Mapping the Social World Boundaries of Interdisciplinary Teams: Processes for Working Across Disciplines

Nicole Dolores Alemanne
FLORIDA STATE UNIVERSITY
COLLEGE OF COMMUNICATION AND INFORMATION

MAPPING THE SOCIAL WORLD BOUNDARIES OF INTERDISCIPLINARY TEAMS:
PROCESSSES FOR WORKING ACROSS DISCIPLINES

By
NICOLE DOLORES ALEMANNE

A Dissertation submitted to the
School of Information
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Degree Awarded:
Fall Semester, 2014
Nicole Dolores Alemanne defended this dissertation on October 22, 2014.
The members of the supervisory committee were:

Paul F. Marty
Professor Directing Dissertation

Pat Villeneuve
University Representative

Michelle M. Kazmer
Committee Member

Besiki Stvilia
Committee Member

The Graduate School has verified and approved the above-named committee members, and certifies that the dissertation has been approved in accordance with university requirements.
To my parents, Anita and Nicholas, who showed me that learning is fun and who always gave me unconditional love
ACKNOWLEDGEMENTS

First and foremost, I must express my deepest appreciation to my major professor, Paul Marty, who was the first person I told about my crazy idea to get a Ph.D., and with whom I have shared so many academic adventures over the years. Thank you for sticking with me through all the dissertation topic ideas and for teaching me that a poster is always better with a big picture of a bobcat. And unending thanks to the members of my doctoral committee—Michelle Kazmer, Besiki Stvilia, and Pat Villeneuve—all of whom have been mentors and sources of inspiration since I was a master’s student. Thank you for your support, your hard work, and the constructive[ist] criticism that makes my work better.

There are so many people from so many incarnations of the School of Information and the College of Communication and Information who have contributed to any success that I have had so far as an information scientist. Special thanks are due to Chuck McClure, Ian Douglas, Kathy Burnett, Gary Burnett, Marcia Mardis, Richard Urban, Lynne Hinnant, Chris Hinnant, Melissa Gross, Chris Landbeck, Mia Lustria, Jenny Ma, Melinda Whetstone, Jung-A Lee, Pam Doffek, Corrine Jörgensen, Wade Bishop, John Brobst, Dean Dennis, and the great iSchool staff. I would not have been able to complete this dissertation without the iSchool’s financial support, including the Esther Maglathin Doctoral Fellowship and many, many semesters of graduate assistantships. Thanks are also due to Sherry Southerland, Vic Sampson, Anne Mendenhall, Amanda Clark, Jennifer Schellinger, and Aldo de la Paz. And of course, thanks to the amazing iSchool doctoral student community, including Lenese Colson, Adam Worrall, Laura Spears, Shuheng Wu, and Casey Yu; to Mikki Smith and Hazel Urban; and to Lauren Mandel, Melissa Johnston, and Aaron Elkins, who have been there from the beginning and who make me smile when I really need it (and even when I don’t).

And last, but absolutely not least, thanks to my family—this journey would not have been possible without your overwhelming love, your constant support, and your abiding good humor.
# TABLE OF CONTENTS

List of Tables ......................................................................................................................... viii
List of Figures ........................................................................................................................... ix
Abstract ....................................................................................................................................... xi

## CHAPTER ONE: INTRODUCTION .................................................................................. 1
  1.1 Purpose of the Research ................................................................................................. 1
  1.2 Problem Statement and Significance of the Research ..................................................... 1
  1.3 Research Questions ........................................................................................................ 3
  1.4 Overview of the Theoretical Approach and the Sensitizing Concepts ......................... 4
    1.4.1 The Social Approach to Research ........................................................................... 5
    1.4.2 Sensitizing Concepts .............................................................................................. 5
  1.5 Overview of the Research Design .................................................................................. 7
  1.6 Assumptions, Biases, and Limitations .......................................................................... 9
  1.7 Organization of the Dissertation .................................................................................... 10
  1.8 Summary ....................................................................................................................... 10

## CHAPTER TWO: LITERATURE REVIEW .................................................................. 12
  2.1 Interdisciplinary Collaboration ..................................................................................... 12
    2.1.1 Collaborative Teams and Teamwork ....................................................................... 12
    2.1.2 Interdisciplinarity .................................................................................................. 14
    2.1.3 Characteristics of Interdisciplinary Research and Researchers ......................... 15
    2.1.4 Structural and Process Issues ................................................................................ 17
    2.1.5 Interdisciplinary Collaboration in Library and Information Science ................. 21
    2.1.6 Process Studies in Interdisciplinary Research ....................................................... 22
    2.1.7 Summary of Interdisciplinary Collaboration ........................................................ 22
  2.2 Technology-Enhanced K-12 Scientific Practice ............................................................. 23
    2.2.1 K-12 Scientific Practice ........................................................................................ 24
    2.2.2 Technology-Enhanced Scientific Practice ............................................................ 26
    2.2.3 Barriers to Technology Integration ....................................................................... 27
    2.2.4 Enabling Technology Integration ......................................................................... 29
    2.2.5 Summary of Technology-Enhanced K-12 Scientific Practice ............................ 30
  2.3 Iterative User-Centered Technology Design and Development .................................... 31
    2.3.1 User-Centered Design .......................................................................................... 31
    2.3.2 Iterative Design and Development ....................................................................... 33
    2.3.3 Summary of Iterative User-Centered Technology Design and Development ........ 35
  2.4 The Social Approach to Research ............................................................................... 35
    2.4.1 Social Constructionism ......................................................................................... 36
    2.4.2 The Social Approach to Information Science ......................................................... 38
    2.4.3 Summary of the Social Approach to Research ..................................................... 39
  2.5 Sensitizing Concepts ...................................................................................................... 39
    2.5.1 The Social Worlds Perspective .............................................................................. 40
    2.5.2 Intrinsically Transient Social Worlds .................................................................... 44
    2.5.3 Boundary Objects and Social Worlds ................................................................... 48
    2.5.4 Summary of Sensitizing Concepts ........................................................................ 50
4.3.4 Rules, Policies, and Procedures ................................................................. 131
4.3.5 Technology Issues ..................................................................................... 132
4.3.6 Dissemination and Outreach .................................................................... 135
4.3.7 Finishing and Planning for the Future ...................................................... 136
4.4 Summary of Findings..................................................................................... 137

CHAPTER FIVE: DISCUSSION ........................................................................... 139
5.1 Interdisciplinary Team Social Worlds .......................................................... 140
  5.1.1 Social World Composition and Traits .................................................... 140
  5.1.2 Social World Segmentation and Change Over Time ............................ 142
  5.1.3 Information Researchers in the Social Worlds ...................................... 144
5.2 Portrait of an Intrinsically Transient Interdisciplinary Team ..................... 145
  5.2.1 Team Member Roles .............................................................................. 145
  5.2.2 Challenges and Strategies .................................................................... 147
  5.2.3 Intrinsically Transient Social Worlds ..................................................... 148
5.3 Bridging Social Worlds ............................................................................... 150
5.4 Iteratively Designed Teamwork .................................................................. 153
5.5 Implications and Future Research ............................................................... 156
  5.5.1 Validate, Refine and Expand the IDT Model ....................................... 156
  5.5.2 Refine the Research Design and Instrumentation ............................... 156
  5.5.3 Further Theoretical Implications ......................................................... 157
5.6 Summary ....................................................................................................... 157

APPENDIX A: SEMI-STRUCTURED INTERVIEW SCHEDULE ............................ 159
APPENDIX B: INTERVIEW INFORMED CONSENT FORM ............................. 160
APPENDIX C: E-MAIL INFORMED CONSENT FORM .................................. 162
APPENDIX D: MEETING NOTES INFORMED CONSENT FORM .................. 164
APPENDIX E: HUMAN SUBJECTS APPROVALS ............................................ 166
REFERENCES ................................................................................................. 168
BIOGRAPHICAL SKETCH ............................................................................... 186
LIST OF TABLES

Table 1.1. Research Design Alignment ................................................................. 9
Table 3.1. Alignment of Research Questions, Sensitizing Concepts, Methods, and Data Types. 59
Table 3.2. Team Composition...................................................................................... 60
Table 3.3. Project Stages and Durations ..................................................................... 61
Table 3.4. Purposive Interview Sample ....................................................................... 64
Table 3.5. Alignment of Interview Prompts with Research Questions and Sensitizing Concepts 65
Table 3.6. Social Network Analysis E-mail Subsample ............................................... 71
Table 3.7. Evaluative Model ....................................................................................... 74
Table 4.1. Team Structure......................................................................................... 87
LIST OF FIGURES

Figure 1.1. Dissertation Research Design ................................................................. 8

Figure 3.1. Research Design .......................................................................................... 58

Figure 3.2. Purposive E-mail Sample .............................................................................. 62

Figure 4.1. Ordered Situational Map ............................................................................. 82

Figure 4.2. Social Worlds/Arenas Map of The Project and Intersecting Social Worlds .... 86

Figure 4.3. Project Stages by Year .................................................................................. 88

Figure 4.4. Project Map of the Project Team in Stage 1 .................................................. 93

Figure 4.5. Project Team's Social Network in Stage 1 .................................................... 95

Figure 4.6. Stage 1 Social Network Without $PI$ ........................................................... 96

Figure 4.7. Project Map of the Project Team in Stage 2 .................................................. 97

Figure 4.8. Project Team's Social Network in Stage 2 .................................................... 98

Figure 4.9. Stage 2 Social Network Without $PI$ ........................................................... 99

Figure 4.10. Project Map of the Project Team in Stage 3 ............................................... 101

Figure 4.11. Project Team's Social Network in Stage 3 ................................................ 102

Figure 4.12. Stage 3 Social Network Without $PI$ ........................................................ 103

Figure 4.13. Project Map of the Project Team in Stage 4 ............................................... 105

Figure 4.14. Project Team's Social Network in Stage 4 ................................................ 106

Figure 4.15. Stage 4 Social Network Without $PI$ ........................................................ 107

Figure 4.16. Project Map of the Project Team in Stage 5 ............................................... 109

Figure 4.17. Project Team's Social Network in Stage 5 ................................................ 110

Figure 4.18. Stage 5 Social Network Without $PI$ ........................................................ 111
Figure 4.19. Project Map of the Project Team in Stage 6 ......................................................... 113
Figure 4.20. Project Team's Social Network in Stage 6 ............................................................... 114
Figure 4.21. Stage 6 Social Network Without PI ........................................................................ 115
Figure 4.22. Project Map of the Project Team in Stage 7 ............................................................... 117
Figure 4.23. Project Team's Social Network in Stage 7 ............................................................... 118
Figure 4.24. Stage 7 Social Network Without PI ........................................................................ 118
Figure 5.1 Iteratively Designed Teamwork (IDT) Model ............................................................. 154
ABSTRACT

Interdisciplinary research is often problem-based, arising to serve needs that cannot be fulfilled without crossing domain boundaries. Interdisciplinary researchers face a number of issues such as poor communication, methodological differences, and sources of funding. As any academic team comes together it has to organize, develop work processes, and create deliverables. Teams that form for a relatively short time to accomplish a specific goal (e.g., for the duration of a grant) have the added pressure of a deadline. Interdisciplinary time-limited teams must do all this while communicating and negotiating across disciplinary boundaries, most likely with different disciplinary norms and vocabularies. This study fills a gap at the junction of studies of teamwork processes and academic interdisciplinarity and contributes to theoretical knowledge of the process of academic interdisciplinary teamwork.

This study explores an intrinsically transient interdisciplinary research team’s process of collaboration across domain boundaries to design an educational technology intervention. It combines grounded theory method and social network analysis, using purposive samples of 4260 team e-mails and eight intensive interviews with key informants. The study takes a social approach to research, using Strauss’s social worlds perspective, Kazmer’s intrinsically transient social worlds model, and Star’s boundary object theory as sensitizing concepts to explore the boundaries of the social worlds of the team and how they segmented and changed over time, the roles of the team members, challenges that emerged and strategies developed to address them, and how the team members bridged the social worlds of the team.

The importance of iterative design emerged as a strong concept from the findings and this concept extended to the workings of the team as well. A model of interdisciplinary team technology development in a time-limited setting is proffered that includes inputs (activities, the project goals, and roles and responsibilities as originally understood by the team), outputs (the system, publications, project reports, and applications for new grants), intervening elements (rules, policies, and procedures and technology issues), and strategies to keep progress moving (multiple deadlines, entrepreneurialism, and a flexible role structure). Future research should be used to validate, refine, and expand the theory; to refine the research design and the instrumentation; and to further explore theoretical implications.
CHAPTER ONE
INTRODUCTION

This dissertation research project explains an intrinsically transient interdisciplinary research team’s process of collaboration across domain boundaries to design an educational technology intervention. This chapter begins with an overview of the research purpose, a statement of the problem under consideration and an overview of the significance of the research. It then presents the research questions that were used for the study; overviews of the theoretical approach, the sensitizing concepts, and the research design; and a discussion of my assumptions and biases and the limitations of the study. The chapter concludes with an overview of the organization of the dissertation.

1.1 Purpose of the Research

The purpose of this dissertation research study is to explain an intrinsically transient interdisciplinary team’s process of collaboration across domain boundaries to design an educational technology intervention. The definition of interdisciplinary research collaboration that frames the study is taken from the National Academy of Sciences (2004, p. 26):

Interdisciplinary research … is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice.

This multiple method study used grounded theory method (GTM) (Charmaz, 2006; Strauss & Corbin, 1998) situational analysis (Clarke, 2005), and social network analysis to create a robust description of a short-term project team’s processes of interdisciplinary collaboration.

1.2 Problem Statement and Significance of the Research

Government funding agencies are increasingly concerned that the research questions needed to solve scientific and social problems are too complex be addressed by single disciplines, research methods, and epistemologies (Etzkowitz, 2003; Golden-Biddle et al., 2003; Hait, 2005; National Academy of Sciences, 2004; Sellers, Caporaso, Lapidus, Petersen, & Trent, 2006). They have therefore called for interdisciplinary approaches that “hold unusual potential
for transformative outcomes” and “[transform] the way scientists do their work and how their work is reviewed and supported” (National Institutes of Health, 2004). Beyond the role of funding and funders, interdisciplinary academic research is being driven by factors such as the inherent complexity of nature and society, the drive to explore basic research problems at the interfaces of disciplines, the need to solve societal problems, and the stimulus of generative technologies (National Academy of Sciences, 2004). The comprehensiveness of interdisciplinary efforts makes them responsive to complex problems and collaboration can lead to creative approaches to complex problems (Brewer, 1999; Reich & Reich, 2006). Interdisciplinary approaches may allow for the formulation of complex research questions and the use of multiple methods, concepts, and paradigms (Klein, 1994). This can result in the establishment of new theoretical frameworks, leading to greater “explanatory coherence” (Thagard, 1997, p. 255).

A review of the literature suggests that there is scope to explore the processes of time-limited interdisciplinary research teams from a social perspective. There has been much study of teamwork, covering issues such as interactions (e.g., McGrath, Arrow, & Berdahl, 2000), emergent cognitive or affective states (e.g., Marks, Mathieu, & Zaccaro, 2001), and inputs-processes-outputs research (e.g., Hackman, 1987; Kozlowski, Gully, Nason, & Smith, 1999; McGrath, 1984; Steiner, 1972). A number of researchers have examined group processes, with subjects including group process framework (Marks et al., 2001), the effects of size (Masoodian & Apperley, 1996) and personality types (Watson, BarNir, & Pavur, 2005) on teams, and group coherence (Sheard & Kakabadse, 2002). The effect of time on time-limited teams has been studied as well (Engwall & Westling, 2004; Gersick, 1988, 1989; Grabher, 2002; Jones & Lichtenstein, 2008; Lanzara, 1983). Several studies have examined the processes of interdisciplinary academic teams (Galt, 2009; Kollasch, 2012; O’Connor, Rice, Peters, & Veryzer, 2003; Rhoten, 2003). Research on interdisciplinary work has covered structure and process connected to issues such as academic disciplinary structure, knowledge production, communication, methods and epistemologies, funding and funders, peer review, and dissemination. A research opportunity exists at the junction of studies of teamwork processes and academic interdisciplinarity. There is little literature on the processes of interdisciplinary academic teams, as most studies of teamwork process do not include academic teams and most studies of interdisciplinary academic teams do not focus on process. There is also a gap in the literature relating to processes by which time-limited teams develop over time (Bakker, 2010).
Finally, there is a need for the development of theory to frame the study of interdisciplinary team processes, as there is little literature that presents a theoretical basis for the study of the process of academic interdisciplinary teamwork.

This dissertation research project had two major outcomes: a discussion that answers the research questions posed in section 3.1 and the generation of a substantive grounded theory that explains the process of distributed team collaboration across domain boundaries to design an educational technology intervention. In addition, the proposed study produced the following artifacts:

1. The substantive theory presented as a model;
2. An ordered situational map of the project team’s situation;
3. An ordered social worlds/arenas map of the project arena’s social worlds and social worlds that intersected with the project arena;
4. Project maps of the projects social worlds and subworlds for seven project stages; and
5. Social network visualizations of the project’s social network in each project stage.

A substantive theory grounded in the experiences of an interdisciplinary research team that approaches knowledge production and knowledge production processes as socially constructed and that explores the effects of time can be used as a basis for further research into a critically important and growing area, the concepts and propositions that emerged from the research may be used to frame future research in interdisciplinary teamwork and on sociotechnical systems to support teamwork, and the maps of team processes can inform future research on multiple types of teamwork.

1.3 Research Questions

In a grounded theory study the research question or questions, while moving the research in a particular direction, must be designed to be flexible enough for all phenomena related to the subject at question to be explored thoroughly (Strauss & Corbin, 1998). Three overarching conceptual process questions guided this study in order to address its research purpose. These questions were informed by the sensitizing concepts described in Chapter Two: the social worlds perspective (Strauss, 1978, 1982, 1984), the intrinsically transient social worlds model (ITSW) (Kazmer, 2002, 2010), and boundary objects theory (Star, 1989; Star & Griesemer, 1989). These questions are:
RQ1: What defines the different social worlds of an interdisciplinary team? (Social worlds perspective)

RQ2: How do team members view and identify with the social worlds of the team? (Intrinsically transient social worlds theory)

RQ3: How do team members bridge the social worlds of the interdisciplinary team? (Boundary object theory)

Within each conceptual question, several sub-questions guided a deeper exploration of the processes targeted by each question:

RQ1: What defines the different social worlds of an interdisciplinary team?
   RQ1a: How do social worlds segment?
   RQ1b: How do social worlds change over time?
   RQ1c: How do information researchers fit into the social worlds?

RQ2: How do team members view and identify with the social worlds of the team?
   RQ2a: What role(s) do(es) each team member play in the social worlds and sub-worlds?
   RQ2b: How have each team member’s roles changed over time?
   RQ2c: What challenges emerged at critical points in the project?
   RQ2d: What strategies were developed to address challenges?

RQ3: How do team members bridge the social worlds of the interdisciplinary team?
   RQ3a: What processes and objects enable translation across social world boundaries?
   RQ3b: What processes and objects enable coherence across social world boundaries?

The three sensitizing concepts that informed these research questions are explicated in sections 1.4.2 and 2.5.

1.4 Overview of the Theoretical Approach and the Sensitizing Concepts

This dissertation research project takes a social approach to research and uses three sensitizing concepts to help ground the data.
1.4.1 The Social Approach to Research

This dissertation research project takes a social constructionist (Berger & Luckmann, 1966) approach to a multiple method grounded theory study, with the research design and the principles undergirding that design based on the proposition that the categories we use to organize and develop thoughts and objects are specific to cultural concepts (Burr, 1995). This study design also recognizes that researchers are human beings living in the world—that both “[r]esearchers and researched make assumptions about what is real, possess stocks of knowledge, occupy social statuses, and pursue purposes that influence their respective views and actions in the presence of each other” (Charmaz, 2006, p. 15). The study is also based on the social metaphor of information, which posits that information needs have social contexts because humans are social animals (Raber, 2003) and that the social contexts in which users operate affect their understanding and use of information.

1.4.2 Sensitizing Concepts

This dissertation research project primarily took a grounded theory approach to data collection, generation, and analysis (see Chapter Three for a literature review on grounded theory). Traditional grounded theory approaches are designed for the development of new theory. However, Strauss and Corbin (1998) leave room for the researcher to be aware of previously developed theory, noting that "literature can provide a rich source of events to stimulate thinking about properties and for asking conceptual questions" (p. 47). In this vein, sensitizing concepts provide "a general sense of reference and guidance in approaching empirical instances” (Blumer, 1954, p. 7).

Three sensitizing concepts informed this study’s three overarching research questions:

1. The social world perspective (Strauss, 1978, 1982, 1984) informs the research question, “What defines the different social worlds of an interdisciplinary team?”

2. Intrinsically transient social worlds theory (Kazmer, 2002, 2010) informs the research question, “How do team members view and identify with the social worlds of the team?”
3. Boundary objects theory (Star, 1989; Star & Griesemer, 1989) informs the research question, “How do team members bridge the social worlds of the interdisciplinary team?”

1.4.2.1 The social worlds perspective. The social worlds perspective (Strauss, 1978, 1982, 1984) derives from the symbolic interactionist tradition (Clarke & Gerson, 1990) and is concerned with the ways in which actors define and interpret their social interactions. Social worlds, according to Strauss, are more than arenas of discourse. There are endless numbers and types of worlds possible, and it is contingent upon the analyst to examine quotidian factors such as activities, memberships, sites, technologies, and organizations, as well as higher level areas such as discourse and symbolization. Social worlds are “characteristic of any substantive area” (Strauss, 1978, p. 122); they can be any size, public or private, with solid or porous boundaries, hierarchical or not, and class-linked or not. Through the analysis of social worlds one can understand the ways in which actors collectively create meaning and develop action (Clarke & Star, 2008). Social worlds can be examined analytically and systematically through the analysis of four facets:

- A primary *activity* (although there will be related activities) that will be “strikingly evident” (Strauss, 1978, p. 122);
- *Sites*, in which the activities occur;
- *Technology*, though which members carry out activities; and
- *Organization*, or divisions of labor that emerge.

All of these facets involve processes, which divide further into subprocesses, which can be seen in relation to each other. Social worlds continually segment into subworlds that have their own activities, sites, technologies, and organization schemes and they intersect at the subworld level, specifically in social arenas (Strauss, 1978; Strauss, Schatzman, Bucher, Erlich, & Sabshin, 1964), abstract areas of discourse where activities intersect and in which agents of the worlds interact. The social worlds perspective, through the identification and analysis of subworlds and their intersections, allows for the analysis of fluid work boundaries and the segmentation of work activities. For example, this framework can be used to understand if the social worlds and subworlds in an interdisciplinary work team coincide with disciplinary boundaries or if shared activities and processes cut across those boundaries to support interdisciplinary subworlds.
1.4.2.2 Intrinsically transient social worlds theory. Intrinsically transient social worlds (Kazmer, 2002, 2010, 2012) are designed such that “each person’s participation in the world, and sometimes the existence of the world, will end at a specific time or upon completion of a specific goal” (Kazmer, 2002, p. 20). Intrinsically transient social worlds can be collocated or distributed and the features of transience can inform studies of social world involvement, maintenance, or departure. Kazmer (2002, 2010, 2012) focuses on the process of disengagement from intrinsically transient social worlds, but the literature suggests time is an important factor in the processes of intrinsically transient teams throughout their lifespans (Grabher, 2002; Jones & Lichtenstein, 2008; Lanzara, 1983). This dissertation research project is concerned with the processes of involvement and maintenance in a time-limited intrinsically transient world that was officially collocated but exhibited features of distributed work as well.

