums as resources for teachers: An exploratory study on what teachers believe*. Paper presented at the National Association for Research in Science Teaching, Dallas, TX.

- Gee, J. P. (2001). Identity as an analytic lens for research in education. *Review of Research in Education, 25*, 99-125.
- Guba, E. & Lincoln, Y.S. (1989). *Fourth generation evaluation*. Newbury Park, CA: Sage Publications.
- Hargreaves, A. (2000). Mixed emotions: teachers' perceptions of their interactions with students. *Teaching and Teacher Education, 16*, 811-826.
- Jenkins, J., Anderson, D, & Mayer-Smith, J. (2007). *Investigating the impact of the extended practicum beyond the classroom option on pre-service teachers*. University of British Columbia. Department of Curriculum Studies.
- Kincheloe, J. (2003). *Teachers as Researchers: Qualitative Inquiry as a Path to Empowerment* (2nd ed.). London: Routledge Falmer.
- Kisiel, J. (2007). Examining teacher choices for science museum worksheets. *Journal of Science Teacher Education, 18*, 29-43.
- Kos, M. (2005). Who are the Explainers? A case study at the House of Experiments. *Journal of Science Communication, 4*, 1-5.
- LaVan, S., & Beers, J. (2005). The Role of Cogenerative Dialogue. In K. Tobin, Elmesky, R., & Seiler, G. (Ed.), *Improving urban science education: New roles for teachers, students, & researchers*. Oxford: Rowman & Littlefield Publishers, Inc.
- Luehmann, A. (2007). Identity development as a lens to science teacher preparation. *Science Education, 91*, 822-839.

- Jardine, D. (2006). Hermeneutics: “over and above our wanting and doing”. In Tobin, K., & Kincheloe, J. (Eds.). *Doing educational research [p:269-288]*. Rotterdam: Sense Publishers.
- hooks, b. (1994). *Teaching to Transgress: Education as the Practice of Freedom*. London: Routledge.
- Lemke, J. (1990). *Talking Science: language, learning and values*. Westport, CT.: Ablex Publishing.
- Martin, S., & Scantlebury, K. (in press). More than a conversation: using cogenerative dialogues in the professional development of high school chemistry teachers. *Journal of Personnel Evaluation in Education*.
- Michelli, N., & Keiser, D.L. (2005). *Teacher education for democracy and social justice*. New York: Taylor and Francis Group.
- Middlebrooks, S. (1999). *Preparing tomorrow's teachers: pre-service partnerships between science museums and colleges*. Washington, D.C.: Association of Science Technology Centers Inc.
- Monet, J., & Etkina, E. (2008). Fostering self-reflection and meaningful learning: Earth science professional development for middle school science teachers. *Journal of Science Teacher Education*, 5, 455-475.
- Nias, J. (1996). Thinking about feeling: the emotions in teaching. *Cambridge Journal of Education*, 26, 293-306.
- Nieto, S. (2005). *Why we teach*. New York City: Teacher's College Press.

- Olitsky, S. (2007). Promoting student engagement in science: Interaction rituals and the pursuit of a community of practice. *Journal of Research in Science Teaching*, 44, 33-56.
- Osborne J. & Dillon, J. (2007). Research on learning in informal context: Advancing the field? *International Journal of Science Education*, 29, 1441-1445.
- Packer, J. (2008). Beyond learning: Exploring visitors' perceptions of the value and benefits of museum experiences. *Curator*, 51, 33-54.
- Pekarik, A., Zahava, D. Karns, D. (1999). Exploring satisfying experiences in museums. *Curator*, 42, 152-173.
- Penuel W.R. & Wetsch, J. V. (1995). Vygotsky and identity formation: A sociocultural approach. *Educational Psychologist*, 30, 83-92.
- Phillips, M., Finkelstein, D., & Wever-Frerichs, S. (2007). School site to museum floor: How informal science institutions work with schools. *International Journal of Science Education*, 29, 1489-1507.
- Pitts, W. (2007). Being, becoming and belonging: Improving science fluency during laboratory activities in urban education. Unpublished doctoral dissertation, City University of New York, Graduate Center.
- Rodari, P., & Xanthaoudaki, M. (2005). Introduction. *Journal of Science Communication*, 4.
- Rounds, J. (2006). Doing identity work in museums. *Curator*, 49, 133-150.
- Roth, W. M. (2005). *Doing qualitative research: Praxis of method*. Rotterdam: Sense Publishers.