1.4.2.3 Boundary objects theory. Boundary objects theory (Star, 1989; Star & Griesemer, 1989) extends the social worlds perspective, specifically supporting study of the intersections of social worlds and the discourses in arenas. Clarke and Star (2008) suggest that boundary object analysis can open up complicated situations through the study of participants in their relation to, and discourses about, the objects. Boundary objects cross the boundaries between social worlds. They can be abstract or concrete and have weak structure when used across social worlds but have strong structure when used in individual worlds. Because they have different but overlapping meanings across social worlds they cause information mismatches that require negotiation and translation to maintain coherence across and social worlds. This study will identify boundary objects that enable translation and coherence across the social worlds of the interdisciplinary research team.

1.5 Overview of the Research Design

This study employed a multiple methods design combining a qualitative method (GTM) and a quantitative method (social network analysis) to create a robust description of the processes of interdisciplinary collaboration (Figure 1.1). Data for the study included documentary traces of the team's activities (e-mails) and interview data.
Figure 1.1. Dissertation Research Design

To address the research questions, these data were analyzed using two methods: GTM and social network analysis (Table 1.1). The grounded theory approach integrated methods of Strauss and Corbin (1998), Charmaz (2006), and Clarke (2005) (see section 3.5 for more information). Clarke’s situational analysis applies a grounded theory approach to Strauss’s social worlds/arenas conception. It focuses on a situation of inquiry rather than individual actors, and is explicitly concerned with accounting for all the elements of that situation, including actors, nonhuman actants, discourses and the silent/implicated actors. It augmented the grounded theory analysis by providing tools to situate the analysis, to analyze the social worlds of the team, and to identify the nonhuman boundary objects at play.
<table>
<thead>
<tr>
<th>RQ</th>
<th>Sensitizing Concepts</th>
<th>Methods</th>
<th>Data Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Social worlds perspective</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td></td>
<td>Social worlds perspective</td>
<td>Social network analysis</td>
<td>E-mail header metadata</td>
</tr>
<tr>
<td>1b</td>
<td>Social worlds perspective</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td></td>
<td>Social worlds perspective</td>
<td>Social network analysis</td>
<td>E-mail header metadata</td>
</tr>
<tr>
<td>1c</td>
<td>Social worlds perspective</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td></td>
<td>Social worlds perspective</td>
<td>Social network analysis</td>
<td>E-mail header metadata</td>
</tr>
<tr>
<td>2a</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>2b</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>2c</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>2d</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>3a</td>
<td>Boundary objects theory</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>3b</td>
<td>Boundary objects theory</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
</tbody>
</table>

### 1.6 Assumptions, Biases, and Limitations

This study is based on several assumptions. The first assumption is that the groups of people form into social worlds that may subdivide and intersect. The second assumption is that such patterns apply to the research team in question. The third assumption is that the categories that we use to organize and develop thoughts and objects are socially constructed and that both researchers and research participants make assumptions about what is real that affect their interpretations of the world. The bias underlying this study is that I was a member of the team that constitutes the population for this study.

Limitations of the study include the availability of documents, the fact that it is based on one research team, and issues connected to validation of the research. This project relies to a great extent on e-mails as a source of data so their availability was a potential concern. However, the study’s research design does not call for random sampling of a full sampling frame, and the available documents offered a sufficient quantity for theoretical sampling of the data to saturation (see section 3.5.4 for an explanation of theoretical saturation). Because GTM is used to build substantive theory, the goal is not generalizability—the power of a substantive theory is its explanatory power for the population under study. While a substantive theory, with its focus on a specific situation and/or population, does not have the explanatory power of a grand theory, systematic and thorough theoretical sampling help increase its explanatory power (Strauss &
Corbin, 1998). In addition, I integrated results from the multiple methods and interviews to corroborate evidence and conclusions. Finally, the design of this study does not allow for post-positivist evaluation methods such as inter-coder reliability. Within this context however, the use of multiple types of data and multiple methods allowed me to approach concepts from a range of aspects and this represent a strength of the design. An evaluative model based on criteria from Birks and Mills (2011) and Chivotti and Piran (2003) was developed to evaluate the rigor of the study.

1.7 Organization of the Dissertation

The dissertation contains five chapters: Chapter One, Introduction; Chapter Two, Literature Review; Chapter Three, Methodology and Research Design; Chapter Four, Findings; and Chapter Five, Discussion, Implications, and Conclusion. Chapter One serves as an introduction to this dissertation research project, delineating the research purpose and significance and providing overviews of the research approach, sensitizing concepts, and research design. The literature review in Chapter Two covers relevant literature on five main topics—interdisciplinary collaboration, technology-enhanced K-12 scientific practice, iterative user-centered technology design and development, the social approach to research, and sensitizing concepts for the study—and concludes with a summary of key issues identified from the literature. Chapter Three begins with an explanation of the methodology and philosophy underlying the research design, presents the research design, and then includes details of the data collection and generation and data analysis, as well as data management techniques, evaluative criteria, strengths and limitations of the research, ethical considerations, outcomes of the research, and a summary of the chapter. Chapter Four presents the findings of the study including the situation of the research team, the social worlds of the research team, and themes constructed from the grounded theory analysis. Chapter Five answers the research questions, presents the substantive theory, and discusses implications and future research directions.

1.8 Summary

This chapter introduced the dissertation research study designed to an intrinsically transient interdisciplinary team’s process of collaboration across domain boundaries to design an educational technology intervention. It identified a need for the development of theory to frame
the study of interdisciplinary team processes, as well as a dearth of literature on the processes of interdisciplinary academic teams and a gap in the literature relating to processes by which time-limited teams develop over time. The chapter introduced the research questions that were used for the study; presented overviews of the theoretical approach, the sensitizing concepts, and the research design; my assumptions and biases; and outlined the limitations of the research. It concluded with an overview of the organization of the dissertation.
CHAPTER TWO
LITERATURE REVIEW

This chapter comprises a review of literature relevant to the study. It begins with a review of significant literature on interdisciplinary teamwork, including collaborative teams and teamwork, concepts of interdisciplinarity and characteristics of interdisciplinary research and researchers, structural and process issues related to interdisciplinarity, interdisciplinary research in library and information studies, and process studies in interdisciplinary research. It then reviews the state of play in technology-enhanced K-12 scientific practice. The next section discusses iterative user-centered technology design and development. It then gives an overview of the social approach to research, including the social constructionist framework and the social approach to information research and outlines the three sensitizing concepts that inform the research questions (the social worlds perspective, ITSW, and boundary objects theory). The chapter concludes with a summary of the findings of the literature review.

2.1 Interdisciplinary Collaboration

The literature about interdisciplinarity is vast, and much of it lies outside this project’s scope (e.g., literature on interdisciplinary academic programs, interdisciplinary epistemology, and university structural support of interdisciplinarity). This section of the literature review focuses on general studies of teamwork and studies of interdisciplinary teams, as well as providing a general context for understanding interdisciplinary work.

2.1.1 Collaborative Teams and Teamwork

Teams in one form or another are a signal feature of modern society. Teams are currently understood to be complex, with processes that are influenced by situational contexts. They have become an important factor in creating organizational adaptability and effectiveness (Kozlowski et al., 1999). Kozlowski and Ilgen (2006) present a definition of teams as

a) Two or more individuals;
b) Who socially interact (face-to-face or virtually);
c) Possess one or more common goals;
d) Are brought together to perform organizationally relevant tasks;
e) Exhibit interdependencies with respect to workflow, goals and outcomes;
f) Have different roles and responsibilities; and
g) Are together embedded in an encompassing organizational system, with boundaries and linkages to the broader system context and task environment.

The definition of teams versus groups is dynamic, with some researchers distinguishing between the terms and others using them interchangeably (Kozlowski et al., 1999; Salas, Dickinson, Converse, & Tannenbaum, 1992)

Research on teamwork focuses on a number of issues, the scope of which is too broad to contain herein, but includes interactions (e.g., McGrath, Arrow, & Berdahl, 2000), emergent cognitive or affective states (Marks et al., 2001), and inputs-processes-outputs research (Hackman, 1987; Kozlowski et al., 1999; McGrath, 1984; Steiner, 1972). In a recent literature review, Ilgen, Hollenbeck, Johnson, and Judt (2005) use the taxonomy forming (trusting, planning, and structuring), functioning (bonding, adapting, and learning), and finishing. This is reminiscent of the classic work of Tuckman (1965), which proposed four stages of group development: forming (orientation via testing of interpersonal and task boundaries), storming (interpersonal conflict and resistance to group influence), norming (ingroup cohesiveness, standards, and roles develop), and performing (interpersonal and structural issues are resolved and group energy is devoted to task performance). Tuckman and Jensen (1977) updated the model with a fifth stage, adjourning, to recognize the role of separation in group lifecycles.

A number of researchers have looked at group processes. Marks et al. (2001) proffer a group process framework (from a synthesis of previous research) that focuses on time and team processes; it includes ten processes in three categories: conflict management, motivating/confidence building, and affect management. McGrath’ conceptual framework for the study of groups (1984) includes five inputs: the properties of individuals (e.g., personality, beliefs, habits.), the properties of the group structure (patterns of relationships among the individuals), the properties of the environment (e.g., physical, social, technological), and the properties of the task or situation (patterns of relationships among the environmental inputs) that in multiple combinations affect group interaction process within a setting. Masoodian and Apperley (1996) examined the effect of size on teams, finding that small teams are more effective than larger teams. Sheard and Kakabadse (2002) identify nine factors in group coherence: clearly defined goals, priorities, roles and responsibilities, self-awareness, leadership,
group dynamics, communication, context, and infrastructure. Bradley (1982) proposed processes for ensuring ethical behavior in academic sociology teams, studying such teams as composed of “collegial, bureaucratic, and ‘quasi-primary’ forms of social organization” (p. 88).

2.1.2 Interdisciplinarity

There is a range of understandings of the concept of cross-disciplinary collaboration. A number of prefixes come into play among the definitions, such as inter-, multi-, trans-, pluri- and cross- (Salter & Hearn, 1996). However, there is little agreement on the applications of these prefixes among scholars of interdisciplinarity. Much of the definitional discussion focuses on the extent and nature of disciplinary knowledge and theory integration (Klein, 2010a; Lattuca, 2001; National Academy of Sciences, 2004). For example, Lattuca (2001) offers a laddered list of interdisciplinary approaches in which the original disciplines are less and less visible, with the most interdisciplinary approach forgoing disciplinary lenses entirely and focusing on the best methods, theories, and content to address research topics. Klein (1996) offers a taxonomy with three levels in which the least interdisciplinary category is based on problem-solving with no attempt to synthesize perspectives and the most interdisciplinary category aims toward a unity of knowledge. Both Lattuca (2001) and Klein (1996) use the term ‘transdisciplinary’ for the category representing the highest level of interdisciplinarity. On the other hand, Salter and Hearn (1996) suggest a two-category definition that distinguishes between practical and theoretical approaches: instrumental interdisciplinarity, which focuses on the problem-solving characteristics of interdisciplinary work and does not entail a fusion of different perspectives, and conceptual interdisciplinarity, a “theoretical, primarily epistemological enterprise involving internal coherence, the development of new conceptual categories, methodological unification, and long-term research and exploration” (Salter & Hearn, 1996, p. 9). Aboelela et al. (2007) propose several characteristics of multidisciplinary, interdisciplinary, and transdisciplinary research, including their different approaches to problem definition:

- Multidisciplinary: different disciplines either address the same question while utilizing different paradigms or address different but related questions.
- Interdisciplinary: the problem is described and defined in the language of at least two fields, using multiple models or intersecting models.
• Transdisciplinary: the problem is stated in new language or is addressed by theory that is broader than any one discipline. (p. 340)

For the purposes of this research, a definition from the National Academies (National Academy of Sciences, 2004, p. 26) that is flexible and focuses on motivations of problem solution and knowledge production was used:

Interdisciplinary research … is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice.

2.1.3 Characteristics of Interdisciplinary Research and Researchers

The National Academy of Sciences (2004) identifies four drivers of interdisciplinary research:

1. The inherent complexity of nature and society;
2. The drive to explore basic research problems at the interfaces of disciplines;
3. The need to solve societal problems, and
4. The stimulus of generative technologies.

Characteristics of successful interdisciplinary collaboration include “parity, reciprocity, and a common language” (Crow, Levine, & Nager, 1992, p. 739). As interdisciplinary teams continue to work together, their research questions can become more interdisciplinary as teams members’ move beyond their individual disciplinary silos (Crow et al., 1992). Benefits of interdisciplinary research include the ability to address complex research questions by employing multiple methods, concepts, and paradigms (Klein, 1994). The comprehensiveness of interdisciplinary efforts makes them responsive to complex problems (Brewer, 1999). Collaboration can lead to creative approaches to complex problems (Reich & Reich, 2006). The use of multiple methods imported from varying disciplines can result in the establishment of new theoretical frameworks, leading to greater "explanatory coherence" (Thagard, 1997, p. 255).

A common theme in the literature is that interdisciplinary research is problem-based—that researchers come together to address problems that cannot be solved using single disciplines and their associated theories and methods. In the service of solving these problems, members must take on roles and the managers of successful collaborations help members define those roles. Bärmark and Wallén (1980) identify several potential roles: theoreticians, empirical
scientists, specialists, and generalists. In this view the generalist promotes integration, providing “a link between the scientists in the group” (1980, p. 231) as “the generalist must have an understanding of the cognitive as well as the social problems of research” (1980, p. 232).

In interviews with faculty members doing interdisciplinary work, Lattuca (2001) reports that most evolved toward addressing interdisciplinary content areas and using interdisciplinary methods and theories because disciplinary-based work was not a sufficient base from which to address their research questions. A number of researchers also suggest interdisciplinarity as a researcher character trait—interdisciplinary researchers maintain disciplinary ties (although a number of them also critique their disciplines), but they enjoy working in new areas and learning new things. As one put it:

Many academics are very comfortable with becoming really expert in an area and mining it, really becoming a deep specialist in a certain field, and that is important. That’s really important. There are other people who sort of take a broad view of things or whose personality is maybe very sequentially monogamous as far as academic disciplines go—I spend a few years on this subject and then I move and spend a few years on this subject. Those are people who more naturally gravitate toward doing interdisciplinary work. For those kinds of people, I think the main reason for doing this kind of work is the intellectual challenge and excitement. It’s not for everybody and I wouldn’t say it has to be for everybody. (Lattuca, 2001, p. 219)

There is a dilemma regarding interdisciplinarity and the training of junior researchers, as the culture and structure of higher education guides graduate students to think through a disciplinary lens. The socialization of faculty starts during graduate school (Austin & McDaniels, 2006; Becher, 1987; Fagen & Suedkamp Wells, 2004; Pruitt-Logan & Gaff, 2004), and the forces working upon graduate students include the need to master a field of knowledge, the power individual faculty members hold over graduate students and their choices, the disciplinary nature of graduate student funding, and student concerns about finding jobs in a discipline-based academic culture (Golde & Gallagher, 1999). While graduate students desire opportunities to participate in interdisciplinary research and education, many are not able acquire the skills they would need to conduct interdisciplinary research as junior faculty (Austin & McDaniels, 2006; Fagen & Suedkamp Wells, 2004; Golde & Dore, 2004; Nerad, Aanerud, & Cerny, 2004; Nyquist & Woodford, 2000). However, there have been calls for students to be better prepared to work in an increasingly collaborative world (Golde & Gallagher, 1999) and for interdisciplinary research to be integrated in graduate education (National Academy of Sciences, 2004; Ostriker, Kuh, & Voytuk, 2003).
2.1.4 Structural and Process Issues

This section reviews relevant literature covering several structural and process issues related to interdisciplinary research and researchers: disciplinariness, knowledge production, methods and epistemology, funding, peer review, and dissemination.

2.1.4.1 Interdisciplinarity and disciplinariness. Interdisciplinarity “exists in the ‘white space’ of organizational charts” (Klein, 2000, p. 8). In recent years a number of studies have pointed to interdisciplinarity as a goal or strategy at research universities (Brint, 2005; Feller, 2002; Sá, 2008). However, disciplinary culture plays a large role in the lives of academic researchers, and can have multiple types of impact on interdisciplinary research teams. Cultural differences relate to traditions and norms (Huber & Shaw, 1992; Reich & Reich, 2006); Becher (1989) presents the disciplines as tribes with territories, pecking orders, patterns of communication, and hidden assumptions. Disciplinary connections are supreme in most domains, superseding and existing beyond the boundaries of individual institutions (Becher, 1987; Clark, 1986; Finkelstein, 2006). Researchers who move beyond these boundaries may risk losing their professional identities (Lattuca, 2001), and may experience higher levels of stress and more time management problems than do colleagues who pursue domain-connected research (Lattuca, 2001; Spanner, 2001). They also risk working at odds with a rewards system (e.g., promotion and tenure, publication) that is centered in the disciplines (Brewer, 1999; Kahn & Prager, 1994; Kezar, 2005; Klein, 2010b; National Academy of Sciences, 2004; Spanner, 2001). Academic pecking orders can transfer to interdisciplinary teams, with contributions by faculty from different disciplines being afforded different levels of importance (Klein, 1996).

2.1.4.2 Knowledge production. The classic view of academic knowledge production is as the result of disciplinary discourse (see for example, Clark, 1986). Tierney (2008) pushes back against the concept of disciplines as reflecting “natural categories that have developed over time” (p. 50), and instead (while not discounting the role that disciplines play) positions knowledge production as socially constructed—“the way disciplines define knowledge is constantly reinterpreted and redefined; social institutions and forces combine to determine what accounts for knowledge in a particular moment in history” (p. 52). Disciplines create knowledge, but they also limit knowledge production (Giroux, 1983; Tierney, 2008). Klein (1996) positions interdisciplinarity as disruptive knowledge production:
All interdisciplinary work is critical in that it exposes the inadequacies of the existing organization of knowledge to accomplish given tasks. … When intellectuality is premised on rediscovery and rethinking, resocialization and reintellectualization, interdisciplinarity becomes not just a way of doing things but a new way of knowing. (pp. 14-15)

Interdisciplinarity challenges “the limitations of premises of the prevailing organization of knowledge or its representation in an institutionally recognized form” (Salter & Hearn, 1996, p. 43). The Mode 1-Mode 2 taxonomy is another framework that has been proposed to understand academic knowledge production. Mode 1 represents traditional academic knowledge production, discipline-based with a homogeneous group of producers and based on the context of a specific academic community. Mode 2 is characterized by collaboration, with a preference for flatter hierarchies and transient organizations; it is more heterogeneous, more accountable to and engaged with society, and more problem-oriented in a localized context. It is transdisciplinary while drawing from disciplinary contexts (Gibbons, 2000; Jacob, 2000; Nowotny, Scott, & Gibbons, 2003).

2.1.4.3 Communication. Effective communication can be key to interdisciplinary success; however, differences in disciplinary cultures, value systems, and language may present difficulties (Boland & Tenaski, 2001; Clark, 1995; DuRussel, Derry, & Cotrell, 1996; Klein, 1996; Lattuca, 2001), with team members from different disciplines bringing their own vocabularies (Kahn & Prager, 1994; Klein, 1994; Palmer, 1996). These difficulties may lead to contested collaboration, in which “unique language, expectations, and beliefs may make negotiation of differences and mutual creation of knowledge difficult” (Sonnenwald, 1995, p. 873). Communication difficulties may be mitigated by finding common ground on which to communicate or through dominant vocabulary adoption, in which the vocabulary of one discipline is privileged (DuRussel et al., 1996). Klein (1996) suggests that “communicative competence” (p. 220), rather than bilingualism or mastery of multiple languages, is a precursor to successful interdisciplinary collaboration, and that a metalanguage, based on new and redeployed terminology, may be developed as conceptual synthesis increases. Language differences do not disappear even when they are “negotiated and mediated” (p. 221).

2.1.4.4 Methods and epistemologies. Regarding methods and epistemology, the whole can be greater than the sum of the parts in interdisciplinary collaboration:

But the need for development of sustained collaboration by interdisciplinary groups of active research scientists does not arise only from the urgency of social problems; it is intrinsic to the scientific process itself, and it becomes more acute as the accumulation of
scientific knowledge continues. No one person can comprehend the full range of that knowledge; science is a collective rather than an individual possession. Scientific training is, and must remain, specialized; no student could hope to master the content and methods of all the sciences. (Kahn & Prager, 1994)

In a study of interdisciplinary health research teams, O’Cathain, Murphy, and Nicholl (2008) report that one characteristic of successful teams is respect for disparate methods and that a principal investigator who is dedicated to integrating methods is a key part of that success. A particular issue in dysfunctional teams is a lack (or a perceived lack) of respect for qualitative methods by quantitative researchers. The authors report that “teams with the right expertise, with respect for different methods, working closely together and communicating, could exploit the contribution of each method, and attempt some form of integration of methods, be that visible or invisible in the public documentation of the study” (p. 1583). Divergent paradigms of inquiry can become a complication in interdisciplinary collaboration, especially between researchers who use hypothesis-driven positivist or post-positivist modes and those that work from critical theory or constructivist approaches. Much of this divide is disciplinary in nature, with scholars in the natural and social sciences tending to work in the first tradition and scholars in the humanities tending to use the second approach (Aboelela et al., 2007). Collaborators must understand and accept the basic theoretical and epistemological substrates of each other’s work (Caudill & Roberts, 1951; Kahn & Prager, 1994).

2.1.4.5 Funding and funders. The problem-based nature of interdisciplinary research has been a characteristic of these initiatives from early on. In the United States the federal government has encouraged interdisciplinary work, with a specific focus on improving scientific output. During World War II it was found that interdisciplinary approaches were needed to reach those ends, and in the post-war era federal funding expanded, especially with the creation of the National Science Foundation (NSF) and the National Institutes of Health (NIH). This funding was inspired by the need to address problems in a wide range of areas such as defense, aerospace, and industry (Klein, 1996; Lattuca, 2001). The NSF’s current strategic plan notes that it will “[e]mphasize interdisciplinary and system-oriented approaches that often lead to transformational concepts” in funding “research projects that hold unusual potential for transformative outcomes” (National Science Foundation, 2011, p. 7). For example, NSF’s Interdisciplinary Behavioral and Social Science Research program requires teams to include three or more senior personnel from at least two different social, behavioral, and economic
sciences disciplinary fields (National Science Foundation, 2013). The NIH has funded a number of interdisciplinary research centers in recent years (Aboelela et al., 2007) and the goal of its Interdisciplinary Research Fund is “to change academic research culture such that interdisciplinary approaches and team science spanning various biomedical and behavioral specialties are encouraged and rewarded” (National Institutes of Health, 2013, para. 1). With that said, however, funding agencies face multiple barriers to facilitating interdisciplinary research, including the traditional peer review process, the complexity of planning and coordinating recruit interdisciplinary researchers, and the complexity of scaling up such initiatives (National Academy of Sciences, 2004). And interdisciplinary research can be focused on questions and topics that cross the boundaries of funding agencies (Klein, 1996)

2.1.4.6 Peer review. Because peer review plays a large part in research funding and academic publication, the question of whether a generally discipline-based review system is biased against interdisciplinary work is important. In a study of NSF proposals, Porter and Rossini (1985) found that well-established research areas are favored over newer areas and that reviewers tend to favor proposals from their own disciplines. A citation analysis of the effect of journal rankings on the research from Innovation Studies units of Business and Management Schools in the United Kingdom reports a bias in favor of disciplinary research by the Association of Business Schools’ top-ranked journals (Rafols, Leydesdorff, O’Hare, Nightingale, & Stirling, 2012). Conversely, a study of ex post peer reviews of Dutch physics groups by an international panel (the International Review Committee for Physics) found no general evidence of peer review bias against interdisciplinary research (Rinia, van Leeuwen, van Vuren, & van Raan, 2001). It is not easy to come to conclusions based on the small corpus of literature in this area, but there is some evidence that biases against risk-taking and toward the familiar may negatively affect peer review outcomes for interdisciplinary researchers (Langfeldt, 2006; Travis & Collins, 1991).