- Roth, W. M. (2005). *Auto/biography and auto/ethnography: Praxis of research method*. Rotterdam: Sense Publishers.
- Roth, W. M. (2007). Theorizing passivity. *Cultural Studies of Science Education*, 2, 1-8.
- Roth, W. M. (2007). The ethico-moral nature of identity: Prolegomena to the development of third-generation cultural-historical activity theory. *International Journal of Educational Research*, 46, 83-93.
- Roth, W. M., Lawless, D.V., & Masciotra, D. (2001). Spielraum and teaching. *Curriculum Inquiry*, 31, 183-207
- Roth, W. M., Tobin, K., & Zimmerman, A. (2002). Coteaching/cogenerative dialoguing: Learning environments research as classroom praxis. *Learning Environments Research*, 5, 1-28.
- Roth, W. M., & Lee, Y.J. (2007). "Vygotsky's neglected legacy": Cultural historical activity theory. *Review of Educational Research*, 77, 186-232.
- Roth, W. M., & Tobin, K. (Ed.). (2007). *Science, learning, identity: Sociocultural and cultural-historical perspectives*. Rotterdam: Sense Publishers.
- Sewell, W. H. (1992). A theory of structure: duality, agency, and transformation. *American Journal of Sociology*, 98, 1-29.
- Sewell, W. H. (1999). The concept(s) of culture. In V.E. Bonnell & L. Hunt (Eds.) *Beyond the cultural turn: New directions in the study of society and culture* [pp. 35-61]. Berkeley, CA: University of California Press.
- Signorello, F. (2001). *How partnering with an informal science education institution can help prepare pre-service teachers for the formal classroom*. Unpublished Master's thesis. Queens College. New York.

- Siry, C. (2009). *Fostering solidarity and transforming identities: A collaborative approach to elementary science teacher education. Unpublished doctoral dissertation.* City University of New York, Graduate Center, New York
- Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytical tool for investigating learning as a culturally shaped activity. *Educational Researcher*, 34, 14-22.
- Stetsenko, A., & Arieviditch, I.M. (2004). The self in cultural-historical activity theory. *Theory & Psychology*, 14, 475-503.
- Stetsenko, A. (2005). Activity as object-related: Resolving the dichotomy of individual and collective planes of activity. *Mind, Culture and Activity*, 12, 70-88.
- Stetsenko, A. (2008). From relational ontology to transformative activist stance on development and learning: expanding Vygotsky's (CHAT) project. *Cultural Studies of Science Education*, 3, 471-491
- Stetsenko, A. (2008) Collaboration and cogenerativity: on bridging the gaps separating theory-practice and cognition-emotion. *Cultural Studies of Science Education*, 3, 521-533.
- Stetsenko, A. (in press). Standing on the shoulders of giants: A balancing act of dialectically theorizing conceptual understanding on the grounds of Vygotsky's project. In Roth, W-M. & Tobin, K. (Eds). (in press). *Re/thinking science education: ReUniting sociological and psychological perspectives.* (pp \*\*\*-\*\*\*).Dordrecht: Springer.

- Storksdieck, M., Haley-Goldman, K., & Jones, M.C. (2002). *Impact of the New York Hall of Science Career Ladder Program on its former participants*. Annapolis, MD: Institute for Learning Innovation.
- ten Dam, G. T. M., & Blom, S. (2006). Learning through participation. The potential of school-based teacher education for developing a professional identity. *Teaching and Teacher Education*, 22, 647-660.
- Tyack, D. C., L. (1995). *Tinkering towards utopia: A century of public school reform*. Cambridge: Harvard University Press.
- Tobin, K. (2005). Urban science as a socially and culturally adaptive practice. In K. Tobin, Elmesky, R., & Seiler, G. (Eds.), *Improving urban science education: New roles for teachers, students and researchers [pp.21-42]*. Oxford: Rowman & Littlefield Publishers, Inc.
- Tobin, K. (2009). Repetition, difference and rising up with research in education. In K. Erickson & W. M. Roth, (Ed.) *Generalizing from educational research* (pp. 149-172). New York: Routledge.
- Tobin, K. (2009). Research priorities for transforming urban science education. In W. M. Roth, & Tobin, K. (Ed.), *The world of science education: Handbook of research in North America* (Vol. 1, pp. 451-472). Rotterdam: Sense Publishers.
- Tobin, K., & Roth, W.M. (2006). *Teaching to learn: A view from the field*. Rotterdam: Sense Publishers.
- Tobin, K., & Roth, W.M. (Ed.). (2007). *The culture of science education*: Sense Publishers.

- Turner, J. (2002). *Face to face, Towards a sociological theory of interpersonal behavior*. Stanford: Stanford University Press.
- Urbanski, A. (2004). Teachers' use of data to improve student learning. In *What is a qualified, capable teacher?* (pp. 1-10). Washington D.C.: National Evaluation Systems, Inc.
- Van Manen, M. (1990). *Researching lived experience*. Ontario: The University of Western Ontario.
- Villegas, A. M., & Lucas, T. (2002). *Educating culturally responsive teachers*. Albany: State University of New York.
- Wang, J., & Odell, S.J. (2002). Mentored learning to teach according to standards-based reform: A critical review. *Review of Educational Research*, 72, 481-546.