2.1.4.7 Dissemination. Interdisciplinary researchers also face dissemination problems. In one study of cross-disciplinary researchers, Palmer notes that the researchers spent much more time importing knowledge across field boundaries than exporting it (1996). Publications are often focused on disciplines and sub-disciplines (Kahn & Prager, 1994) and this disciplinary focus not only makes it hard to disseminate findings across all potential audiences, but means
that interdisciplinary researchers must become expert in the differences in publication
conventions and language for outlets outside their home domains (Lattuca, 2001; Palmer, 1996).

2.1.5 Interdisciplinary Collaboration in Library and Information Science

Library and information science (LIS) is a historically interdisciplinary field, influenced
by multiple cognate fields such as communication, cognitive science, computer science,
linguistics, and philosophy. In fact LIS is interdisciplinary at its core, concerned with "the
organization, preservation and mobilization of knowledge across the entire landscape of
disciplines" (Palmer, 2010, p. 175; see also Baradol & Kumbar, 1998; Prebor, 2010; Saracevic,
1999 for similar comments). Bates has referred to LIS as a meta field that is “orthogonal to …
the conventional academic disciplines” (2008, p. 1044) and Gunawardan, Weber, and Agosto
(2010) note the field’s “predisposition for interdisciplinarity” (p. 211).

Interdisciplinarity in LIS is also influenced by the divergent academic portfolios of
researchers drawn to the field. Saracevic (1999) notes that “interdisciplinarity in information
science was introduced and is being perpetuated to the present by the very differences in
backgrounds of people addressing the described problems” (p.1059). Wiggins and Sawyer
(2012) present a taxonomy of domains from which the faculty of iSchools (schools of library and
information science that focus on information) are drawn. The nine categories are: computing,
information, library, social and behavioral, management and policy, science and engineering,
education, humanities, and communication. At 30 percent of the total, computing is the largest
category, and information and library together constitute 21 percent of the total. Social and
behavioral represents 10 percent, and the others are in single digits. Wiggins and Sawyer note
that faculty research streams do not necessarily comport with their educational background and
that hiring practices of individual schools are related to each school’s specific needs. However,
they conclude that intellectual diversity is a value and strength of the iSchools movement. Other
studies of LIS interdisciplinarity have examined disciplinary backgrounds. Pluzhenskaia (2007)
found that 37 percent of faculty had non-LIS PhDs. Sugimoto, Ni, Russell, and Bychowski
(2011) report that an increasing amount of LIS PhD authors have mentors with degrees in other
disciplines such as computer science, business, and communication, with a correlative decrease
in mentors holding LIS degrees.
McNichol (2003) found LIS researchers working in collaboration with researchers across a wide spectrum of domains, including learning technology, biology and biotechnology, chemistry, computer science and public health. Interviewees noted a number of reasons for working with partners outside of LIS, including finding experts and solving practical problems. The relative scarcity of LIS funding was another generator of interdisciplinarity, with LIS researchers reaching out to other funding sources. McNichol notes that in support of such interdisciplinary efforts, LIS curricula may need to be broadened, including expansion of joint degrees and collaboration with other departments, and that LIS researchers may need to become familiar with methods and concepts outside the range of their educational backgrounds.

2.1.6 Process Studies in Interdisciplinary Research

There is little literature on the processes of interdisciplinary academic teams. Much of the work in the broader area of interdisciplinarity is not focused on teamwork, and the work that exists tends toward descriptive accounts of specific team experiences (Arabi & Ahmed, 2006; Fernald & Duclos, 2005). Several studies have used grounded theory or social network analysis to explore the processes or structures of interdisciplinary academic teams. O’Connor, Rice, Peters, and Veryzer (2003) conducted a longitudinal grounded theory study of multidisciplinary academic teams, identifying issues that arise in their management. Galt (2009) conducted a grounded theory study that proposed a participatory leadership theory to explain how individuals participate in academic interdisciplinary health services research teams. Kollasch (2012) used social network analysis and social capital theory to examine the social structures of international research teams at the individual, subgroup, and team levels and the perceptions of team members of that structure. Rhoten (2003) used social network analysis and ethnography to model the structure, relations, and positions of the research networks of interdisciplinary research centers; to assess the relationship between attributes of the individuals in the networks, the conditions of their organizations, and the nature of their interactions; and to identify “hotspots” (p. 3) of interdisciplinary academic collaboration within the networks.

2.1.7 Summary of Interdisciplinary Collaboration

Teams are a signal of modern society, are understood to be complex, and have become an important factor in creating organizational adaptability and effectiveness. Research on teams has
covered questions related to interactions, emergent cognitive or affective states, and inputs-processes-outputs. A number of researchers have studied group processes, including work on time, conflict and affect management, group interaction processes, the effect of team size, and ethical behavior. The work on academic interdisciplinarity is wide-ranging. Much of the definitional discourse focuses on the extent and nature of disciplinary knowledge and theory integration; for the purposes of this research, a definition that is flexible and focuses on the motivations of problem solution and knowledge production was used. Interdisciplinary research is driven by complex social and scientific problems. Interdisciplinary researchers come together to address problems that cannot be solved using single disciplines and their associated theories and methods. A number of structural and process issues were identified, including the effect of disciplinarity traditions, knowledge production, communication, methods and epistemologies, funding, peer review, and dissemination. Library and information science is a historically interdisciplinary field influenced by multiple cognate fields and by the divergent academic portfolios of researchers drawn to the field (although faculty research streams do not necessarily comport with their educational backgrounds). Several studies that have used grounded theory or social network analysis to explore the processes or structures of interdisciplinary academic teams were identified.

2.2 Technology-Enhanced K-12 Scientific Practice

New models of inquiry learning for K-12 students need new types of support. In this approach to science education, students become working scientists, doing background research, conducting investigations and experiments, collecting and analyzing data, and presenting and distributing their findings to colleagues (i.e., other students and teachers). Therefore, students’ use of technology is not just a matter of gaining proficiency—technology becomes a part of the student scientist’s tool kit, just as it is for adult scientists.

This section defines the concept of scientific practice, discusses some of the major challenges inherent in developing curricula to support scientific practices, and reports on several ways that technology can help overcome these challenges.
2.2.1 K-12 Scientific Practice

The newest K-12 science standards, *The Next Generation Science Standards*, were released in April 2013 (Achieve, Inc., 2014). The standards were conceived based on the idea that science and engineering concepts undergird all aspects of modern life and it is essential for all citizens to understand these concepts in order to participate in public life, to understand and evaluate public policy, and to make personal decisions, and that education in these areas prepares students for lifelong learning (National Research Council, 2012). The framework developed by the National Research Council (NRC) includes three dimensions: the practices that scientists use to investigate and build models and theories about the natural world and the practices that engineers use to build models and systems; the crosscutting concepts that link scientific disciplines and help students develop empirical models of the natural world; and disciplinary core ideas from the physical sciences; the life sciences; the earth and space sciences; and engineering, technology and applications of science. These new standards were based on earlier work and standards that position scientific inquiry skills (along with nature of science knowledge) as the basis of scientific literacy. This approach calls for students to understand and to be able to work with the culture and language of science in the service of learning about science and about the world (Barab & Luehmann, 2003). It is an active, constructivist, learning model in which students are supported in taking control of their own scientific learning rather than a transmission model in which students are supplied with scientific knowledge (Abrams, Southerland, & Evans, 2008).

Practice-based instruction is generally understood to involve students “‘doing’ science to learn about the world” (Abrams et al., 2008, p. xvi)—in other words, students should have authentic, real-world scientific experiences. The NRC promotes this student-centered, hands-on approach, stating that “students who are proficient in science 1) know, use, and interpret scientific explanations of the natural world; 2) generate and evaluate scientific evidence and explanations; 3) understand the nature and development of scientific knowledge; and 4) participate productively in scientific practices and discourse” (Duschl, Schweingruber, & Shouse, 2007, p. 2). Windschitl, Thompson, and Braaten (2008) propose a framework for student inquiry that lays out five features of scientific knowledge: it is testable (based on models or theories that can be evaluated through data collection), revisable (can change based on new evidence), explanatory (causal explanations are sought, rather than descriptions of phenomena),
conjectural (causes may be based on inferences from the data) and generative (scientific knowledge is not an end in itself but is the basis of further work). This framework is proposed as a way for students to create their own investigations to answer their own questions about the world. Students develop their own learning goals instead of being presented with research questions and experiments that will answer those questions (Barab, MaKinster, Moore, & Cunningham, 2001; Windschitl et al., 2008). Young (1993) suggests messiness is another facet of real-world science that should be included in the inquiry classroom—goals and data should not always be clear.

A number of challenges confront those who would create curricula that support this approach:

- **Contextualizing inquiry and providing support for students:** This involves creating investigations or experiments, collecting and analyzing data, working with rich datasets, and sharing data and findings (Reiser, Krajcik, Moje, & Marx, 2003) and producing and finding deep stores of resources (Barab & Luehmann, 2003).

- **Localizing university-designed curricula:** Teachers must work within local cultures and will have other curricula that they must implement. They will need support to implement innovative curricula (Barab & Luehmann, 2003; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003).

- **Meeting science standards:** National and state science standards are written inclusively, to "enumerate all important exemplars of a concept or possible values of a category" (Reiser et al., 2003, p. 14). Project-centric inquiry curricula must find a balance between addressing the encyclopedic nature of the standards and the time and focus inherent in problem solving activities. Teachers may want to address this issue through a lecture format that can lead to a superficial understanding of the material and a focus on the memorization of facts that might be soon forgotten as opposed to a deep connection with the material (Barab & Luehmann, 2003; Reiser et al., 2003).

- **Reconciling innovative teaching best practices with demands for accountability:** In the current climate, curriculum designers must take into account the criteria by which student learning is evaluated by legislators and policy makers who demand "scientifically based educational research" (D. T. Hickey & Zuiker, 2003, p. 541) such as randomized controlled trials.
Scalability and sustainability: If curricula are to be implemented in multiple schools they must be flexible to meet the needs of the diverse situations in which teachers work (for example, teachers may be unable to divide students into groups or to allow students to work individually), the many types of teachers that will be using the curricula (teachers run the gamut from newly hired to experienced and self-starting), and the resources that available to teachers (Songer, Lee, & McDonald, 2003).

Teacher knowledge: Teachers need to be prepared to work in this way, and many science teachers lack subject area and technology knowledge (Crawford & Cullin, 2004; Flick & Bell, 2000; Hew & Brush, 2007; Windschitl, 2003). Curricula may need to scaffold teacher learning as well as student learning (Squire et al., 2003).

2.2.2 Technology-Enhanced Scientific Practice

Researchers have called for schools to institute a new kind of science classroom and a pedagogy that supports students in conducting their own investigations, integrating the use of technological tools into the curriculum (Linn, Davis, & Bell, 2004; Reiser et al., 2003). Blumenfeld et al. (2000) suggest that project-based learning experiences include (a) a driving question that is connected to a real problem to organize the investigation; (b) student learning through the development of artifacts; (c) collaboration among students, teachers, and others; and (d) use of cognitive technological tools. In this model students learn actively about science by designing and conducting experiments and working collaboratively with other students, discussing understandings and coming to conclusions (Barab & Luehmann, 2003). Barab, Hay and Duffy (1998) provide a framework of technology support for student learning, with technology being used as an information resource to support inquiry, for content contextualization to situate learning, as a communication tool to facilitate collaborative and distributed learning, as a construction kit to provide building tools, and for visualization and manipulation. Similarly, the NRC’s components of technological fluency for students include: engaging in sustained reasoning, managing complexity, testing solutions, managing problems in faulty solutions, organizing, navigating, and evaluating information, collaboration, communication with audiences, and expecting the unexpected (National Research Council, 1999). Technology supports students in activities that they would not otherwise be able to do (such as modeling complex systems) and can add breadth and flexibility to student scientific
practice by making multiple types of resources available in different formats, on different levels, and when they are needed. Technology tools make data collection and manipulation easier and more efficient, enabling students to focus on critical thinking (Novak & Krajcik, 2004).

Information-rich technology environments help students learn the critical thinking and analysis skills that they will need to fully participate as citizens. Research that addresses the curricular and technology problems that inhibit the best use of technology can take the form of iterative design experiments, in which design innovations are introduced and lessons learned inform the next design generation. Barab and Luehmann (2003) note that because “design experiments develop theory based on practice, they are likely to lead to the development of designs that are trustworthy, credible, transferable, and ecologically valid” (p. 459). However, much of the research on information-rich technology environments is focused on classrooms in more privileged schools, those that have resources and teachers that are self-starting and innovative. Schools and classrooms in these programs may also have support from technology researchers and other technology experts. (Songer et al., 2003).

2.2.3 Barriers to Technology Integration

A number of barriers to technology integration and enablers for technology integration have been identified, including resources, knowledge and skills, leadership and institutional support, attitudes and beliefs, and assessment issues.

- Resource issues: This is a wide-ranging barrier that includes not only lack of hardware and software, but also problems related to lack of technology access, time, and technical support. Of course, lack of technology itself is a big problem, but the multiple facets of this barrier work interchangeably. For example, in schools that provide technology, access issues can range from placing the equipment in over-used computer labs to prioritizing access to technology by subject domain. Even in situations in which teachers have access to technology, they may not be provided with the time to plan and prepare for its use and to integrate it into their curriculum (such as being able to create presentations and find needed resources). Other problems, such as unreliable Internet connectivity, continue to bedevil teachers. Finally, extant support personnel may have too many support requests to be able to respond in a timely manner or with the full support necessary (Hew & Brush, 2007; Lee & Songer, 2001).
• Knowledge and skills issues: Knowledge and skill issues include lack of knowledge and experience in using technology, including basic computer and Internet skills such as logging onto a network and more advanced skills such as the use of databases and spreadsheets. But technology-related pedagogy skills are as important, especially in areas essential to scientific inquiry such as data manipulation and visualization for the purposes of developing and answering research questions. For teachers to be able to suffuse curricula with “transformative” (Hew & Brush, 2007, p. 228) uses of technology (in which technology is not being used merely to supplant other media such as posters or to make work easier or more efficient) they need professional support and training opportunities that go beyond basic technology use. Technology-related classroom management skills, such as creating procedures that ensure that all students have access to equipment and managing the classroom atmosphere during technology use, are also essential (Hew & Brush, 2007; Songer, Lee, & Kam, 2002).

• Leadership and institutional issues: Institutional issues include supervisor support, class scheduling, and technology planning. Support issues include a lack of understanding by principals of the impact of technology in the classroom. School schedules can inhibit teachers’ use of technology where inflexible schedules do not provide enough time for teachers to implement technology into the curriculum. Large class sizes can inhibit the teachers’ ability to create one-on-one technology experiences. Finally, schools cannot just bring in technology without first developing an implementation plan that supports a shared vision of why technology is being implemented and how best to do so (Barab & Luehmann, 2003; Hew & Brush, 2007).

• Attitudes, beliefs, and culture issues: Teacher attitudes (feelings about issues) and beliefs (premises that are thought to be true) about technology have been found to impact its use and integration into the curriculum. Teachers may consider computers to involve busywork, or to be most useful as a reward. Subject culture, or the ways in which teachers view technology in relationship to pedagogical norms in their subject domains, has also been found to be a barrier (Hew & Brush, 2007). However, one can speculate that science is an area in which this would be less of a problem than in, for example, the arts.
• **Assessment issues:** The assessment barrier is related to the existence of the high-stakes testing culture. Such testing can result in the need for teachers to cover a large amount of material related to standardized tests; this may crowd out time for other pedagogical activities, or teachers may feel that the best way to transmit this material is through lecturing rather than the use of individualized activities. The testing culture can also lead to a minimization of learning activities that do not have specific official assessments, or that do not conform to the way that tests are given (e.g., not allowing students to use technology that will not be available to them during a test). Finally, schools may need to utilize their existing technology assets for testing-related activities rather than learning opportunities (Barab & Luehmann, 2003; Hew & Brush, 2007).

### 2.2.4 Enabling Technology Integration

In discussions of barriers and enablers, the list of enablers tends to be a mirror image of the barriers list. The essential proposition, therefore, is to identify strategies that can be employed to eliminate, or more realistically, minimize identified barriers.

• **Leadership and strategic planning:** Leadership and strategic planning are overarching strategies to address technology integration barriers. A technology integration plan that includes goals for technology use and a plan for how to achieve those goals can help school leaders involve teachers in creating a vision beyond the idea of just buying and installing technology. Ensuring that the technology plan addresses a vision of the way forward that is shared among key constituencies in the school, especially in terms of the connection to curriculum, such as how technology tools can be used to scaffold learning. This means that technology is not just considered a standalone issue, but as an integrated part of the school’s overall vision of its goals for student learning and the methods by which those goals can be implemented successfully (Hew & Brush, 2007; Johnston, 2012).

• **Resource issues:** In order to overcome resource issues, strategic use of available resources is suggested, such as saving money and space by equipping classrooms with systems that include only monitors and network connection devices instead of full desktop computers and saving the need for a computer lab setup through the use of Wi-Fi-enabled laptops that can be provided to students one-to-one on an as-needed basis.
Another idea for doing away with computer labs involves spreading the available workstations among the classrooms, creating computer stations that can be rotated through during class. Technology can be introduced to the school in a planned rollout that brings it into one or two subject areas at a time, which would allow for those classrooms and teachers to have adequate resources rather than spreading resources thinly across the entire school (Hew & Brush, 2007)

- Usable and scalable tools: Technology tools should be appropriate for the classroom situation (Barab & Luehmann, 2003).

- Professional development. Hew and Brush (2007) report that the most effective development programs for technology integration build a platform by focusing on knowledge and skills such as basic technical skills, technology-enhanced pedagogy, and classroom management skills. Building on this platform, teachers should be offered active learning experiences, such as observing expert teachers (Hodson, 1988). Finally, development programs should be designed in response to teachers’ needs, such as presenting the information that they need when they need it (Hew & Brush, 2007).

- Assessment. Alternate assessment techniques for technology-infused curricula have been proposed, but a more immediate way to address the assessment barrier is to align technology-supported curricula with state standards. This strategy can not only help teachers address individual standards and help students meet the standards, but might even help schools address standards-related areas in which they are failing (Hew & Brush, 2007).

### 2.2.5 Summary of Technology-Enhanced K-12 Scientific Practice

New models of inquiry learning for K-12 students need new types of support. The latest K-12 science standards were conceived based on the propositions that science and engineering concepts undergird all aspects of modern life, that it is essential for citizens to understand these concepts in order to participate in public life, and that education in these areas prepares students for life-long learning. This approach is active and constructivist, calls for students to understand and to be able to work with the culture and language of science in the service of learning about science and about the world, and supports students in taking control of their own scientific learning. A number of challenges confront the curriculum designers including contextualizing
inquiry and scaffolding students, localizing university-designed curricula, meeting science standards, reconciling innovative teaching practices with the demands for accountability, making curricula scalable and sustainable, and working with wide ranges of teacher knowledge. Technology supports students in activities that they would not otherwise be able to do and technology tools make data collection and manipulation easier and more efficient, enabling students to focus on critical thinking. A number of barriers to technology integration have been identified related to resources; knowledge and skills; leadership and institutional issues; attitudes, beliefs, and culture; and assessment. Enablers that can minimize barriers are focused on leadership and strategic planning, resources, usable and scalable tools, professional development, and alternate assessment techniques.

2.3 Iterative User-Centered Technology Design and Development

This section describes the philosophy and practice of user-centered design (UCD) as it relates to technology design and the iterative design and development processes utilized by many UCD practitioners.

2.3.1 User-Centered Design

UCD is a philosophy and process in which end users of products are involved in their design, either directly by being brought into the design process or by proxy through research that takes into account user needs, desires, and capabilities. Donald Norman, an early proponent of UCD, suggests that design should:

• Make it easy to determine what actions are possible at any moment (make use of constraints).
• Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions.
• Make it easy to evaluate the current state of the system.
• Follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state. (1988, p. 188)

In support of these general goals and in the service of making tasks simple to complete, he proposes seven design principles:
1. Use both knowledge in the world and knowledge in the head. Three mental models—the design model (the designer’s conceptualization), the user’s model (the user’s explanation of how the system operates), and the system image (the system’s appearance, operations, and user response and the physical documentation of these things)—must comport with each other. The designer and the user can only communicate through the system.

2. Simplify the structure of tasks. Planning and problem solving time should be minimized to decrease the cognitive load on the user. Both short-term memory limitations (users will only be able to remember about five items at a time) and long-term memory limitations (information is more easily acquired if it relates to the user’s conceptual framework) should be taken into account.

3. Make things visible: bridge the gulfs of Execution and Evaluation. Make clear to users the actions that are possible, how they can be accomplished, and the effects they produce. System states should be clear and interpretable and outcomes obvious.

4. Get the mappings right. Users must be able to see the relationships between intentions and possible actions, and between actions and outcomes—graphics will best convey this type of information.

5. Exploit the power of constraints, both natural and artificial. Reduce the number of perceived alternative actions to the one correct action.

6. Design for error. Assume that all possible errors will be encountered; help users recover from errors and make it hard for them to commit irredeemable errors.

7. When all else fails, standardize. While standardization may be hard (e.g., coming to agreement on standards), standardized systems only have to be learned once. (Norman, 1988, pp. 188–189)

Preece, Rogers, and Sharp describe the goal of interaction design as “optimiz[ing] the users’ interactions with a system, environment, or product, so that they match the users’ activities that are being supported and extended” (2002, p. 5). Design principals that move interaction design in this direction support designers in understanding users’ abilities, needs and desires, and in determining how best to support user tasks. This process involves four activities:

1. Identifying needs and establishing requirements.
2. Developing alternative designs that meet those requirements.
3. Building interactive versions of the designs so that they can be communicated and assessed.

4. Evaluating what is being built throughout the process. (Preece et al., 2002, p. 12)

Gould and Lewis (1985) suggest three principals for UCD: early focus on users and tasks (understanding users by studying them and observing while they accomplish tasks), empirical measurement (of users as they interact with scenarios, manuals, simulations, and prototypes), and iterative design (conducting as many cycles of “design, test, measure, and redesign” (1985, p. 300) as are necessary to identify and fix problems users have in interacting with the design). Nielsen (1993b) proposes that usable systems have five attributes: they are easy to learn (learnability), use (efficiency), and remember (memorability); they produce low error rates (errors), and users should find them “pleasant to use” (p. 26) (satisfaction). When designers focus on these attributes they produce systems that require short learning curves, support high levels of productivity, demand little retraining for long-term use, keep users from encountering catastrophic errors and support easy recovery from smaller errors, and produce satisfied users.

In order to move the design focus from the technology to the user, one must identify the users of the system, software, website, etc. “People who interact directly with the product to achieve a task” (Preece et al., 2002, p. 171) is a simple definition, but mostly likely there are many stakeholders who have influence and control (directly or indirectly) over the system requirements, such as the development team, managers, users of the system’s output, and workers displaced by the new technology (Preece et al., 2002; Rosson & Carroll, 2002). Each of these groups will have information and views relevant to the development process that cannot be obtained from representatives of other groups (Rosson & Carroll, 2002).


2.3.2 Iterative Design and Development

Design is a process through which new goals are discovered—it is both formal and empirical (Carroll & Rosson, 1985). This process does not proceed in a straight line toward a specific goal, and it usually involves creating interim products that may be discarded as the
process proceeds (Carroll & Rosson, 1985; Dow et al., 2005). Abstract design goals are based on functional and usability objectives and specifications are built, tested, and rebuilt through an iterative “looping process” (Carroll & Rosson, 1985, p. 12) that typically includes activities such as background research (e.g., work interviews, focus groups, user observation), brainstorming, prototyping, walkthroughs and simulations, development, user testing, and evaluation (Dow et al., 2005; Preece et al., 2002).

Usability objectives must be testable and operationalizing behavioral sub skills enhances usability testing. Testing should begin early in the process. Specifications are provisional and contingent on testing outcomes and designers must be willing to alter or discard them as necessary throughout the process (Carroll & Rosson, 1985). It is also likely that new design problems will be identified through multiple iterations—for example, fixing a problem may create other issues and minor problems may be found lurking beneath major problems (Nielsen, 1993b). Nielsen suggests a minimum of three design versions. He analyzed the outcomes of iterative design testing for four projects and over 12 total iterations studied, the median usability improvement per iteration was 38% and overall usability improvement for the four projects ranged from 41% to 882% (Nielsen, 1993a).

A survey of experienced UCD practitioners who had at least three years of experience and considered UCD as their primary job identified 13 UCD methods, of which iterative design was reported as far and away the most-used, followed by usability evaluation, task analysis, informal expert review, and field studies (including contextual inquiry) as the next most used, focus groups, formal heuristic evaluations, prototyping without user testing, and user interviews in the next group, and surveys, user requirements analysis, participatory design, and card sorting lagging behind in reported usage. A benefits-weaknesses analysis was also conducted, and speed, cost, and perceived validity/quality of results were the factors with the most impact on the results. For iterative design, validity/quality and low cost were considered benefits and speed was considered a weakness, with all three factors showing some of the highest number of mentions (24, 17, and 24, respectively). In contrast, formal heuristic evaluation was considered a benefit for all three factors, but was mentioned much less overall (6 for validity/reliability, 9 for low cost, and 10 for speed) (Mao, Vredenburg, Smith, & Carey, 2005; Vredenburg, Mao, Smith, & Carey, 2002). All of the methods mentioned above can be used as part of the iterative design process, and perceived benefits and weaknesses of methods may affect their inclusion in the mix.
For example, usability analysis, which was considered to have a benefit of validity/reliability (6 mentions) and weaknesses of low cost and speed (6 and 3 mentions) (Vredenburg et al., 2002) can be supplemented with heuristic evaluation (Nielsen, 1993b; Shneiderman & Plaisant, 2004) and discount usability testing (Nielsen, 1993b).

2.3.3 Summary of Iterative User-Centered Technology Design and Development

UCD is a design philosophy and process that focuses on user needs. A number of researchers in human-computer interaction have proposed user-center design principles such as supporting human cognitive needs, simplifying tasks, making potential actions and their outcomes visible, and mitigating user errors. Multiple stakeholders who affect and are affected by design decisions must be taken into account throughout the process. The iterative design model includes activities such as background research, brainstorming, prototyping, walkthroughs and simulations, development, user testing, and evaluation can aid in creating and testing specifications. The development of multiple design iterations in which interim products are created and discarded as needed supports the identification of design problems before development is complete. Many tools are available for UCD design, and experienced practitioners have been found to use a balancing test related to speed, cost, and perceived validity/quality of results when weighing which tools to employ.

2.4 The Social Approach to Research

Guba and Lincoln (1994) describe paradigms as human constructions—that “any given paradigm represents simply the most informed and sophisticated view that its proponents have been able to devise, given the way they have chosen to respond to the three defining questions [ontological, epistemological, and methodological]” (p. 108). Because this research project is primarily qualitative, it is important to place it in a context in which the outcomes may be evaluated and understood. This section of the literature review therefore presents a social constructionist worldview in which the research can be placed and describes the social approach to information science.
2.4.1 Social Constructionism

This dissertation research project takes a social constructionist (Berger & Luckmann, 1966) approach to the question of reality, with the research design and the principles undergirding that design based on the proposition that the categories that we use to organize and develop thoughts and objects are specific to cultural concepts (Burr, 1995). In this view we use symbols and language to construct an order for the world, and humans both create society and are its product (Berger & Luckmann, 1966). The proposition that humans both create, and are products of, society is the result of a dialectic process of externalization (the production of reality by individuals as they use classification to understand and process the world around them), objectivation (the transformation in which subjective classifications come to be viewed as objective facts that are external to human experience), internalization (socialization, as individuals internalize the objectified subjective realities and the constructed reality comes to be understood as a naturally occurring phenomenon of social order) and institutionalization (habitualized actions come to be shared by members of a social group) leads to legitimation (the original nature of the institution is removed from the actors, and it is legitimized). Social order is created through externalization and objectification. However, once individuals are socialized through internalization and institutionalization, they become products of society (Berger & Luckmann, 1966).

The sociology of knowledge flows from phenomenology (Schneider, 2005; Wallace & Wolf, 1999) and the social constructionism of Berger and Luckmann is influenced by sociological phenomenology. However, their emphasis is less on philosophical questions about reality than on a practical analysis of the ways in which specific people in specific situations and contexts construct and understand reality. Their argument is that the only way to understand the social processes through which a shared understanding of reality is developed and maintained is to take into account the social realities and contexts of particular cultures (1966). Another view of this comes from Searle (1995), who proffers an ontology of institutional reality. His claim is that institutional facts exist because people collectively apply to the institutions status functions that do not exist vis-à-vis their physical status. The status of the institution derives from the ability of humans to work collectively and to apply symbols to objects. But as opposed to physical facts, symbols only mean what people agree they mean, and institutions are social, not physical, facts (Searle, 1997; Smith & Searle, 2003).
Constructionism has also been influenced by Foucault and discourse analysis. Discourse analysis is not completely congruent with constructionism, but the concepts are connected through the idea of discourse as enabling knowledge formation. Once one subscribes to that turn of thought, the idea that different discourses will lead to different types of knowledge production is a natural next step (Miller, 2008; Tuominen & Savolainen, 1997; Tuominen, Talja, & Savolainen, 2005). There are a number of constructionist themes that run through Foucault’s work, most specifically his investigations of power and the ethical self. A key stream of thought is the study of disciplinary power, and how power relationships influence societies’ understanding of and creation of truths. In Foucault’s work on the ethical self, the self has to be discovered through reflection—in other words, it is a story, or a construction. Discourse analysis provided the basis for the adoption of constructionist frames in the study of information behavior. This work is part of a larger “linguistic turn” (Talja, Tuominen, & Savolainen, 2005, p. 329) in the social sciences. Discourse is studied to understand how people use conversation about their experiences and feelings to construct meaning. Constructionism in information studies works on the assumption that discourse and dialogue are used to create experience and to construct the categories by which experience is understood (Talja et al., 2005; Tuominen & Savolainen, 1997). The constructionist framework is applied in research of information seeking through discourse (such as accounts of information needs and professional and scientific discourse) and for the design of systems for collaborative knowledge work (Tuominen et al., 2005).

Critics of the social constructionist worldview have noted a perceived relativism and revisionism in its core concepts (Gubrium & Holstein, 2008; Hacking, 2000). However, the varieties known as strong (King, 2004) or vulgar (Best, 2008) constructionism are more likely to be accused of this failing. This study is based on the weaker variety propounded by Berger and Luckmann, which does not propose that objective reality does not exist, merely that our understanding of the world is socially constructed. This study design also recognizes that researchers are human beings living in the world. Charmaz (2006), in describing the constructivist approach to grounded theory, notes:

We are not scientific observers who can dismiss scrutiny of our values by claiming scientific neutrality and authority. Neither observer nor observed come to a scene untouched by the world. Researchers and researched make assumptions about what is
real, possess stocks of knowledge, occupy social statuses, and pursue purposes that influence their respective views and actions in the presence of each other (p. 15).

Qualitative researchers are therefore obligated to practice reflexivity to better understand their approaches and how these approaches affect their perceptions of what they see and their interpretations of what they see. The strength of a constructionist approach to research lies in that very understanding of the illusory nature of human-perceived reality. Researchers who take this approach are more likely to understand their own assumptions and can therefore attempt to account for and minimize them to the extent possible (as opposed to merely minimizing generic human fallibility); just as importantly, they can reveal and acknowledge their assumptions and the processes by which they attempt to minimize the effect on their research so that readers may understand the context(s) in which research was produced.

2.4.2 The Social Approach to Information Science

The social metaphor of information posits that information needs have social contexts because humans are social animals; the social contexts in which users operate are understood to affect their understanding and use of information, and information can be studied as more than an individual phenomenon (Raber, 2003). In the social approach, information cannot be disconnected from its political context—the idea of a natural social or information environment is intrinsically political because information environments are socially constructed (Frohmann, 1992, 1994; Raber, 2003). The physical and cognitive paradigms of information science focus on the information needs of individuals (Raber, 2003). While the cognitive paradigm seeks to involve users, it still operationalizes as a method for experts to determine what users need, why they need it, and how to get it to them—the locus of authority is centralized. When information is considered as a collaborative, social phenomenon, knowledge production and dissemination can be studied in a many-to-many context (Karamuatuoglu, 1998). In this view, knowledge is constructed through ongoing discourses in which identity is fluid and provisional (Frohmann, 1992, 1994; Talja et al., 2005; Tuominen et al., 2005). Information research in this area tends to be problem-oriented and have empirical and theoretical bases, with much of the work focused on knowledge production practices and the use and design of collaborative information systems (Kling, 1999; Sawyer & Eschenfelder, 2002; Tuominen et al., 2005).
2.4.3 Summary of the Social Approach to Research

A social constructionist research approach is based on the propositions that the categories that we use to organize and develop thoughts and objects are specific to cultural concepts, that we use symbols and language to construct an order for the world, and that humans both create society and are its product. This approach comports well with a qualitative research design as it can support researchers in understanding and accounting for their assumptions and in acknowledging them so that readers may understand the context(s) in which research was produced. The social metaphor of information posits that information needs have social contexts that affect users’ understanding and use of information. When information is considered as a collaborative and social phenomenon knowledge production and dissemination can be studied as an ongoing discourse. Much of the information research in this area focuses on knowledge production practices and the use and design of collaborative information systems.

2.5 Sensitizing Concepts

This dissertation research project primarily takes a grounded theory approach to data collection, generation, and analysis (see Chapter Three for a literature review on grounded theory). Traditional grounded theory approaches are designed for the development of new theory. For Glaser (who was concerned about data forcing), although the researcher will have a general understanding of the problem area, "learning not to know is crucial to maintaining sensitivity to data" (Heath & Cowley, 2004, p. 143) and the traditional literature review comes toward the end, providing more data points for the emerging theory (Heath & Cowley, 2004; G. Hickey, 1997). However, Strauss and Corbin (1998) leave room for the researcher to be aware of previously developed theory, noting that "literature can provide a rich source of events to stimulate thinking about properties and for asking conceptual questions" (p. 47). In this vein, sensitizing concepts provide "a general sense of reference and guidance in approaching empirical instances. Whereas definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look" (Blumer, 1954, p. 7). So while theories provide a structural framework for more objectivist types of research, sensitizing concepts are "points of departure from which to study the data" (Charmaz, 2003, p. 259) in the grounded theory approach.
This section provides background on the three sensitizing concepts that inform this study's three overarching research questions: the social world perspective (Strauss, 1978, 1982, 1984), ITSW (Kazmer, 2002, 2010), and boundary objects theory (Star, 1989; Star & Griesemer, 1989).

2.5.1 The Social Worlds Perspective

The social worlds perspective (Strauss, 1978, 1982, 1984) derives from the symbolic interactionist tradition (Clarke & Gerson, 1990) and is concerned with the ways in which actors define and interpret their social interactions. Social worlds analysis is "centered around examining what people do as well as what they say they do, situated in the larger contexts of careers, materials, techniques, theories, organizations, and professions" (Clarke & Star, 2003, p. 539). Strauss (1978, 1982, 1984) was not the first sociologist to theorize the existence of social worlds; most immediately he was extending Shibutani’s concept of reference groups (1955), but much of the work of the symbolic interactionists of the Chicago School is concerned with social change among groups (Clarke & Star, 2008; Strauss, 1978). Social worlds, according to Strauss, are more than arenas of discourse. There are endless numbers and types of worlds possible, and it is contingent upon the analyst to examine quotidian factors such as activities, memberships, sites, technologies, and organizations, as well as higher level areas such as discourse and symbolization. Social worlds can be enormous or tiny, well-established or “so emergent as to be barely graspable” (Strauss, 1978, p. 121), public or private. Their boundaries can be solid or evanescent, they can be hierarchical or display a flat structure. They can be class-linked or can cut across classes. Social worlds, in other words, are “characteristic of any substantive area” (p. 122); through the analysis of social worlds one can understand the ways in which actors collectively create meaning and develop action (Clarke & Star, 2008). Clarke (1997) identifies three types of social worlds: productions worlds, communal worlds, and social movements. Production worlds are places where activities are geared toward production, including production of knowledge. In communal worlds, activities focus on the establishment and maintenance of communities bound by shared goals. Finally, the activities of actors in social movements focus on shared commitments to change. This dissertation research study is concerned with the first type, specifically, the social worlds of a productive academic research team.
Social worlds can be examined analytically and systematically. The analysis is concerned specifically with a quartet of facets. First, the social world revolves around a primary activity (although there will be related activities); this will be “strikingly evident” (Strauss, 1978, p. 122).

These activities need space in which to occur, hence the facet of sites. Its members will need tools with which to carry out activities, and this entails technology (which can become complex). And for all this to work, divisions of labor or organization will emerge. All of these facets involve processes, which divide further into subprocesses, which can be seen in relation to each other. Social worlds intersect through strategic alliances; they are fluid and contain multiple perspectives, and so continually segment into subworlds that have their own activities, sites, technologies, and organization schemes. This subworld level is where intersections occur, specifically in social arenas (Strauss, 1978; Strauss et al., 1964), abstract areas of discourse where activities intersect and in which agents of the subworlds negotiate action, including the establishment of work boundaries (Clarke & Star, 2008; Strauss, 1982). According to Strauss, “a major analytic task is to discover the intersections and to trace the associated processes, strategies, and consequences” (Strauss, 1978, p. 123). Therefore, the social worlds perspective, through the identification and analysis of subworlds and their intersections, allows for the analysis of the construction of fluid work boundaries and the segmentation of work activities. For example, this framework can be used to understand if the social worlds and subworlds in an interdisciplinary work team coincide with disciplinary boundaries or if shared activities and processes cut across those boundaries to support interdisciplinary subworlds.

### 2.5.1.1 Segmentation of social worlds.

Strauss (1984) identified six specific sources of social world segmentation: space, objects, technology and skill, ideology, intersections, and recruitment. Spatial distinctions could be regional or topographical. Objects may be a source of segmentation because specialists within the larger world are associated with specific types of objects. Subworld segmentation based on technologies and skills is usually generated by the specific types of activities performed using the technologies. Ideological differences can be the outcome of disagreements about authenticity. Subworlds develop in several ways. A subworld can “bud off” (Strauss, 1984, p. 126) from the main social world when groups at different sites feel sufficiently different to identify as a specific group or when new specializations of activity and technology arise. The evolution of subworlds can be more like a revolution, in which case the “fervor of ideological position is so evident that the budding off is better referred to as
splitting off” (Strauss, 1984, p. 126). New subworlds can also be produced through the intersection of social worlds when technologies and activities bridge the worlds.

Strauss proposed that whether subworlds bud off, split off, or are created by the intersection of worlds, they evolve through seven processes which are continuous and overlapping: forming, defining and building a legitimate core activity, differentiating, rewriting and writing history, competing for resources, debating and maneuvering in arenas, and further segmenting (Strauss, 1984). The work of segmentation is the work of differentiation. Subworlds begin to form when some members of a social world begin to do something differently—for example, they start to perform activities of the social world at a different place or in a different way—and others in the social world are also doing this thing at this different place or in this different way. The subworld may be perceived as a band of compatriots by others even before members of the subworld see it themselves, but at some point it achieves coherence—or it doesn’t. Nascent groups may break up over boredom, rivalries, a lack of interest in risking the differentiation, and so on. But subworlds that maintain themselves for a length of time differentiate through organizing (to various extents) around their core activities, designing their own sites, networks, and technologies. The care and feeding of the subworld involves differentiation activities that may be more or less aggressive—the subworld must define its differences with other subworlds but not to the point that it is no longer part of the parent world. The differentiating activities also involve telling the subworld’s story—not only writing contemporary history, but also actually rewriting the history of the parent social world or the subworld. Subworld segmentation is a story of commitment and a story of conflict. Subworlds must compete for resources (to different extents as resources are not equitably distributed in the parent world) and they intersect in arenas where they debate and negotiate. External and internal debates may be existential, and they encompass questions about activity, organization, resources, and technologies. Amidst all this, even with strong segments of the subworld maneuvering to keep it together, the segmentation process continues, with subworlds intersecting, budding, splitting, splintering, and evolving.

2.5.1.2 Legitimation of social worlds. Inside social worlds and in their subworlds, questions about the authenticity of social world membership and the activities of the worlds can arise—“organizations or subworlds, not just persons, may compete for claimed and awarded authority” (Strauss, 1978, p. 124). These issues lead to questions of legitimation, such as about
the mechanisms through which the power to authenticate is bestowed. Strauss highlights five legitimation processes: discovering and claiming worth; distancing; theorizing; standard setting, embodying, evaluating; and boundary setting and boundary challenging (Strauss, 1982). Social worlds *claim worth* based on their particular specializations of activities or technologies—the claim of worthiness flows from their evaluation that their particular “core activities” (1982, p. 174) are worth doing. This is a collective conviction, and the collective recognition that the subworld’s activities are worthy may mutate into a feeling that they are essential. Claims of legitimacy involve at least some conflict within and across the parent world as they are connected to claims on resources. *Distancing* may describe a more radical split from the main world when subworlds begin defining their worthiness in comparison to other worlds—the people in these subworlds begin to think they are more worthy than those of other subworlds. This tends to occur in subworlds that have splintered off from the parent world. Distance may also be achieved less from how the subworld was born but in the activities that differentiate it from the other subworlds. Distancing can occur through closeness as well, as when subworlds evolve through the association of likeminded members strolling off from other parts of the parent world. But it is the “distancing process” (1982, p. 176), not the distancing tactics, that is essential. *Theorizing* is the work that subworlds do toward internal legitimation. This process may be undertaken in defense if the subworld comes under “antagonistic scrutiny” (1982, p. 176) from outside—promulgators of established fill-in-the-blank (truth, beauty, propriety, etc.) may attack with force to stop subworld formation. Theorizing may also be undertaken as part of the subworld’s conceptualization process. This may involve great disagreements and conflicts as the subworld’s “legitimate order” (1982, p. 178) is debated—resource allocation issues and rewriting history come into play here as well. Subworlds undertake *standard setting* as they develop exemplifications and models of best practices. Standards that are initially implicit become explicit and formalized. Standard setting is also a process of authentication—negotiation or conflict about what is authentically part of the subworld and which members have the power, (or earn the power, or take the power) to authenticate. Subworlds may also fight for authenticity or status *within* the parent world. Finally, some portion of the authenticity argument is about the legitimate boundaries of the subworld. *Boundary setting and boundary challenging* represents the work of legitimating the activities that are part of the subworld, especially at its gray and fuzzy edges. The question of who authenticates comes into play here as well—if an influential
member of the subworld commits boundary-stretching acts, the boundary may very well stretch. But too much boundary stretching leads to further segmentation.

2.5.2 Intrinsically Transient Social Worlds

As described above, social worlds and subworlds are fluid and constantly segmenting. This means that not all social worlds are permanent. ITSWs (Kazmer, 2002, 2010, 2012) are designed such that “each person’s participation in the world, and sometimes the existence of the world, will end at a specific time or upon completion of a specific goal” (Kazmer, 2002, p. 20). Kazmer (2002) notes that the end of the social world or the actor’s movement out of it, may lead purposely to a ‘logical next world’; that transience can be associated with the actors in the world rather than the worlds themselves; that ITSWs can be colocated or distributed; and that the features of transience can inform studies of social world involvement, maintenance, or departure.

This dissertation research project is concerned with the processes of involvement and maintenance in a time-limited intrinsically transient world that was officially colocated but exhibited features of distributed work as well.

Kazmer’s original model (2002) was developed through the investigation of an online LIS Master’s degree program and includes 12 dimensions: (1) experiencing intrinsic transience, (2) entrainment with a cohort, (3) managing time, (4) shifting focus, (5) pursuing goals, (6) adapting role and identity, (7) moving support, (8) changing the footing of relationships, (9) joining logical next worlds, (10) taking leave and graduating, (11) disengaging from the cohort, and (12) losing membership. She later tested and refined the model by applying it to a distributed, time-limited, grant-funded research project group (Kazmer, 2010), finding that six dimensions (experiencing intrinsic transience, entrainment with a cohort, shifting focus, changing footing of relationships, disengaging from the cohort, and closing membership) were very similar to their original conceptions, that four dimensions (managing time and money, pursuing goals, adapting role and identity, and joining next logical worlds) were still operational but demonstrated different characteristics from their original conceptions, and that two dimensions (moving support and leave-taking) were not germane to the different type of group. She also found two new dimensions through open, emergent coding of the data: preexisting relationships and product.
2.5.2.1 Experiencing intrinsic transience. Group members were aware of the time-limited nature of their undertaking, as it applied both to group work and to personal planning. In the first area, group members displayed a continual awareness of the strictures that the funding’s time limit imposed on their output of materials. In the second area, group members were found to be aware of the effect of the group’s intrinsic transience on decisions regarding career and academic planning (for example, whether they would be staying with the parent organization after the grant ended).

2.5.2.2 Entrainment with a cohort. Kazmer found that activities designed to draw in and incorporate members with the group were performed. Regular face-to-face meetings led to relationship building as well as coordination of activities. The regular schedule of the meetings was found to be a key characteristic, serving to “punctuate the shared progress of the group” (Kazmer, 2010, p. 765). The nature of the meetings changed throughout the time the group shared, moving from preliminary training meetings to work meetings that served as “reunion[s]” (p. 765) in which materials could be reviewed together.

2.5.2.3 Managing time and money. The time-limited nature of such groups is inherent in the typical way in which academic researchers describe their projects (e.g., “a 3-year, $2.5-million project”) (Kazmer, 2010, p. 766). But Kazmer describes other ways that group members understood the project that focus on time and money, such as the constraints inherent in working on multiple projects versus having the funding available to work on one project and individual group members’ changing time allocations on the project over its lifetime.

2.5.2.4 Shifting focus. The focus of group members shifted from internal to external matters as the project neared its end. The external view was exemplified by a focus on product dissemination to external stakeholders such as the funding agency, external users, and academic audiences. This change in focus was a major characteristic of the way in which group members viewed the end stages of the project—Kazmer notes that the subject was broached by interview subjects on their own in response to a mere general prompt about the ending of the project.

2.5.2.5 Pursuing goals. A laser-like focus on project goals was detected in the interviews, with group members subordinating discussion of any personal or professional goals they might have had. This focus was necessarily different than it had been in the original project, in which the students’ goals in completing the master’s degree were exclusively personal.
**2.5.2.6 Adapting role and identity.** Group member roles shifted and adapted over the life of the project. The evolution of role identities was based on the shifting needs of the project over time, but could also be based on an individual member’s conception of project needs. For example, a Web design team member not only noted an evolution in responsibilities from transcribing existing information into the Web pages to site and procedure redesign, but described a process of “trying to impose myself on the various procedures in that they involved the Web, to make sure things got to me, and in general, just taking a lot more initiative in finding more gaps I could fill” (Kazmer, 2010, p. 766).

**2.5.2.7 Changing the footing of relationships.** As the project was ending, disengagement from the group entailed changes in “the expected and real frequency, medium, and purpose and content” (Kazmer, 2010, p. 765) of interactions. In some cases this represented changes in a member’s relationship with the group as a whole, such as a decrease in interaction. Changes in footing among individual members were contingent on specific factors, such as whether the members expected a continuing professional relationship through other projects.

**2.5.2.8 Preexisting relationships.** A number of group members had known each other and worked together previously; in fact, some had very long-term existing relationships. A shared history affected both the members’ project work (e.g., common frames of reference and vocabulary enhancing work processes) and their expectations of continuing relationships after the ending of the project. This relates not only to actual continuing work relationships, but also to individual member’s ease of transition out of the project.

**2.5.2.9 Joining logical next worlds.** For many of the project members, the next logical world was another academic grant project (although the graduate students were looking for new jobs). But even for the student members, success in joining the next logical world was not contingent on successful completion of the project (as it was for the original model’s graduate students completing Master’s degrees). Indeed, for most members the transition to the next logical world was not dramatic; many group members viewed the project as one of a “flow of ongoing projects, where the next logical world is a continuation of multiple related projects” (Kazmer, 2010, p. 767).

**2.5.2.10 Disengaging from the cohort.** While the project itself had a fixed start and end date, group member leave-taking was seen throughout the project: Most members stayed for the length of the project, but others were “lead[ers]” (Kazmer, 2010, p. 765) through early
disengagement. Kazmer notes that some members expressed a desire for continued connection to the project even though they were aware of the hard deadline for group dissolution.

2.5.2.11 Closing membership. As part of the disengagement process, group members were seen to be ready to close their relationships with the group and move on. This aspect is exemplified by the characteristic of forgetting—members noted this in a number of ways, such as forgetting details of the project.

2.5.2.12 Product. The shared nature of the project’s product (a database) significantly affected group member disengagement. Even before the process of general disengagement began, the project enabled group cohesion, giving members “a shared focus and a mutual stake in its success” (Kazmer, 2010, p. 768). During the run of the project it also enabled the disengagement “lead[ers]” (Kazmer, 2010, p. 765) to be confident that their leaving would not negatively affect delivery of the product.

2.5.2.13 Other studies of transience. Other studies have identified the effect of transience on group work as well. In discussing what he calls “collectivities of practice” (as opposed to communities of practice), Lindkvist (2005) notes some characteristics of short term business projects in which teams change for each assignment: working with a set of goals (time, money, outcome quality), the team has “freedom with responsibility” (p. 1200), in which there is great autonomy regarding how to reach the set goals, and project members represent a range of knowledge bases and methodologies. Because team members are coordinating activity in a short time frame without a shared knowledge base, they must rely on “‘cool cooperation’ based on ‘swift trust’” (p. 1200). Myerson, Weick, and Kramer (1996) lay out dimensions of such “temporary systems” (p. 169):

1. Participants with diverse skills are assembled by a contractor to enact expertise they already possess.
2. Participants have limited history working together.
3. Participants often are part of limited labor pools and overlapping networks.
4. Tasks are often complex and involve interdependent work.
5. Tasks have a deadline.
6. Assigned tasks are nonroutine and not well understood.
7. Assigned tasks are consequential.
8. Continuous interrelating is required to produce an outcome.
So here we have intersecting social worlds (diverse skill sets, limited history, overlapping networks), intrinsically transient (deadline), with a need to be able to work cooperatively (nonroutine consequential tasks with interrelating required to produce an outcome).

In general, the literature suggests time is an important factor in the processes of intrinsically transient teams throughout their lifespans (Grabher, 2002; Jones & Lichtenstein, 2008; Lanzara, 1983). Time as a work pattern, with short-term teams experiencing punctuated equilibrium in which change is a sudden event (Engwall & Westling, 2004; Gersick, 1988, 1989), has been shown to be a factor. Gersick (1988) reports that progress is related to team members’ awareness of passing time rather than the amount of work completed in each delineated stage—teams were seen to experience cycling states of inertia and revolution (e.g., a jolt of activity at a project’s halfway point) throughout the project. In contrast, Kazmer’s refined model (2010) found that group members had an ongoing awareness of time throughout the project. Bakker (2010) identifies a gap in the literature related to alternate visions of how temporary forms develop over time, for example, concepts of linear versus cyclical time.

2.5.3 Boundary Objects and Social Worlds

Boundary object theory (Star, 1989; Star & Griesemer, 1989) extends the social worlds perspective, specifically supporting study of the intersections of social worlds and the discourses in arenas. Clarke and Star (2008) suggest that boundary object analysis can open up complicated situations through the study of participants in their relation to, and discourses about, the objects. Bowker and Star (2000) note the use of boundary objects in managing information needs at the intersections of social worlds:

Boundary objects are those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use and become strongly structured in individual–site use. (p. 297)

Boundary objects can be abstract or concrete, have specific meanings for different social worlds and are the “sites of intense controversy and competition for the power to define them” (Clarke & Star, 2008, p. 121). At the same time, because their structure “is common enough to more than one world to make them recognizable,” (Star & Griesemer, 1989, p. 412) they are able to support translation across social world boundaries by “facilitat[ing] cooperation without
consensus” and enabling *coherence* across the social world boundaries (Clarke & Star, 2008, p. 121). Boundary objects were theorized to explain that process. To wit:

- The object (a set of work arrangements that are material and processual) resides between social worlds where it is ill structured.
- When necessary, the object is worked on by local groups who maintain its vaguer identity as a common object, while making it more specific, more tailored to local use within a social world, and therefore useful for work that is not interdisciplinary.
- Groups that are cooperating without consensus move back and forth between the two forms of the object (Star, 2010, pp. 604–605).

Boundary objects can become infrastructure when the movement between the vague and specific versions either scales up or becomes standardized (Bowker & Star, 2000; Star, 2010; Star & Ruhleder, 1996), and there are forms and processes related to boundary objects that are yet to be uncovered (Star, 2010).

Lyndkvist (2005) suggests that project goals can function as a boundary object for a work team, providing explicit guidance about both required outcomes and some constraints (e.g., time and money) to all, while adapting to local needs (in this case, different team specialties).

Star and Griesemer’s original case was the creation of a natural history museum in the early part of the twentieth century, where actors (researchers, amateurs, administrators, and others) with shared objectives (e.g., promoting the protection of species and developing a guide to fauna and flora) but different specific goals and points of view, cooperated in research and species categorization projects. The researchers found that boundary objects supported this cooperation while allowing the various actors to work toward their own objectives. For example, in the course of a project, two maps of California were drawn, one by amateurs and conservationists and another by the scientists. The amateur/conservationist map looked like a roadmap and highlighted campgrounds, trails, and places to collect specimens; the scientists’ map detailed ecological life zones. In this case the boundary object was the state of California, robust enough to translate across the social world boundaries and to support both maps; the state was also plastic enough to support local (amateur/conservationist and scientist) needs (Star & Griesemer, 1989).
2.5.4 Summary of Sensitizing Concepts

In a grounded theory study a sensitizing concept can be used as a jumping off point from which to study and contextualize phenomena in a specific situation. This study was guided by three sensitizing concepts: the social worlds perspective, intrinsically transient social worlds, and boundary objects theory. The social worlds perspective is concerned with the ways in which actors define and interpret their social interactions. The identification and analysis of subworlds and their intersections allows for the analysis of the construction of fluid work boundaries and the segmentation of work activities. An intrinsically transient social world has a definite ending point either because the world ends or because individuals’ participation in the world has a logical end point. The ITSW model includes 12 dimensions and focuses on disengagement from intrinsically transient worlds. Boundary objects theory extends the social worlds perspective, supporting study of the intersections of social worlds and the discourses in arenas. Boundary objects cross the boundaries between social worlds; they have different but overlapping meanings across social worlds and cause information mismatches that require negotiation and translation to maintain coherence across the worlds.

2.6 Summary of Findings from the Literature Review

This chapter has established the need for research into the processes of time-limited educational technology development-focused interdisciplinary research teams from a social perspective. The key findings from the literature review are that there has been much study of teamwork, including work on group processes and the effect of time on time-limited teams; studies have also examined the processes of interdisciplinary academic teams; and research on interdisciplinary work has covered structure and process connected to issues such as academic disciplinary structure, knowledge production, communication, methods and epistemologies, funding and funders, peer review, and dissemination. However, there is little literature on the processes of interdisciplinary academic teams and there is also a gap in the literature relating to processes by which time-limited teams develop over time. There is also little literature that presents a theoretical basis for the study of the process of academic interdisciplinary teamwork.

It is essential that research continue to address curricular and technology problems that inhibit the best use of technology for K-12 scientific practice, as there are both barriers and
enablers to K-12 technology integration. Information-rich technology environments help students learn the critical thinking and analysis skills that they will need to fully participate as citizens. Design is a process through which new goals are discovered, but it does not proceed in a straight line toward a specific goal, and it usually involves creating interim products that may be discarded as the process proceeds. User-centered design principals support designers in understanding users’ abilities, needs and desires, and in determining how best to support users tasks.

The literature review provided several theoretical constructs that can be used as sensitizing concepts for a grounded theory study of the social world processes of academic research teams. These constructs can support research on social world formation and segmentation, the effects of time on time-limited research projects, and ways in which such teams can promote translation and coherence across disciplinary boundaries. The following chapter outlines a research study with the goal of producing a robust explanation of an intrinsically transient interdisciplinary team’s process of collaboration across domain boundaries to design an educational technology intervention.
CHAPTER THREE
METHODOLOGY AND RESEARCH DESIGN

This chapter outlines the research methodology and design for this multiple method exploratory grounded research dissertation research study. It begins by describing the research purpose and delineating the research questions, and then provides context for the research design through a discussion of the philosophical and methodological underpinnings of the study. Next, the chapter details the study’s design and research methods, including the research setting, and data collection, analysis, and data management procedures. It then discusses the outcomes of the study, criteria by which the finished study was evaluated, the limitations of the research, and ethical considerations. The chapter closes with a summary of the method.

3.1 Research Questions

The purpose of this dissertation research study is to explain the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team working on an educational technology intervention. In a grounded theory study the research questions, while moving the research in a particular direction, must be designed to be flexible enough for all phenomena related to the subject at question to be explored thoroughly (Strauss & Corbin, 1998). Three overarching conceptual process questions guided the study in order to address its research purpose. These questions are informed by the sensitizing concepts described in Chapter Two: the social worlds perspective (Strauss, 1978, 1982, 1984), ITSW (Kazmer, 2002, 2010), and boundary objects theory (Star, 1989; Star & Griesemer, 1989).

RQ1: What defines the different social worlds of an interdisciplinary team? (Social worlds perspective)

RQ2: How do team members view and identify with the social worlds of the team? (ITSW)

RQ 3: How do team members bridge the social worlds of the interdisciplinary team? (Boundary object theory)

Within each conceptual question, several sub-questions guided a deeper exploration of the processes targeted by each question:

RQ1: What defines the different social worlds of an interdisciplinary team?
RQ1a: How do social worlds segment?
RQ1b: How do social worlds change over time?
RQ1c: How do information researchers fit into the social worlds?

RQ2: How do team members view and identify with the social worlds of the team?
RQ2a: What role(s) do(es) each team member play in the social worlds and sub-worlds?
RQ2b: How have each team member’s roles changed over time?
RQ2c: What challenges emerged at critical points in the project?
RQ2d: What strategies were developed to address challenges?

RQ3: How do team members bridge the social worlds of the interdisciplinary team?
RQ3a: What processes and objects enable translation across social world boundaries?
RQ3b: What processes and objects enable coherence across social world boundaries?

These questions guided a study using GTM and social network analysis that resulted in the generation of a substantive grounded theory to explain the process of the interdisciplinary team’s collaboration across domain boundaries.

3.2 Philosophical and Methodological Foundations

Researchers using qualitative methods address the problems at hand within the context of a philosophical worldview that is based on five facets: ontological, epistemological, axiological, rhetorical, and methodological assumptions (Creswell, 2007). Because the choices made for these areas affect the methodological choices the researcher makes, it is essential that they be discussed to create context for the research design outline to follow.

3.2.1 Social Constructionism

Guba and Lincoln (1994) describe paradigms as human constructions—that “any given paradigm represents simply the most informed and sophisticated view that its proponents have been able to devise, given the way they have chosen to respond to the three defining questions [ontological, epistemological, and methodological]” (p. 108). As described in Chapter Two, this dissertation research project takes a social constructionist (Berger & Luckmann, 1966) approach
to the questions of reality, with the research design and the principles undergirding that design based on the proposition that our understanding of the world develops through social and cultural processes such as communication and negotiation rather than through the revelation of objective realities. This idea of social process promotes the proposition that multiple cultural communities can contribute multiple points of view to knowledge production, while maintaining that no community owns the truth (Gergen, 2003; Schneider, 2006). Social constructionism presents in opposition to the empiricist tradition—Schneider describes social constructionism as a way to critique theories that promote a view that “this simply is the way things are and/or always have been” (2006, para. 1). Social constructionists understand the categories that we use to organize and develop thoughts and objects as being specific to cultural concepts (Burr, 1995). Following Berger and Luckman (1966), this study is based on a vision of social constructionism that is concerned with a practical analysis of the ways in which specific people in specific situations and contexts construct and understand reality.

### 3.2.2 Qualitative Research

Denzin and Lincoln (2005, p. 3) provide a definition for qualitative research in which the approach is described as situated and interpretive, with an observer working to understand the meanings people bring to phenomena:

Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves and interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them.

This definition shows how a qualitative research design can comport well with a social constructionist research framework in which the researcher is endeavoring to understand how people make sense of the world. Creswell (2007) suggests employing qualitative methods to achieve a “complex, detailed understanding of the issue,” (p. 40) by “talking directly with people, going to their homes or places of work,” (p. 40) to “empower individuals to share their stories, hear their voices, and minimize the power relationships that often exist between a researcher and the participants of a study” (p. 40). Qualitative field research allows for a comprehensive, holistic understanding of behaviors in their natural setting and of social processes over time.
(Babbie, 2013; Patton, 2002; Strauss & Corbin, 1998). This dissertation research study is primarily qualitative; however, a quantitative component was integrated with the results of the qualitative analysis to provide another view of the data.

3.2.3 Grounded Theory Approach to Inquiry

This research project has been developed using the principles and processes of GTM, which was introduced by Glaser and Strauss in their landmark sociological monograph, *The Discovery of Grounded Theory: Strategies for Qualitative Research* (1967). In the forty-plus years that have elapsed since that first publication, Glaser and Strauss independently continued to develop the method (with Strauss partnering with Juliet Corbin), followed by the so-called “second generation” of grounded theorists such as Kathy Charmaz and Adele E. Clark (Morse et al., 2009). The professional split of Glaser and Strauss led to the development of Glaserian and Straussian flavors (Cutcliffe, 2005), with Strauss pursuing his work with Corbin (Strauss & Corbin, 1990, 1998) and Corbin continuing their work after Strauss’ death (Corbin & Strauss, 2008). The form of grounded theory that Strauss moved toward was more relativistic, coming out of his background in symbolic interactionism and his assumption that there were no truths to be uncovered (Mills, Chapman, Bonner, & Francis, 2007). Mills, Bonner, and Francis (2006) and Mills et al. (2007) locate the genesis of the constructivist version of grounded theory in the work of Strauss and Corbin and their use of techniques that focus the researcher on co-constructing meaning with participants. This move past the knowable truth continued with Charmaz (2003, 2006, 2008) and Clarke (2003, 2005). Charmaz, who explicitly identifies her grounded theory as constructivist, seeks “an interpretive portrayal of the studied world, not an exact picture of it” (Charmaz, 2006, p. 10). Clarke’s situational analysis connects grounded theory to Strauss’ social worlds perspective (Morse et al., 2009).

The goal of grounded theory qualitative research as described by Glaser and Strauss is to develop theory about interactions and processes that is grounded through the use of data collected in the field (Glaser, 1978; Glaser & Strauss, 1967; Strauss & Corbin, 1998). GTM represents a combination of deductive and inductive reasoning. While deduction moves from the general to the specific and induction moves from the specific to the general, in grounded theory, reasoning is abductive—data is scrutinized and all possible explanations are considered as the researcher proves and disproves hypotheses until the most plausible explanation for the observed
data is determined (Birks & Mills, 2011; Charmaz, 2006; Reichertz, 2010). In GTM the “researcher does not begin a project with a preconceived theory in mind (unless his or her purpose is to elaborate and extend existing theory). Rather, the researcher begins with an area of study and allows the theory to emerge from the data” (Strauss & Corbin, 1998, p. 12). The methodology “provides a sense of vision, where it is that the analyst wants to go with the research. The techniques and procedures (method) on the other hand, furnish the means for bridging that vision to reality” (p. 8). However, (Strauss & Corbin, 1998) leave room for the researcher to be aware of previously developed theory. These sensitizing concepts (Blumer, 1954; Charmaz, 2006) provide a jumping off point for grounded theory research.

When the generation of theory is the goal of a grounded theory study, the outcome is a substantive theory. A substantive theory “aims to address a studied phenomenon in a specific situation” (Birks & Mills, 2011, p. 173). Therefore, a grounded theory is an explanation of processes, actions, or interactions based on the experiences of study participants. The theory subsequently can help guide practice or act as a framework for future research (Strauss & Corbin, 1998). Qualitative analysis “involves a radically different way of thinking about data” (Strauss & Corbin, 1998, p. 59). Birks and Mills (2011, pp. 9–12) describe nine essential elements of grounded theory practice:

- Initial coding and categorization of data;
- Concurrent data generation or collection;
- Writing memos;
- Theoretical sampling;
- Constant comparative analysis;
- Theoretical sensitivity;
- Intermediate coding;
- Identifying a core category; and
- Advanced coding and theoretical integration.

Procedures and terminology vary amongst the various grounded theory versions, especially regarding the strictness of procedure. However, the essence of GTM is constant comparative analysis and concurrent and iterative data collection and analysis, with the collection of each dataset (e.g., a set of interviews or a set of documents) inciting analysis, and that analysis
informing both the data collection instruments for the next round of data collection and future data analysis.

3.2.4 Rationale for the Use of Grounded Theory

Birks and Mills (2011) delineate three situations in which the use of grounded theory is appropriate:

1. Little is known about the area of study;
2. The generation of theory with explanatory power is a desired outcome; and
3. An inherent process is imbedded in the research situation that is likely to be explicated by grounded theory methods (p. 16).

All three of the Birks and Mills (2011) criteria pertain to this study to some degree. The second rationale (desire to generate theory) is a driving factor for the development of this dissertation project. The third rationale (the likelihood of the grounded theory to explain process) is also extremely applicable, as the multiple disciplinary backgrounds of members of the research team being studied for the dissertation suggest the existence of multiple social worlds and the use of boundary objects for communication. Regarding the first rationale (little is known about the area of study), although there have been numerous studies of interdisciplinarity, there has been little focus on theory generation to date. Finally, a grounded theory approach is appropriate because this dissertation research project is a study of process, which a number of grounded theory proponents maintain is a key characteristic of grounded theory work (e.g., Birks & Mills, 2011; Charmaz, 2006; Strauss & Corbin, 1998).

3.3 Research Design

The design of this dissertation research study is based on three broad conceptual areas of inquiry: How team social worlds are identified, how team members understand the social worlds of the team, and how the social worlds are bridged. A multiple methods design in which a qualitative method (GTM) and a quantitative method (social network analysis) were combined was employed to create a robust description of the processes of interdisciplinary collaboration.
Figure 3.1. Research Design

Two types of data were collected and generated for this study: documentary traces (Geiger & Ribes, 2011) of the team's activities, which included e-mails and meeting minutes, and interview data (see section 3.5, Data Collection, Generation, and Analysis, for more information). Table 3.1 details the types of data and methods that were employed for each research sub-question. The meeting minutes documents were not coded for this analysis, because only 10 sets of minutes existed as standalone documents—the meeting minutes were also distributed via e-mail and the team stopped saving separate meeting minutes documents early in the project’s life. To address the research questions, these data were analyzed using GTM (Charmaz, 2006; Clarke, 2005; Strauss & Corbin, 1998) and social network analysis (Figure 3.1).
Table 3.1
Alignment of Research Questions, Sensitizing Concepts, Methods, and Data Types

<table>
<thead>
<tr>
<th>RQs</th>
<th>Sensitizing Concepts</th>
<th>Methods</th>
<th>Data Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Social worlds perspective</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td></td>
<td>Social worlds perspective</td>
<td>Social network analysis</td>
<td>E-mail header metadata</td>
</tr>
<tr>
<td>1b</td>
<td>Social worlds perspective</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td></td>
<td>Social worlds perspective</td>
<td>Social network analysis</td>
<td>E-mail header metadata</td>
</tr>
<tr>
<td>1c</td>
<td>Social worlds perspective</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td></td>
<td>Social worlds perspective</td>
<td>Social network analysis</td>
<td>E-mail header metadata</td>
</tr>
<tr>
<td>2a</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>2b</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>2c</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>2d</td>
<td>IITSW</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>3a</td>
<td>Boundary objects theory</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
<tr>
<td>3b</td>
<td>Boundary objects theory</td>
<td>GTM</td>
<td>E-mails and interviews</td>
</tr>
</tbody>
</table>

3.4 Research Setting and Population

The population for this study is an interdisciplinary academic team working at an RU/VH public university in the southeastern United States. The team was working on a no-cost extension year (the grant was originally for three years but a fourth year was added) of an education technology grant from the U.S. Department of Education’s Institute for Education Studies (IES) during data collection. Over the course of the grant term the team included a principal investigator, four co-investigators, and 25 undergraduate and graduate students. The domains represented by the team members include library and information studies, teacher education, instructional design, computer science, information technology, mathematics, and art (Table 3.2). Further information about the team and the project are provided in section 4.1.1.

For this study I took an emic, or insider, approach (Creswell, 2007). This perspective is necessary because I was a student member of the interdisciplinary team. Insider status is both a positive and a negative—while it provides the researcher with a deeper understanding of the research setting, procedures must be put in place to ensure objectivity on the part of the researcher (Strauss & Corbin, 1998).
Table 3.2

Team Composition

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Home Department</th>
<th>Project Stages*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Investigators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>Information</td>
<td>1-7</td>
</tr>
<tr>
<td>CoPI1</td>
<td>Information/Institute</td>
<td>1-4</td>
</tr>
<tr>
<td>CoPI2</td>
<td>Teacher Education</td>
<td>1-7</td>
</tr>
<tr>
<td>Co-PI3</td>
<td>Teacher Education</td>
<td>1-7</td>
</tr>
<tr>
<td>Co-PI4</td>
<td>Information</td>
<td>4-7</td>
</tr>
<tr>
<td>Graduate Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS1</td>
<td>Computer Science</td>
<td>1</td>
</tr>
<tr>
<td>Design1</td>
<td>Communication</td>
<td>1-4</td>
</tr>
<tr>
<td>IS1</td>
<td>Instructional Systems</td>
<td>1-6</td>
</tr>
<tr>
<td>IS2</td>
<td>Instructional Systems</td>
<td>6</td>
</tr>
<tr>
<td>IS3</td>
<td>Instructional Systems</td>
<td>6</td>
</tr>
<tr>
<td>LIS1</td>
<td>Information</td>
<td>1-7</td>
</tr>
<tr>
<td>LIS2</td>
<td>Information</td>
<td>2-4</td>
</tr>
<tr>
<td>TeachEd1</td>
<td>Teacher Education</td>
<td>1-6</td>
</tr>
<tr>
<td>TeachEd8</td>
<td>Teacher Education</td>
<td>6-7</td>
</tr>
<tr>
<td>Undergraduate Students</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS2</td>
<td>Computer Science</td>
<td>1-6</td>
</tr>
<tr>
<td>CS3</td>
<td>Computer Science</td>
<td>5-7</td>
</tr>
<tr>
<td>Design2</td>
<td>Art/Information Technology</td>
<td>1-6</td>
</tr>
<tr>
<td>Design3</td>
<td>Art</td>
<td>4-6</td>
</tr>
<tr>
<td>Design4</td>
<td>Art</td>
<td>4-6</td>
</tr>
<tr>
<td>IntlEd</td>
<td>International Education</td>
<td>4-6</td>
</tr>
<tr>
<td>IT1</td>
<td>Information Technology</td>
<td>1-4</td>
</tr>
<tr>
<td>IT2</td>
<td>Information Technology</td>
<td>2</td>
</tr>
<tr>
<td>IT3</td>
<td>Information Technology</td>
<td>2</td>
</tr>
<tr>
<td>IT4</td>
<td>Information/Math/Business</td>
<td>5-6</td>
</tr>
<tr>
<td>TeachEd2</td>
<td>Biology/Education</td>
<td>4</td>
</tr>
<tr>
<td>TeachEd3</td>
<td>Biology/Education</td>
<td>4</td>
</tr>
<tr>
<td>TeachEd4</td>
<td>Mathematics/Education</td>
<td>4</td>
</tr>
<tr>
<td>TeachEd5</td>
<td>Biology/Education</td>
<td>4-5</td>
</tr>
<tr>
<td>TeachEd6</td>
<td>Mathematics/Education</td>
<td>4-6</td>
</tr>
<tr>
<td>TeachEd7</td>
<td>Education</td>
<td>6</td>
</tr>
</tbody>
</table>

*Team member worked on the project for at least a portion of the project stage

3.5 Data Collection, Generation, and Analysis

Two data types were used for this dissertation research study: e-mails and interviews. Data analysis was conducted using GTM (Charmaz, 2006; Clarke, 2005; Strauss & Corbin, 1998) and social network analysis. GTM was used to construct major themes from the data and situational analysis (Clarke, 2005) to analyze the situation of the project team and its social
worlds and arenas. Social network analysis (using e-mail metadata) was used to supplement the situational analysis of the team’s social worlds. Document collection took place in January 2014. Document analysis, interview data generation, and interview data analysis were conducted iteratively and concurrently from February 2014 through July 2014.

3.5.1 Entering the Field

The principal investigator and co-principal investigators of the team were approached with the idea for this research project as the idea was being developed and they agreed in principle to participate.

3.5.2 Document Collection

The documents collected included project e-mails and meeting minutes. Project e-mails were collected from three team members (including the principal investigator) who touched many different aspects of the project and had retained all project e-mails that flowed through their accounts. Each set of e-mails was imported into a password-protected Filemaker Pro 11 database, which was sorted and expunged of duplicate records. Team meeting notes were downloaded from the project website and imported into a second Filemaker Pro 11 database. Each e-mail and meeting note document was assigned a unique identification number (Record). The e-mail database included the fields Record, Timestamp, From, To, Cc, Subject, Body. The meeting minutes were not coded for this analysis because there were only 10 standalone minutes documents and they were duplicated in e-mails.

Table 3.3

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Stage Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial planning/initial design and development</td>
<td>9 months</td>
</tr>
<tr>
<td>2</td>
<td>Alpha test and continuing development</td>
<td>1 month</td>
</tr>
<tr>
<td>3</td>
<td>Teacher workshops 1/beta test preparation/development</td>
<td>3 months</td>
</tr>
<tr>
<td>4</td>
<td>Beta test and analysis/development</td>
<td>9 months</td>
</tr>
<tr>
<td>5</td>
<td>Teacher workshops 2/pilot test preparation/development</td>
<td>3 months</td>
</tr>
<tr>
<td>6</td>
<td>Pilot test and analysis/development</td>
<td>9 months</td>
</tr>
<tr>
<td>7</td>
<td>Finishing</td>
<td>12 months</td>
</tr>
</tbody>
</table>
The documents were arranged in seven date-range groups that represent major stages of the project based on project milestones (Table 3.3). These are not official stages of the project—I constructed the stages to explore how the social worlds and subworlds of the team developed, and to determine if the worlds changed over time. Although the stages have cleanly delineated boundaries for analysis purposes, work related to the main activities described in the stages bled over these artificial boundaries in real life. The three sets of e-mails were combined into a database and duplicates were removed. This process yielded 10,121 records, from which 4260 were purposively sampled for coding. To create the sample, I graphed the number of e-mails per month, which provided a visualization of the pattern of e-mail conversation (i.e., periods in which e-mail traffic was increasing and decreasing (Figure 3.2). I sampled the periods of increase by including in the sample all e-mails from the months that represented increasing traffic (full months were used to represent threaded discussions). When the up-slope of e-mails included only two months I chose the month with the larger number of e-mails. I did not include January 2014 because I was collecting data in that period and the month is not complete. In addition, I included September 2011 because it had almost as much e-mail traffic as August 2011.

Figure 3.2. Purposive E-mail Sample
and I found that it was important for theoretical coding because it included discussions around the lead-up to and beginning of the beta test. In order to create documents that could be uploaded to Dedoose, the cleaned e-mail database was exported to a Microsoft Excel file and Excel’s mail merge facility was used to export the e-mail records into Microsoft Word. Separate Word files were created for each month in the e-mail sample and uploaded to Dedoose.

3.5.3 Interview Data Generation

Interviews were conducted with project team members using a semi-structured interview schedule (Appendix A). A GTM interview is designed to understand participants’ underlying views of their experiences. It moves some of the power and control from the interviewer to the interviewee, allowing participants to tell their stories in context, to reflect on events, to choose what to talk about and the manner in which those thoughts are expressed, to show the interviewer how to understand their experiences, to express thoughts and feelings not normally allowed to emerge, and to receive affirmation and understanding (Charmaz, 2006). The interviewer-interviewee relationship supports the production of knowledge (Kvale & Brinkmann, 2009). The interviews are loosely structured or, at most, semi-structured. They begin with broad, open-ended questions, with the subsequent interview structure designed to allow the researcher to explore statements and topics; to elicit further detail or information; to inquire about the participant’s thoughts, feelings, or actions; and to slow or quicken the pace as needed. Interviewers may swing back to revisit earlier statements or to restate points to check the accuracy of their understanding. The emergent nature of this type of interviewing is well-matched to the grounded theory approach to inquiry (Charmaz, 2006).

A purposive sample of nine team members who could serve as key informants was devised (Table 3.4). The final sample consisted of eight participants, as theoretical saturation was reached at that point. Based on participant preferences, three interviews were conducted in person, one online via Skype (http://www.skype.com/en/), two online via Skype (http://www.skype.com/en/) combined with phone (due to technical difficulties), and one online via a Google+ hangout (http://plus.google.com). Interviewees were offered a $30 gift card as a participation incentive (to be paid after the close of data collection); all but one participant declined the incentive. Interviews were audio recorded using a digital audio recorder; the recordings were transferred to a password-protected computer and then erased from the recorder.
Each interview was memoed immediately after its conclusion with details from the interview, including notes about how the prompts were working, and overall reflections on the experience. The interviews were transcribed using Microsoft Word.

Table 3.4

*Purposive Interview Sample*

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Project Role</th>
<th>Interviewed</th>
<th>Interview Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI</td>
<td>Principal Investigator</td>
<td>Yes</td>
<td>In person</td>
</tr>
<tr>
<td>CoPI1</td>
<td>Co-Principal Investigator</td>
<td>Yes</td>
<td>Skype and phone</td>
</tr>
<tr>
<td>CoPI2</td>
<td>Co-Principal Investigator</td>
<td>Yes</td>
<td>In person</td>
</tr>
<tr>
<td>CoPI3</td>
<td>Co-Principal Investigator</td>
<td>Yes</td>
<td>In person</td>
</tr>
<tr>
<td>CoPI4</td>
<td>Co-Principal Investigator</td>
<td>Yes</td>
<td>Skype</td>
</tr>
<tr>
<td>IS1</td>
<td>Content/Education</td>
<td>Yes</td>
<td>Google+ hangout</td>
</tr>
<tr>
<td>TeachEd1</td>
<td>Content/Education</td>
<td>Yes</td>
<td>Skype</td>
</tr>
<tr>
<td>Design1</td>
<td>Webmaster</td>
<td>Yes</td>
<td>Skype and phone</td>
</tr>
<tr>
<td>CS2</td>
<td>Programmer</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

The semi-structured interview schedule was designed as a series of prompts to promote a discussion between the interviewer and the participant. As such, the natural direction of the discussion dictated the use of follow-up questions. The schedule includes 10 prompts, some of which are multi-part. The prompts were designed to align with the research questions and the sensitizing concepts that informed the questions (the Social Worlds Perspective, ITSW Theory, and Boundary Objects Theory); most questions aligned with multiple research questions (Table 3.5). During the interviews I periodically restated points in my own words to confirm my understanding or to clarify important points. The interviews began with a general question about the participant’s view of the nature of the project and how it came about, to get the participant talking and to provide context for the rest of the discussion. The second question prompted the participant to discuss how team members were chosen for the project. Besides providing more context about the participant’s view of the project, this is the first time that participants listed people who worked on the project. The participant was then asked to describe her or his role with the project team and whether that role changed over time. This is the first time that the participant spoke about team roles and their evolution over time; in addition, important project
milestones began to be evident in most interviews, and more discussion of team members ensued.

Table 3.5
Alignment of Interview Prompts with Research Questions and Sensitizing Concepts

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Research Question</th>
<th>Sensitizing Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,2</td>
<td>Social worlds perspective, ITSW</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Social worlds perspective</td>
</tr>
<tr>
<td>3</td>
<td>1,2</td>
<td>Social worlds perspective, ITSW</td>
</tr>
<tr>
<td>4</td>
<td>1,2,3</td>
<td>Social worlds perspective, ITSW, Boundary objects theory</td>
</tr>
<tr>
<td>5</td>
<td>1,2</td>
<td>Social worlds perspective, ITSW</td>
</tr>
<tr>
<td>6</td>
<td>1,2</td>
<td>Social worlds perspective, ITSW</td>
</tr>
<tr>
<td>7</td>
<td>1,2</td>
<td>Social worlds perspective, ITSW</td>
</tr>
<tr>
<td>8</td>
<td>1,2,3</td>
<td>Social worlds perspective, ITSW, Boundary objects theory</td>
</tr>
<tr>
<td>9</td>
<td>1,2,3</td>
<td>Social worlds perspective, ITSW, Boundary objects theory</td>
</tr>
<tr>
<td>10</td>
<td>1,2,3</td>
<td>Social worlds perspective, ITSW, Boundary objects theory</td>
</tr>
</tbody>
</table>

The participant was then queried about the main tasks he or she performed on the project, with a follow up about whether those tasks changed over time. Most interviewees had begun to mention tasks in the discussions of earlier questions, and in those cases the interviewee was asked for more specificity about the tasks at this point. In addition to clarifying the roles discussion and possibly prompting more discussion of team structure, this discussion provided an opportunity to begin to see the role of boundary objects in the participant’s work on the project. Next, the participant was asked directly about which team members he or she worked with, and whether that changed over time; the initial plan was to ask interviewees to draw diagrams to accompany this discussion but that plan was abandoned due to the large percentage of online interviews. Answers to this prompt provide a participant-eye view of the social networks of the team. As a follow-up, interviewees were queried about team members whose names were not mentioned. The participant was then asked about the types of topics on which the participant communicated with other team members and the participant was asked to elaborate vis-à-vis different team members. This led into a discussion of opportunities for collaboration with other team members. These discussions provided more insight into team social worlds and boundary object use. The interview ended with a discussion of major turning points in the project and changes that occurred after any of these turning points. Besides finally coming to an explicit
discussion of project turning points, this served as a summative discussion of the social worlds of the team. At the end of the interview participants were given a chance to make any other comments that they felt were appropriate.

### 3.5.4 Grounded Theory Coding and Analysis

The e-mails and interviews were analyzed using grounded theory procedures to answer all research questions and sub-questions. Memos were developed throughout the process. Memos are not just reminder notes jotted down by the researcher. Instead, they represent one of the major strengths of grounded theory as a qualitative method—reflexivity. They are written as part of the constant comparative process in grounded theory coding and analysis, and the memoing process was used to track my assumptions and biases as I analyze the documentary evidence and the participant interviews. Memos are also data and were used for tasks such as keeping track of participants’ vocabulary; comparing documents to documents, documents to interviews and interviews to interviews; and deciding when more or new data must be obtained. The memos were employed to contemplate the data in light of the sensitizing concepts and to track hypotheses as they were developed, scrutinized, rejected, and redeveloped. Finally, they created an audit trail for evaluation of the research (see section 3.7, Evaluating the Study) (Charmaz, 2006; Strauss & Corbin, 1998).

The coding process began with open or initial coding in Dedoose. During this process the data were coded incident to incident (Charmaz, 2006) and examined for similarities and differences to identify phenomena—"ideas in the data" (Strauss & Corbin, 1998, p. 101)—using a “language of action” (Charmaz, 2006, p. 48). I worked very quickly during the open coding process, with a focus on naming concepts. Concepts are phenomena (events, objects, actions, or interactions) that the researcher believes are significant; identifying and naming concepts allows for categories to be developed. As open coding progressed some codes were used multiple times, but many were not. The primary reason for this is that open codes are provisional—as I compared incidents I found new ways of describing the phenomena being examined—the codes were built to fit the data, rather than fitting the data to the codes (Charmaz, 2006). Many of these new codes were only slightly different from previous codes because the essence of the activity seemed different or because I was working out the best ways to describe types of activities and interactions. The goal of this process was to refine concepts through constant comparison. While
staying close to the data and remaining open to concepts, I was also working within the context of the project as detailed in the first two chapters of the dissertation. This context includes the sensitizing concepts of the study (social worlds, intrinsically transient social worlds, and boundary objects) and my focus on work processes (articulated in the research questions). Although I was not looking for particular concepts, I was aware of the context of my research throughout data coding and analysis and I made note of concepts related to my approach. For example, I developed a number of open codes related to team members’ expressions of an awareness of time. There are multiple ways in which these incidents could have been coded, but time is a part of my context. The microanalysis conducted during open coding can yield ways of looking at data that separate them from the ordinary, leading to new theoretical explanations. Sensitivity, backed up by the researcher’s experience and knowledge, allows the researcher “to see alternative explanations and to recognize properties and dimension of emergent concepts” (Strauss & Corbin, 1998, p. 59). An important characteristic of open coding is that the process includes data, the researcher’s interpretations of data, and the interplay between these elements. At this level of coding I remained open to all theoretical possibilities inherent in the data—the codes were interpretative and preliminary (Charmaz, 2006; Strauss & Corbin, 1998).

The open codes were then arranged into relational groups to narrow and refine the categories. My method for this step was most inspired by Charmaz’s (2006) focused coding approach—working through the data, looking for the most significant or most frequent codes with a goal of synthesizing and starting to find themes in the data. I also used Kazmer’s (2010) reimagining of Strauss and Corbin’s axial coding (1998), in which she retained the concept of comparing codes in multi-dimensional space while jettisoning the contentious formal procedures developed by Strauss and Corbin (cf. Bryant, 2009). During this stage I began to connect the codes through subcategories. For example, the activities developing iPhone app and writing documentation were coded as part of the concept sustainability and the activities exploring sources of new funding and piloting new instruments were coded with the concept applying for grants. The concepts sustainability and applying for grants were then classified as subcategories of the category finishing. These activities could be coded with other concepts and the concepts could certainly fall into other categories, but I built classifications by distinguishing the properties that connect them from those that make them dissimilar as well as by connecting concepts to the context of the research (Strauss & Corbin, 1998). My process was both
systematic and constructivist—it was systematic in the use of constant comparison and constructivist in my use of the sensitizing concepts and the processual context.

After I built categories through focused coding I moved to selective, or theoretical, coding in which theorizing is integrated and refined. For Strauss and Corbin (1998) the outcome of selective coding is the identification of a central category or theme that connects all the categories. Strauss (1987) describes six characteristics of a central category:

- All major categories can be related to it;
- The concept is seen in almost all the cases;
- It emerges from the categories logically and without being forced;
- Its name is abstract enough to be employed in the analysis of new areas of investigation;
- It provides the theory with explanatory power; and
- It can explain a range of variation in cases.

Theory building in GTM works through theoretical sampling, in which the researcher constructs provisional ideas from data, examines them in light of other data, and revises them. This process is an important aspect of the iterative nature of GTM in which data collection and analysis are integrated. Theoretical sampling continues with the researcher evaluating hypotheses, integrating new data as necessary through further data collection, working with memos, and evaluating ideas in light of the literature. The process continues until categories reach theoretical saturation—the point at which new concepts and properties are not forthcoming. This is saturation in the sense that new categories are not emerging, not saturation in the sense that patterns in the data are repeating (Charmaz, 2006). During this stage I worked with 10 themes that I constructed from the focused coding stage and began to identify major concepts that tied the themes together. These concepts were used to develop the model that is presented in Chapter Five. I had planned to use a conditional matrix to situate action (Mills et al., 2007) and aid in theory development. The concept of the conditional/consequential matrix was developed by Strauss and Corbin (1998) to reflect the “structural context in which action/interaction occurs” (p. 192). They propose that structure is interrelated with process, and that in order to build a contextual account of the process under examination the analyst must be aware of the macro and micro conditions and how they intersect and interact. Their conditional/consequential matrix is designed to facilitate that work. However, as I worked I began to be drawn farther into situational mapping.
as a method to situate my analysis and to integrate multiple elements of the project team’s situation that emerged during data analysis (this process is explicated in section 4.1.2).

Clarke’s situational analysis (2005) applies a grounded theory approach to Strauss’s social worlds/arenas framework. It focuses on a situation of inquiry rather than individual actors, and is explicitly concerned with accounting for all the elements of that situation, including actors, nonhuman actants, discourses and the silent/implicated actors. Situational analysis involves laying out three kinds of maps: situational maps, social worlds/arenas maps, and positional maps. Situational maps identify the human, nonhuman, discursive and cultural elements in the situation and analyze the relations among them (Clarke, 2005). Social worlds/arenas maps "lay out all of the collective actors, key nonhuman elements, and the arena(s) of commitment within which they are engaged in ongoing discourse and negotiations" (Clarke, 2005, p. xxxvi). Positional maps present the major positions taken and not taken in the data (Clarke, 2005). As with all grounded theory techniques, situational analysis is an iterative method. Maps are first laid out in a messy and abstract form, and are reworked throughout the research process. These iterations help “the researcher think systematically through the design of research, especially decisions regarding future data collection" (Clarke, 2003, p. 561). The constant comparison method is also at play here as the researcher questions “what ideas, concepts, discourses, symbols, sites of debate, and cultural ‘stuff’ may ‘matter’ in this situation” (Clarke, 2005, p. 88) (situational maps) and “What are the patterns of collective commitment and what are the salient social worlds operating here” (Clarke, 2005, p. 110) (social worlds/arenas maps). Finally, ordered versions of the maps are completed.

I used the e-mail (headers and body) and interview data to construct a situational map of the research team’s situation, a social worlds/arenas map of the project arena of the team and other social worlds that intersect with the that arena, and individual project maps of the team’s social worlds in each of the seven stages. The situational map includes 10 categories that have been iteratively constructed through constant comparison and analysis: individual human actors, collective human actors, political/economic elements, nonhuman elements/actants, discursive themes of human actors, concepts, related discourses, temporal elements, spatial elements, and implicated/silent actors. The social worlds of the team were constructed by analyzing the email and interview data to determine with whom the team members were working during the stages and to create visualizations of the social worlds and subworlds of the team.
3.5.5 Social Network Analysis

A second view of the social worlds was derived through a social network analysis of the e-mail metadata. This analysis was used to help answer research questions 1a (how social worlds segment), 1b (how social worlds change over time), and 1c (how information researchers fit into the social worlds). The fundamental concern of social network analysis is an understanding of the relationships among social entities and the consequences of these relationships (Wasserman & Faust, 1994). These relationships are derived from the data, rather than through a priori assumptions based on demographics or social standing (Haythornthwaite, 1996). Likewise, the existence of groups of actors is not presupposed but arises from the analysis of the networks among the actors (Haythornthwaite, 1996; Wellman, 1988). This study is focused on the relationships among the actors on the project team. The social network analysis was used in conjunction with the social worlds/arena maps of the interdisciplinary team to analyze the social worlds through actor relationships. The social network perspective proposes that actors and their actions are interdependent rather than operating as independent units, that relational links are the avenues for the transfer (or flow) of resources, that individual action is both enabled and constrained by the network structural environment, and that multiple types of structure (e.g., social, economic, political) grow from lasting patterns of actor relationships (Wasserman & Faust, 1994).

Eight key concepts are fundamental to an understanding of social network analysis: actor, relational tie, dyad, triad, subgroup, group, relation, and social network. The social entities under consideration in the analysis are referred to as actors. Actors may be individuals, or they may be collective social units such as departments within a corporation, governmental or non-governmental agencies, or nations. Social network analyses usually are concerned with actors of a single type (e.g., team members), but multiple types of actors may be included (Wasserman & Faust, 1994). The actor element of this dissertation study's social network analysis consisted of the individual members of the research team being studied. Actors are related through social connections called relational ties. Wasserman and Faust (1994) suggest a number of types of relational ties between actors such as expressed evaluation of an actor by another actor, transfers of material resources between actors, association or affiliation, behavioral interactions such as sending e-mails, movement between physical locations or social statuses, physical connections such as a bridge connecting two places, formal relations such as authority relationships, and
biological relationships. The relational tie element of this dissertation study's social network analysis will be expressed by association/affiliation among members of the research team being studied. The connections among actors may be expressed as the relationship between two entities (a dyad) or the relationships among three entities (a triad). When we move to examining the ties among all actors in subsets, we are dealing with subgroups; the study of subgroups is a major preoccupation of social network analysis. It follows logically that groups represent the full, bounded, sets of actors and ties that are to be examined. While relational ties represent the relationship between pairs of actors, a relation is a collection of ties among specific members of groups—more than one kind of relation can be measured for any group of actors. And, finally, a “social network consists of a finite set or sets of actors and the relation or relations defined on them” (Wasserman & Faust, 1994).

For this dissertation research study fourteen social network visualizations were created using Gephi version 0.8.2 using the e-mail header metadata of a subsample of 1855 e-mails. The subsample represents the most active week in each month of the main sample (i.e., the weeks with the highest level of e-mail traffic in those months) (Table 3.6). Two visualizations were created for each stage, illustrating the team’s social network during the stage and the network without PI. The second type of visualization was created to highlight the relationships among the other team members, which were not always evident in the first type of visualization because of PI’s central place in the network.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Subsample n</th>
<th>Total Sample n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>286</td>
<td>551</td>
</tr>
<tr>
<td>2</td>
<td>127</td>
<td>178</td>
</tr>
<tr>
<td>3</td>
<td>97</td>
<td>253</td>
</tr>
<tr>
<td>4</td>
<td>433</td>
<td>1129</td>
</tr>
<tr>
<td>5</td>
<td>143</td>
<td>468</td>
</tr>
<tr>
<td>6</td>
<td>770</td>
<td>1522</td>
</tr>
<tr>
<td>7</td>
<td>59</td>
<td>159</td>
</tr>
<tr>
<td>Total</td>
<td>1855</td>
<td>4260</td>
</tr>
</tbody>
</table>

The visualizations were used to analyze the networks across the life of the project. A whole-network approach was taken, with the network, “an entity consisting of a collection of
individuals and the linkages among them” (Wasserman & Faust, 1994, p. 5) acting as the unit of analysis. This approach produces a view of both the network and its patterns (Wellman, 1988). Although much of the e-mail used for the analyses flowed through the account of one actor (PI), a whole-network approach, rather than an egocentric-network approach, is appropriate because it the analysis involves a complete (or almost complete) enumeration of the population (Marsden, 1990, 2005).

3.5.6 Harmonizing the Analyses

This study includes two data sources (e-mails and interviews) and two methods (GTM/situational analysis and social network analysis). One of the data sources, the e-mails, was approached from two perspectives: The whole e-mails (headers and body) were used as data for the grounded theory/situational analysis coding and the header metadata were used as data for the social network analyses. Finally, three units of analysis were employed: incidents (GTM), the team as a network (social network analysis), and the situation as a whole (situational mapping). The data were harmonized on several levels:

- Thematic bridging of the e-mails and interviews: The two data sources were bridged by the set of major themes that was constructed through GTM coding of the e-mails and the interviews.
- Triangulation: E-mail and interview data were incorporated into the social world mapping and quotations from the interviews were used to explicate the findings of the social world mapping.
- Corroboration: Several aspects of the team’s general e-mail practices (e.g., including multiple people on e-mails to keep everyone informed, using the reply all function, including multiple topics addressed to different people in single e-mails) made it impossible to use the header metadata to make inferences from details such as who e-mailed whom (e.g., analysis of the From and To fields), how CC lists varied, the content of subject lines, and so on. However, the social network visualizations were used to corroborate the social world project maps on a directional basis through comparison of tie strength and major social world groupings to the project maps.
- Holistic view of the situation of the project team: The situational map accounts for all of the elements in the situation of the team: Individual human actors, collective human
actors, nonhuman elements/actants, political/economic elements, temporal elements, spatial elements, the discursive themes of human actors, related discourses, major concepts, and the silent/implicated actors. This holistic view of the situation was used to situate the findings (Chapter Four) and the discussion (Chapter Five), with the 10 categories threading throughout those chapters.

3.6 Data Management

The e-mails and interview transcripts were uploaded to Dedoose (http://app.dedoose.com/) for coding and analysis. Dedoose is a web-based tool that aided in developing codes and sorting codes to identify emerging themes. In addition, the use of Dedoose helped fortify the security of the data during analysis. The Dedoose data center is SAS 70 type 2 certified, and staff members have undergone background checks and need multiple forms of identification for access. Virtual access security is accomplished in multiple steps including a private VPN connection to order to manage the servers, with a separate authentication combination for the VPN, as well as each server (http://app.dedoose.com/LearnMore/Security.aspx). Interview documents were stored with recording files. Interviews were saved in Windows Media Audio (WMA) format and stored on the researcher’s personal computer and backed up on an external drive. The researcher's computer and all electronic files were password protected and any paper documents (including printed e-mails, interview transcripts, memos, and diagrams) were stored in a locked cabinet at the researcher’s residence. Recordings, transcripts, and notes will be kept for a period of five years after the conclusion of the study. All regulations and processes put in place by the human subjects committee of the researcher’s current academic institution will be followed, and the researchers will adhere to any changes in these rules.

3.7 Evaluating the Study

When using the grounded theory method, the types of research evaluations that are conducted for post-positivist study designs (such as inter-coder reliability) are very difficult to design. Therefore, other evaluative criteria that have been developed for qualitative research will be used. Birks and Mills (2011, pp. 153–154) suggest the following set of criteria:
• Researcher expertise: the researcher demonstrates skills in scholarly writing, there is evidence that the researcher is familiar with grounded theory methods, and citations of relevant sources have been used.
• Methodological congruence: the researcher has articulated a philosophical position, grounded theory method is appropriate for the study, the outcomes achieve the stated aims, and the end result is a grounded theory.

Table 3.7
Evaluative Model

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fit</strong></td>
<td></td>
</tr>
<tr>
<td>The researcher demonstrates skills in scholarly writing</td>
<td>Dissertation</td>
</tr>
<tr>
<td>Citations of relevant sources have been used</td>
<td>Chapters 1, 2, 3, and 5</td>
</tr>
<tr>
<td>The researcher has articulated a philosophical position</td>
<td>Section 3.2</td>
</tr>
<tr>
<td>Grounded theory method is appropriate for the study</td>
<td>Section 3.2.4</td>
</tr>
<tr>
<td>Criteria built into the researcher’s thinking are specified</td>
<td>Section 3.7</td>
</tr>
<tr>
<td>How and why participants in the study were selected are specified</td>
<td>Sections 3.5.2 and 3.5.3</td>
</tr>
<tr>
<td>Sample, setting, and the level of the theory generated are delineated</td>
<td>Sections 3.4 and 3.5</td>
</tr>
<tr>
<td><strong>Precision</strong></td>
<td></td>
</tr>
<tr>
<td>Participants guided the inquiry process</td>
<td>Section 3.5.3</td>
</tr>
<tr>
<td>Evidence of memoing</td>
<td>Section 3.5.3</td>
</tr>
<tr>
<td>Mechanisms by which an audit trail was maintained are specified</td>
<td>Sections 3.5.3 and 3.5.4</td>
</tr>
<tr>
<td>Data management procedures have been described</td>
<td>Section 3.6</td>
</tr>
<tr>
<td>Researcher familiarity with grounded theory methods is evident</td>
<td>Sections 3.2.3 and 3.3</td>
</tr>
<tr>
<td>Appropriate use of grounded theory procedures is evident</td>
<td>Section 3.3</td>
</tr>
<tr>
<td><strong>Credible Outcomes</strong></td>
<td></td>
</tr>
<tr>
<td>The researcher has explored personal views and insights</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>The outcomes achieve the stated aims</td>
<td>Chapters 4 and 5</td>
</tr>
<tr>
<td>Evidence of member checks</td>
<td>Section 3.5.3</td>
</tr>
<tr>
<td>Logical connections made between data and abstractions</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>The end result is a grounded theory</td>
<td>Section 5.4</td>
</tr>
<tr>
<td>Theory employs in vivo language</td>
<td>Chapter 5</td>
</tr>
<tr>
<td>Evidence that the theory is grounded in data</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>Theory is credible and potential applications of the are explored</td>
<td>Chapter 5</td>
</tr>
</tbody>
</table>

• Procedural precision: there is evidence of memoing in support of the study, the researcher states the mechanisms by which an audit trail was maintained, data management procedures have been described, there is evidence that essential grounded theory procedures have been employed appropriately for the described study, logical
connections have been made between data and abstractions, there is evidence that the theory is grounded in data, the theory is credible, and potential applications of the theory are explored.

Another set of evaluative criteria is propounded by Chivotti and Piran (2003):

- **Creditability**: the inquiry process is guided by participants, the theory is checked against participants’ meanings, and the participants’ words are used in the theory; the researcher has explored her personal views and insights through memoing procedures and monitoring how the literature was used.
- **Auditability**: the study’s criteria and how and why participants were chosen are specified.
- **Fittingness**: the sample, setting, and level of theory generated and how the literature relates to each category that emerged in the theory are described.

These sets of criteria cover three major areas: fit, precision, and credible outcomes. An evaluative model based a combination of the Birks and Mills and Chivotti and Piran criteria was used to evaluate the rigor of the study at the end of the process (Table 3.7).

### 3.8 Limitations of the Research

Patton notes that, “there are no perfect research designs. There are always trade-offs” (2002, p. 223), and this is true for this dissertation study. There are several facets of the design—the emic approach, and the available methods to validate the research—that are inherent to my approach to the study and represent strengths and limitations of that design. Where facets are noted as limitations here, it is in the sense that the reader must understand the boundaries of the study—what it “is and is not” (Marshall, 2011, p. 76), rather than in the sense that the research design is lacking in rigor.

#### 3.8.1 Emic Approach

As noted in section 3.4.2, I was a member of the team that constitutes the population for this study. Strauss and Corbin (1998) write about the balance between maintaining objectivity and developing sensitivity, issues that confront all researchers conducting qualitative studies. For qualitative research, objectivity means openness to “giving voice” (p. 43) to respondents. I used the grounded theory techniques of constant comparison, using the literature to help explicate
concepts, obtaining multiple viewpoints about events, using multiple sources (documents and interviews) to understand events, memoing, and questioning to maintain objectivity. In addition, as Strauss and Corbin suggest, I relied on the data for guidance, asking, “‘What is going on here?’ and ‘Does what I think I see here fit the reality of the data?’” (p. 45). Finally, I took a skeptical approach to analysis, testing and retesting all potential hypotheses by comparing conclusions across the analyses of the documents and the interviews and between individual documents and interviews. Using these fundamental processes I reflected constantly on all assumptions.

My insider status was a boon for the other side of this equation, the need to develop sensitivity. “Having sensitivity means having insight into, and being able to give meaning to, the events and happenings in the data” (Strauss & Corbin, 1998, p. 46). Although I was not collecting data systematically for the full duration of the funded project, my participant status provided a deeper understanding of the events and processes that I was studying. However, I relied on the data as my true north to be able to move outside the insider view of the project and “see beneath the obvious to discover the new” (p. 46). As Strauss and Corbin note, “personal experience can increase sensitivity if used correctly” (p. 48). However, while I drew on my insider status for a deeper understanding of the processes and events analyzed, the need to protect the identities of study participants hampered my ability to create the full, rich narratives that might be expected from this type of approach as I was constrained from adding details that might identify individuals.

3.8.2 Availability of Documents

This project relied to a great extent on e-mails as a data source so their availability was of interest. As noted in section 3.5, the study’s research design did not call for random sampling of a full sampling frame and the e-mail database was built from three collections of project e-mails. It would have been impossible to assure that a full sampling frame could have been constructed, as I could not assume that each team member’s e-mails were available or even still extant. But a full sampling frame was not necessary because generalizability was not a goal of this study. In designing the e-mail collection, I had worked on a supposition that the owners of these collections were in central locations in the e-mail stream—that they wrote, received, or were copied on much of the e-mail traffic in the study and this was confirmed by the findings of this
study. Furthermore, the findings show that the custom of the team in using e-mail was to CC multiple team members and then to use Reply All—this means that many e-mails that were not specifically related to the owners of the three collections still landed in their in boxes. The available documents offered a sufficient quantity for theoretical sampling of the data to saturation and I used constant comparison and questioning to understand the findings of the e-mail analysis in light of the findings of the analysis of the interviews and the findings of the analysis of the interviews in light of the findings of the e-mail analysis (although there is not a perfect fit between these as the interviewees were remembering events and the e-mails documented processes as they occurred).

3.8.3 Reliability and Validity

The design of this study does not allow for post-positivist evaluation methods such as inter-coder reliability. Within this context however, the use of multiple types of data and multiple methods that allowed concepts to be approached from a range of aspects and the processes of grounded theory that focus on constant comparison and reflexivity represent strengths of the design.

3.9 Ethical Considerations

This dissertation study did not violate any ethical principles or procedures. Informed consent was obtained from the owners of the e-mail collections and the owner of the meeting minutes collection before data was collected, and from interview participants before interviews began. The document owners were assured that participation was voluntary and that they could withdraw permission at any time without consequence. Interview subjects were assured that participation was voluntary and that they could stop an interview or withdraw from the study at any time without consequence. The study’s purpose, potential risks, and benefits were explained through the recruitment scripts and informed consent documents (see Appendices B, C, and D), and in verbal form at the beginning of each interview. Deceptive practices were not used at any time during the study. The identity and affiliation of the researcher and the researcher’s advisor were disclosed to participants through the recruitment scripts and in the informed consent documents (see Appendices B, C, and D), and were disclosed verbally at the beginning of each interview. Pseudonyms are used here and will be used in any other published or unpublished
reports of the results and conclusions, and personally identifying information has been and will be kept confidential to the extent possible. Details of the project under study and the names of members of the research team are available through the project’s public website and through research papers that have been, and will be, published by the team. The researcher has not voluntarily disclosed these details and will not in the future, but if they are to become known there is little risk to the participants because of the nature of this research project. I am studying collaborative research processes; the team members’ opinions about the project or about other project team members were not solicited, and this research does not evaluate the success or failure of the project on which the team worked. Approval from Florida State University’s Human Subjects Committee was obtained prior to data collection. Due to the nature of grounded theory research processes, I anticipated that the direction of the research might change during the study, although it was not possible to anticipate what kind of changes could occur. However no changes that required a protocol revision did occur.

3.10 Outcomes of the Dissertation

This dissertation research project had two major outcomes: a discussion that answers the research questions posed in section 3.1 and the generation of a substantive grounded theory that explains the process of distributed team collaboration across domain boundaries to design an educational technology intervention. In addition, the proposed study produced the following artifacts:

1. The substantive theory presented as a model;
2. An ordered situational map of the project team’s situation;
3. An ordered social worlds/arenas map of the project arena’s social worlds and social worlds that intersected with the project arena;
4. Project maps of the projects social worlds and subworlds for seven project stages; and
5. Social network visualizations of the project’s social network in each project stage.

3.11 Summary of Methodology and Research Design

Chapter Three described the research methodology and design for this multiple method exploratory grounded research dissertation research study. It described the research purpose and delineated the research questions, and then provided context for the research design through a
discussion of the philosophical and methodological underpinnings of the study and the rationale for the use of grounded theory. Next, the chapter detailed the study’s design and research methods, including the research setting, and data collection, analysis, and data management procedures. It then discussed the criteria by which the study was evaluated, strengths and limitations of the research, ethical considerations, and outcomes of the study.
CHAPTER FOUR
FINDINGS

This chapter presents findings from analyses of the documentary and interview data conducted using grounded theory (Charmaz, 2006; Strauss & Corbin, 1998), situational analysis (Clarke, 2005), and social network analysis techniques (see Chapter Three for detail on the methods used in this dissertation). The chapter begins by explicating the project team’s situation. An overview of the project's social worlds follows. I then examine the project's team's social worlds and subworlds. The chapter ends with an analysis of the major themes constructed during analysis. Quotations are employed throughout the chapter to provide insight into the team members' views of the project and to include their voices. Pseudonyms for the team members are used to protect their confidentiality and are italicized to avoid confusion (e.g., “I went to the meeting with CoPI1”), information that might identify other people or institutions has been redacted, with notations in brackets (e.g., “we were working in [name of school redacted]”), and ellipses are used to indicate the removal of nonessential details or utterances. The source of each quotation is noted at the end of the quote in brackets (e.g., [Interview with PI]).

4.1 The Situation of the Research Team

4.1.1 Overview of the Project

Working on a Goal 2 education technology grant from the U.S. Department of Education’s Institute of Education Sciences (the grant was had a three year term, and a fourth year was added through a no-cost extension), the project team investigated an intervention that used interactive technologies to support fourth and fifth grade students as they worked as scientists—collecting data during a field trip to an outdoor natural wildlife center (referred to here as the museum), producing collaborative analyses, and disseminating their findings. The project team designed and developed two connected technologies: an interactive iPad application that students used to record observational data that were contributed to a shared database that could be accessed by other students online and to record qualitative observations through journal entries about the field trip experience; and a website, where students conducted research by accessing content about museum wildlife, accessed their journal entries, and analyzed the
observational data collected at the Museum. The team also developed a standards-based curriculum that took students through a tripartite process in which they spent time in the classroom learning about the nature of science, the elements of scientific inquiry, and the nature of scientific investigation; wrote in their journals and collected observational data during the field trip; and returned to the classroom to analyze their data, develop presentations, and communicate their findings. In addition to the intervention technologies and materials, the team designed and developed a project website that provided information about the project for teachers, parents, students, and other interested parties; project news; and a publications page, as well as housing project meeting minutes that were accessible exclusively by project members; designed and developed a website for teachers; and designed three professional development workshops that teachers participating in the intervention attended. The museum participating in the intervention includes 10 outdoor habitats that house animals native to the state in which the museum is located. The main intervention website included sub-websites devoted to each habitat and the iPad application had separate areas for each habitat.

4.1.2 Situational Mapping

Clarke’s situational analysis (2005) applies a grounded theory approach to Strauss’s social worlds/arenas framework. It focuses on a situation of inquiry rather than individual actors, and is explicitly concerned with accounting for all the elements of that situation, including actors, nonhuman actants, discourses and the silent/implicated actors. I used Clarke's situational mapping procedures in concert with grounded theory techniques (Charmaz, 2006; Strauss & Corbin, 1998) to identify the human, nonhuman, discursive and cultural elements in the situation and to analyze the relations among them. The situational mapping process was iterative, and I continually reworked my situational map throughout data collection and analysis. I began working with a "messy" (Clarke, 2005, p. 87) version of the situational map (to identify human actors and non-human actants, concepts, discourses, etc.) during data collection. The messy working version of the situational map allowed me to lay out the elements of the situation as I identified them, without having to worry about how they related to each other or about what the final elements would be. I continued to work with the messy version of the map throughout data collection and analysis, and slowly began playing with "ordered" (Clarke, 2005, p. 89) versions as well. The messy working versions of the map supplied the data used for the ordered working
versions, and I created ordered versions of the map as I examined the relationships among the elements in the messy version. The road to the final ordered working version of the situational map was rutted and filled with detours, obstructions, and roundabouts, and I found that the best way to develop the map was to keep it at my side as I transcribed interviews and coded the documents and the interviews.

Figure 4.1. Ordered Situational Map

In *Situational Analyses: Grounded theory Mapping After the Postmodern Turn* (2005), Clarke uses a set of categories for the exemplar situational maps that derive from her work and from that of Strauss. Although these categories "seem basic" (2005, p. 89) to her, she urges researchers to use any or all of her categories or to construct new ones from the situation of inquiry at hand. When I began to order my situational map, I found myself trying to "fill in the blanks" (2005, p. 89). As I worked through the process, I slowly began to reposition my data in categories that worked for my analysis, with a resulting map that includes many of Clarke's
categories, categories that I derived from hers, and categories that I constructed through the analysis of my data.

4.1.3 Situating the Analysis

Clarke designed all of her mapping techniques as analysis tools, and the maps themselves are not always included as part of the final product (Clarke, 2005). I decided to include my final ordered situational map here (Figure 4.1) to situate the analysis. The map represents my construction of the situation of the project team based on the analysis of project e-mails and interviews with project team members in light of my research questions and the sensitizing concepts underlying this work—it is one view of the project from a specific vantage point. It includes 10 categories that have been iteratively constructed through constant comparison and analysis: individual human actors, collective human actors, political/economic elements, nonhuman elements/actants, discursive themes of human actors, concepts, related discourses, temporal elements, spatial elements, and implicated/silent actors.

4.1.3.1 Individual human actors. There were many people who touched this study, both on the project team and in social worlds that intersected with the project team arena (the social worlds of the team are explicated in section 4.2). Because this study focuses on the project team, this category includes team members—other individuals who interacted with the team are categorized as collective human actors.

4.1.3.2 Collective human actors. The collective human actors interacted with the project team and are part of the situation of the project. This category comprises the individuals from the university, including those from the colleges containing the school of teacher education and the information school, and the research institute that managed the project funding; individuals who worked at the museum that participated in the study, members of the project’s advisory committee, and the fourth and fifth grade teachers who participated in the study and other individuals connected to the schools and school districts. These individuals were coded as part of their institutions during the email coding (a methodological decision based on the large number of individuals mentioned in the emails) and they did not emerge as individuals in the interviews.

4.1.3.3 Political/economic elements. These organizations include actors who interacted with the project team arena, but had political and economic impacts on the project team arena as
organizations: the state Department of Education, the school districts, the U.S. Department of Education and its Institute of Education Sciences (the funding agency), and Apple, Inc.

4.1.3.4 Nonhuman elements/actants. These are objects that materially affected interactions within the situation “through their agencies, properties, and requirements—the demands they place on humans who want to or are forced to deal with them” (Clarke, 2005, p. 87).

- Project websites: Refers to all the websites developed through the project, including the project website (used for outreach and dissemination), the habitat websites (one for each habitat), and the teacher website (created to help teachers who want to use the intervention materials after the intervention was over; used for sustainability).
- iPad applications: The application developed for the intervention that was used by the students and a public version of the application (created for sustainability) that is available for no cost in the Apple App Store.
- iPhone application: A public version of the iPad application that was developed to run on the iPhone and is available for no cost in the Apple App Store.
- Intervention curriculum: The custom curriculum developed as part of the project that was used in the classrooms and on field trips and that is available on the teacher website.
- Professional development curriculum: The curriculum used in the professional development workshops for teachers; informed material used in the teacher website.
- Grant narrative: The narrative submitted as part of the grant proposal. Includes a discussion of the purpose and importance of the intervention, a literature review, a description of the proposed intervention, and a discussion of the measurement instruments to be used.
- Student surveys: Refers to three measurement instruments administered to the students before and after the intervention to assess learning gains. The instruments are: Understanding the Nature of Science (Kang, Scharmann, & Noh, 2005), Attitude Toward Science (Moore & Foy, 1997), and Views of Scientific Inquiry-Elementary Version (Schwartz, Lederman, & Lederman, 2008).
- Project calendars: Refers to a several types of calendars and lists used to manage student office schedules and school, field trip, and personnel schedules during the three testing
periods of the intervention (the alpha test, the beta test, and the pilot test—these are explicated throughout this chapter).

- Alpha test instrument: A worksheet and list of survey questions used during the alpha test to record observations and student descriptions of the usability of the iPad app.
- Implementation tracking tools: Refers to a suite of tools developed to track teacher fidelity of implementation to the intervention (used in the beta and pilot tests).

4.1.3.5 Discursive themes of human actors. I constructed the discursive themes through grounded theory coding of project documents and interviews with project members. The themes were built in light of my research questions and the sensitizing concepts that inform the study (i.e., they are connected to discussions of process issues). The themes are explicated in section 4.3; they cover the design and development process, the testing process, roles and responsibilities, project management, discussions of policies and procedures, technology issues, dissemination and outreach, and finishing the project and planning for the future.

4.1.3.6 Concepts. These are major concepts built from the themes that contribute to the theorizing in Chapter Five.

4.1.3.7 Related discourses. This category represents important discourses found in the grounded theory coding that are not process-focused.

4.1.3.8 Temporal elements. These are elements related to time that emerged in the coding and analysis.

4.1.3.9 Spatial elements. These are elements that represent physical and virtual spaces in which the team worked.

4.1.3.10 Implicated/silent actors. This category represents actors who do not play roles in the analysis due to the process-based frame but who are important elements of the situation.

These elements inform the Chapter Four analysis of finding and the Chapter Five discussion.

4.2 Social Worlds of the Research Team

The social worlds of the research team were analyzed using grounded theory, situational analysis, and social network analysis techniques to construct, describe, and visualize the social worlds and their subworlds across seven project stages.
4.2.1 Overview of the Project's Social Worlds/Arenas Context

The arena of the research project (Figure 4.2) is populated by three social worlds: the world of the principal investigators, the world of the content sub-team (referred to as the content team within the project and hereafter in the dissertation), and the world of the design/tech sub-team (referred to as the tech team within the project and hereafter in the dissertation). The three worlds represent the team structure of the project as it was originally envisioned. Over the four years of the project, the team included five principal investigators and 25 graduate and undergraduate students, (Table 4.1).

![Diagram](image)

Figure 4.2. Social Worlds/Arenas Map of The Project and Intersecting Social Worlds

This basic structure remained in place throughout the three years of the original grant duration, although one principal investigator (CoPI1) left during the second year of the project and was replaced by CoPI4, and there were multiple staff changes among the students. For the
fourth (no-cost extension) year the project had two social worlds: principal investigators and the content team.

Table 4.1

*Team Structure*

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Home Department</th>
<th>Project Stages*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principal Investigators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>Information</td>
<td>1-7</td>
</tr>
<tr>
<td>CoPI1</td>
<td>Information/Institute</td>
<td>1-4</td>
</tr>
<tr>
<td>CoPI2</td>
<td>Teacher Education</td>
<td>1-7</td>
</tr>
<tr>
<td>CoPI3</td>
<td>Teacher Education</td>
<td>1-7</td>
</tr>
<tr>
<td>Co-PI4</td>
<td>Information</td>
<td>4-7</td>
</tr>
<tr>
<td><strong>Content Team</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IntlEd</td>
<td>International Education</td>
<td>4-6</td>
</tr>
<tr>
<td>IS1</td>
<td>Instructional Systems</td>
<td>1-6</td>
</tr>
<tr>
<td>IS2</td>
<td>Instructional Systems</td>
<td>6</td>
</tr>
<tr>
<td>IS3</td>
<td>Instructional Systems</td>
<td>6</td>
</tr>
<tr>
<td>LIS1</td>
<td>Information</td>
<td>1-7</td>
</tr>
<tr>
<td>TeachEd1</td>
<td>Teacher Education</td>
<td>1-6</td>
</tr>
<tr>
<td>TeachEd2</td>
<td>Biology/Education</td>
<td>4</td>
</tr>
<tr>
<td>TeachEd3</td>
<td>Biology/Education</td>
<td>4</td>
</tr>
<tr>
<td>TeachEd4</td>
<td>Mathematics/Education</td>
<td>4</td>
</tr>
<tr>
<td>TeachEd5</td>
<td>Biology/Education</td>
<td>4-5</td>
</tr>
<tr>
<td>TeachEd6</td>
<td>Mathematics/Education</td>
<td>4-6</td>
</tr>
<tr>
<td>TeachEd7</td>
<td>Teacher Education</td>
<td>6</td>
</tr>
<tr>
<td>TeachEd8</td>
<td>Teacher Education</td>
<td>6-7</td>
</tr>
<tr>
<td><strong>Tech Team</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS1</td>
<td>Computer Science</td>
<td>1</td>
</tr>
<tr>
<td>CS2</td>
<td>Computer Science</td>
<td>1-6</td>
</tr>
<tr>
<td>CS3</td>
<td>Computer Science</td>
<td>5-7</td>
</tr>
<tr>
<td>Design1</td>
<td>Communication</td>
<td>1-4</td>
</tr>
<tr>
<td>Design2</td>
<td>Art/Information Technology</td>
<td>1-6</td>
</tr>
<tr>
<td>Design3</td>
<td>Art</td>
<td>4-6</td>
</tr>
<tr>
<td>Design4</td>
<td>Art</td>
<td>4-6</td>
</tr>
<tr>
<td>IT1</td>
<td>Information Technology</td>
<td>1-4</td>
</tr>
<tr>
<td>IT2</td>
<td>Information Technology</td>
<td>2-3</td>
</tr>
<tr>
<td>IT3</td>
<td>Information Technology</td>
<td>2-3</td>
</tr>
<tr>
<td>IT4</td>
<td>Information/Math/Business</td>
<td>5-6</td>
</tr>
<tr>
<td>LIS2</td>
<td>Information</td>
<td>2-4</td>
</tr>
</tbody>
</table>

*Team member for at least a portion of the project stage*

Several social worlds intersected with the project team arena. These include the university and several of its units—the institute through which the project's funding flowed (and
which is associated with the college of education, and the college in which the information school resides. The political, economic, and cultural forces that shaped, acted on, and influenced the project and its team members include the social worlds of the United States Department of Education and its Institute of Education Sciences, which provided the funding for the project; the State Department of Education, the local school districts and the schools that participated in the project; the social world of the natural science museum that worked with the project; the social world of the project's advisory committee, members of whom were drawn from museums, zoos, and higher education institutions from around the country; and the social world of Apple, Inc., from which the team purchased equipment and which distributes two applications developed from the project in the Apple App Store.

In the following subsections I detail findings about the project and its social worlds.

### 4.2.2 Overview of the Project Stages

The balance of this section of the dissertation follows the seven project stages (Figure 4.3) developed to sample the project documents (see Chapter Three for detail on the sampling method). These are not official stages of the project—I constructed the stages based on project milestones to explore how the social worlds and subworlds of the team developed, and to

![Figure 4.3. Project Stages by Year](image)

**Figure 4.3. Project Stages by Year**
determine if the worlds changed over time. Although the stages have cleanly delineated boundaries for analysis purposes, work related to the main activities described in the stages bled over these artificial boundaries in real life.

I begin this part of the dissertation with background on the development of the project and then I provide findings on the social worlds and subworlds of the project in each of the seven project stages. Two types of visualizations are used: project maps (Clarke, 2005) and social network visualizations. The project maps are close-in views of the project arena (Figure 4.2) over time. They depict the three social worlds (the principal investigators, the content team, and the tech team) and subworlds within and that intersect the social worlds. The subworlds were constructed through grounded theory coding of the project documents and the interviews. The social network visualizations were created by running the e-mail header metadata for a subset of the e-mail sample through Gephi 0.8.2 (see Chapter Three for details on sampling for the social network analyses). These visualizations include actors from other social worlds depicted in Figure 4.2 who interacted with the project team. These broader views of the social worlds complement the close-in views provided by the project maps. In addition, an alternate view of the social worlds is provided by a second set of social network visualizations that exclude PI and that are used to visualize relationships among other team members.

4.2.3 Prehistory: Getting to Stage 1

The history of the project includes two previous unfunded grant applications, and it was developed and refined through the process of applying and re-applying for grants (first to the National Science Foundation and then to the U.S. Department of Education). PI and CoPI1 had been discussing finding something to work on together, and PI’s original inspiration for the project came from a conversation at the Museum that would eventually participate in the project:

The idea for the project came about because I was out talking to the folks at [name of museum redacted] about what they do with the kids on the school trips, and whether there’s any interest in doing stuff online, and just to see what was going on, and we were brainstorming and one of the educators out there, who is no longer there, told me about this journaling project that they do where the kids write paper-based journals and the thing that really stuck with me as she told this story about how—there was an example, something that one of the kids wrote in one of their journals helped the animal curator understand that one of the wolves was about to give birth. So we talked about this sort of citizen science angle and if all that information could be shared in real time what could be done with that. [Interview with PI]
Although the two initial researchers had a shared interest in using technology, there was an interdisciplinary nature to the project from the beginning:

I just know that PI was interested in doing something with the Museum, he was interested in technology, particularly all the new Apple products, the iPads, and I'd been interested in using mobile devices in learning. I wasn’t so concerned about the domain, but I thought that that would be a good domain; particularly, I’m interested in how you create more active learning spaces. So his interest was mainly in the Museum, my interest was mainly in the learning, we were both interested in the mobile device phenomenon, particularly smart phones, and then the iPad came out. [Interview with CoPI1]

An early attempt at getting a grant based on informal learning at museums fell into the void between academics and practice:

It seemed to be that the review committee for that wasn’t academics, it was mainly people from the museum community, and they were a bit snippy about the academic, and they were, I remember, they were asking why we were using students to create the software, why weren’t we using a software company like museums do, and that was the one, you were also required to hire an evaluation company to do the evaluation for you, and the kind of evaluation these evaluation companies were doing were just smile test-type evaluations, this is the kind of companies that were employed by museums, just to check if visitors were happy. It wasn’t whether people were being educated, it was whether they were happy with the exhibits that were being funded. So, yeah, I remember that, that was quite a trauma and that PI was particularly upset about that one because he considers himself in the museum community, but the museum community rejecting that as it was too academic. [Interview with CoPI1]

The project idea was developed through this brainstorming process, and its focus evolved through the grant proposals from the idea of children using technology to conduct citizen science projects to the final conception of employing technology to support children working as scientists and to connect field trips to the school curriculum. As the focus changed, the two researchers determined that involving education experts would be fruitful in scholarly and practical terms:

So, I know from talking to PI that some of it is getting the right names in there, people with recognizable names, like, “oh, yeah, if CoPI2 is interested in this, this would be really helpful, if CoPI3 …” So part of it is familiar names, part of it, of course, is particular skill sets, so when you needed somebody who could do the kind of research design and skills that they brought to the table, and access. Who can get us access to the schools? So, because PI really came in with access to the museums, but getting access into the public school systems was something that he didn't have expertise with, so he needed people to facilitate that as well. [Interview with CoPI4]

And CoPI2 agreed with this:

I think that they—so we had PI and CoPI1, they had tried, you know, thrown themselves against the wall a few times, and then figured at some point they were going to have to
embrace educators, that it wasn't just a … that they had gone the public-doing-science route and it didn't get them anywhere, and someone had given them the clue that they should bring a science educator in, and so I think they found me on the website. [Interview with CoPI2]

CoPI1 agreed as well, and brought in an issue that researchers working across domain boundaries often confront—the insider/outsider view that pertains within many disciplines:

I knew from previous experience that if you don't have an educational person on your list as a PI you probably won't get funding because you are going to be reviewed by people from the educational sphere and they'll see you as an outsider. And no matter how good you are and how much you understand their domain, they will be nervous about funding something that doesn't have a professor from education involved in the team. So that was part of the process that we had to get someone from education involved in the project. [Interview with CoPI1]

The researchers from the information school (PI and CoPI1) had not previously worked with the researchers from the education school (CoPI2 and CoPI3), but as CoPI2 explained,

That's pretty common, again, the nature of our job is to go, "Oh, I think I could do that," particularly at [name of university redacted], that's so resource-poor, on the surface we look so resource-poor, but if you can re-faction yourself there's a lot of stuff to do, you just need to be willing to go, "I can figure that out, give me 10 minutes." [Interview with CoPI2]

And so the team began to come together through a chain of connections. CoPI2 had been brought on for an earlier version of the grant, and CoPI3 joined the team for the version that was funded:

Knowing that we were going to need education specialists on board the project and finding out who here did this, and I'm pretty sure that the connection came from CoPI1 because of course at [name of Institute redacted] he knew who was involved in these education projects around campus, and CoPI1 was the one who said I should go and talk to CoPI2 and then CoPI2 was the one who said that we should involve CoPI3. [Interview with PI]

4.2.4 Stage 1: Initial Planning and Initial Design and Development

Stage 1 comprised project planning and initial design and development and constituted the first nine months of the project from August through April of Year 1. The milestone for Stage 1 was the design and development of an initial working version of the technology tools (the iPad application and the intervention website) for a prototype habitat at the Museum. A proof of concept alpha test of the technology was scheduled for May of the first year, so the team had to move quickly to staff up and develop the prototype habitat. Four graduate students were hired
immediately: LIS1, one of PI’s Ph.D. students who had been involved with an earlier version of the grant as a research assistant for CoPI1; TeachEd1, one of CoPI2’s Ph.D. students; Design1, a Master’s student in digital media with an information technology B.S.; and CS1, a computer science Ph.D. student. But fairly soon it became apparent that this staffing level would not be sufficient for the team to make that first milestone. This led to a reconsideration of the staffing plan, and the personnel line devoted to a full-time project manager was transformed into funding to hire more students:

Yeah in the proposal we said we were going to have four graduate students, one from LIS, one from education, and then a couple of techie people. But when we found out that it was just going to be impossible for two half time, two 20 hour a week GAs, to do all the development and design of this project we realized it was just not going to happen. And unless we found a magic project manager who was also a programmer … [Interview with PI]

At that point four additional students were hired—IS1, a Ph.D. student in instructional systems, and the first three undergraduate interns: CS2 from computer science; Design2, a double major in graphic design and information technology; and IT1, from information technology:

And then for myself, I was hired because I saw PI, PI gave a presentation at one of our doctoral seminars, and at that time I was already working for [name of Institute redacted], but my funding, I was on another grant that was possibly going away, but it was just something that I had a lot of interest in, and so I contacted PI and had an interview with CoPI3, and then PI called me and hired me later. But I think I was hired because of my experience working on grants and my experience with technology and curriculum development, and so I think that was part of it. [Interview with IS1]

The Stage 1 project map (Figure 4.4) includes the four principal investigators, the three members of the content team, and the five members of the tech team that had been hired during the stage. The members of each social world (principal investigators, content team, and tech team) are laid out individually within their worlds, representing their interactions within the worlds. Ten subworlds are delineated on the map, with five subworlds that segment the main worlds and five social worlds that intersect the social worlds. The subworlds within the main worlds represent groupings that emerged based on roles and responsibilities, or based on collaborative work within the social worlds. The subworlds that intersect the social worlds represent cross-team collaborative work.
Within the social world of the principal investigators, the subworlds emerged primarily around domain-based roles and responsibilities. *CoPI1* (information) focused on technical design and development and worked with *PI* on project management and administration issues, and

![Diagram of Project Team Map in Stage 1](image)

**Figure 4.4. Project Map of the Project Team in Stage 1**

*CoPI2* and *CoPI3* (teacher education) focused on development of the website educational content and the intervention curriculum. *PI*’s placement in both subworlds is due to the role he played in the project rather than his domain (information):

Early on I was involved in every single decision and then as the project went on and we had more people involved, a lot more of the decisions I had to delegate to other people. But the issue is that early on it was my vision that was driving us forward, right, because I knew what I wanted this to be … [Interview with *PI]*

The principal investigators functioned as a social world primarily through PI and staff meetings, but their main work was focused on the parts of the project that connected to their domains. As *CoPI2* put it:

Yeah, *PI’s* in the center and I’m over here (indicating one direction) and *CoPI1’s* over here (indicating an opposite direction) and then *CoPI3* is somewhere even a little more extreme than me [Interview with *CoPI2*]
CoPI2 and CoPI3 saw each other often, as they were in the same department and were collaborating on other projects. When asked about this, CoPI3 said:

We, so we're in the same department, and we're both in the same major within our department, we collaborate on a lot of different things, right? So we knew each other very well. So we would have, so probably what you're asking about is, we would definitely have impromptu meetings about things going on with this project when we would see each other, like, “how's things going with that,” “oh, I need to get working on th--,” “oh, I forgot to do …” “we need to get this done,” “what are we thinking about,” these kinds of things. Or even kibitzing about what direction we think the thing should be going, in some ways, right? So you always have these little side meetings about, “oohhh, the group seems to be wanting to go this way, are we sure we're happy with that, are we going to be able to, is this …” That kind of stuff, so there's all these little, casual conversations that come up. [Interview with CoPI3]

Much of the work that the students were doing was domain-based, with the content team focusing on developing website content and getting schools onboard for the alpha test (Stage 2) and recruiting teachers for the first summer professional development workshops (Stage 3) and the tech team focusing on design and development of the website and the iPad application. The subworlds represent cross-disciplinary collaboration, even within social worlds. Within the content team social world LIS1 and TeachEd1 worked together early in the stage to identify and organize the educational content for the student website, with TeachEd1 (teacher education) focusing on the educational content needs and the connection to state standards, and LIS1 (information) focusing on information needs and information organization. When TeachEd1 worked with IS1 later in the stage on developing the teacher website, she again was focused on content while IS1 (instructional systems) focused both on content and instructional design. The tech team subworld emerged as CS1, Design1, and IT1 worked to link the observational database to the habitat website, with each bringing his disciplinary focus to the task—computer science (CS1), digital media design (Design1), and user-centered design (IT1). The subworlds that intersected the content team-tech team boundary emerged as the students helped each other by applying disciplinary knowledge to a problem or because content and tech tasks merged. For example, IS1 created wireframes for the websites (disciplinary knowledge), and LIS1 worked with Design1 on issues related to the display of website content (content and tech tasks merging). With PI removed from the visualization, Figure 4.6 shows LIS1 to be a connecting hub for much of the interdisciplinary activity in Stage 1. When asked if team members’ project work were mostly discipline-based, PI answered,
No, I think more likely people cut across the different teams based on where their expertise was needed, and they might, their expertise really manifested itself in different ways depending on which team they were working with ... So you look at who communicates with whom, the more of a generalist they were, the more likely they found themselves working with a bunch of different people, and the more of a specialist they were, the more they found themselves focused on a particular area. [Interview with PI]

Figure 4.5. Project Team’s Social Network in Stage 1

In the social network visualizations the actors are represented as nodes and their connections as edges (the actors from the other social worlds that interacted with the project team are represented by their organizational name—for example, College represents any actor from the two colleges shown in Figure 4.2). The strength of the connections (the amount of e-mail traffic among nodes) is represented by the thickness of the edges. PI is the central hub of the Stage 1 social network (Figure 4.5). The content team (IS1, LIS1, and TeachEd1) is loosely clustered on the right-hand side of the diagram, with the two principal investigators who worked on content (CoPI2 and CoPI3) farther to the right. The tech team is less clustered, with CSI and Design1 placed near LIS1 and the balance of the team (CS2, Design2, and IT1) spread around the left-hand side of the figure. CoPI1’s focus on tech and design is seen in his placement on the left side of the figure. The nodes representing members of other intersecting social worlds (the Institute, the Museum, the advisory committee, the colleges, and the local schools) are on the left.
side of the figure, with their edges representing their direct connections to \textit{PI}. Figure 4.6 is the same social network analysis with \textit{PI} removed. Cross-disciplinary connections among the students are more easily seen here through a grouping with \textit{LIS1} at the center, connected to the other content team members and \textit{CSI} and \textit{Design1} (and to a lesser extent \textit{CS2}). The other tech team members (\textit{CS2 and ITI}) are not connected to this group, indicating that the connections ran through \textit{PI} (at least in the e-mail traffic in the sample analyzed). A connection between \textit{Institute} and \textit{IS1} (and to a lesser extent between \textit{Institute} and \textit{LIS1}) is more obvious in Figure 4.6 than in Figure 4.5. This represents the role that these two team members played in project management tasks such as ordering supplies. An artifact of the way the team used e-mail is more easily seen in Figure 4.6 than Figure 4.5—long, inclusive \textit{To} and \textit{CC} lists created fairly strong connections between nodes that were not communicating directly with each other, such as \textit{Museum} and \textit{School}. As \textit{PI} said in an interview,

I also spent a lot of time writing e-mails that were essentially long to-do lists and I would send a lot of those e-mails around to everybody so that everybody knew what other people were working on, but there were always sub to-do lists, so like this group's working on this and this group's working on this, and in theory all of the tasks were going to converge at some point in the future, but we're not really sure how that's going to happen or what it's going to look like at that point. [Interview with \textit{PI}]

\[\text{Figure 4.6. Stage 1 Social Network Without PI}\]
4.2.5 Stage 2: Alpha Test and Continuing Development

The milestone for Stage 2 was the alpha test of the full system that was conducted in May of Year 1. This was a major undertaking for the team, and there had been much pressure toward the end of Stage 1 to have the iPad application and website for the prototype habitat ready for the test. The alpha test was focused on the tech tools but the elementary school students who participated had to have some understanding of the nature of science and scientific inquiry concepts that underlay the intervention to use the tech tools effectively enough for a usability test, and there had to be a learning component for the students to justify the schools dedicating several days of the school year to the intervention. At this point the intervention ran for three days. On the first day team members went into the classrooms and taught nature of science and scientific inquiry concepts using materials from the website and some ancillary materials such as a brief introduction to data analysis. The students handled the iPads in the classroom, were introduced to the application and the work they would be doing at the Museum, and talked about some scientific questions that they would like to answer from their work at the Museum. The field trip occurred on the second day—the team had worked with the Museum to devise a schedule in which the students would receive a full field trip to the Museum and collect data at

Figure 4.7. Project Map of the Project Team in Stage 2
the prototype habitat. On the final day the team conducted a follow-up session in the classroom in which the students discussed topics such as their field trip experiences and the types of scientific questions that could be answered using the observational data that had been collected. The team worked with four schools in three school districts for the test, and running the intervention four times spanned the full month.

Figure 4.8. Project Team's Social Network in Stage 2

*TeachEd* ran the majority of classroom sessions, with help from the other content team members. Tech team members (primarily *CS2* and *Design1*) were in the classroom during the first part of the month as well, helping to run the website and train the students on the use of the iPad, and observing how well the website worked on the schools’ Internet connections and with the operating systems and browser versions that the schools were running. This was a major learning experience for the tech team:

I think some turning points that took a long time to get across, was that the teacher team … had been trying to tell the communications, uh the technology world, *PI* and them, that technology’s just not used like it should be and it's just not available like they say it is in the classrooms. And that, but that didn't change a lot, it just made, it just opened the eyes up a lot, which I think is still an important concept for the rest of the world to understand. But that became an issue because that put more work on the technology team because they had to make, you know we would sit there in the teacher team and say
things like, you really can do, one, for example, Internet Explorer 8 for example (I don't know, it's been a couple of years), and because they all have 4. And they were like, “Who has 4? That's ridiculous!” (I'm using this for an example.) “Who has that? Whatever …” I'm like, “No, really!” No, they didn't believe us a lot. And then we, when we went there they saw it, they were like, “Oh, wow.” I think that was something that changed some mental turning points. Did'nt really change the direction of the project, because we were still kind of reaching for that, and that became something we were looking at. But I think that that was something that stood out. [Interview with TeachEd]

![Diagram]

Figure 4.9. Stage 2 Social Network Without PI

The usability portion of the alpha test took place on the field trips to the Museum, as tech team and content team members collected data systematically on the usability of the iPad application, how much help the students needed to successfully collect the required data, and students’ reactions to the experience while the principal investigators observed the student less formally. Although the alpha test was a major undertaking, development work was continuing back at the office, as CS2 and Design1 were working on upgrades to the system. Three new students had joined the tech team—IT2 and IT3 who were dedicated to development of an iPhone version of the application that visitors to the Museum could use (see the discussion of sustainability in section 4.3.7), and LIS2, who was tasked with developing the multimedia components (pictures and videos) of the iPad application and the website.
Figure 4.7 depicts several continuing subworlds and three new ones. The subworlds of the principal investigators and the intersecting subworlds of the principal investigators and the student teams continued from Stage 1. Inside the social world of the tech team a subworld containing CS2, Design1, and IT1 emerged (CS1 had left the team after Stage 1). There are two cross-team subworlds: The subworld of LIS1 and LIS2 represents cross-team work to identify multimedia content needs and the larger cross-discipline subworld intersecting the content and tech teams reflects the classroom staffing of PI, IS1, LIS1, TeachEd1, CS2, and Design1.

In Figure 4.8 and Figure 4.9 the content team is centralized with PI, representing its members’ work in scheduling and running the alpha test. The tech team is primarily on the right-hand half of the figures, with multiple strong connections among CS2, Design1, and LIS1 and strong connections among CS2, IS1, and LIS1 in Figure 4.9. IT1 and IT2, who did not work on the alpha test, are at the edges of the figure (IT3 was not copied on the analyzed e-mails and does not appear in the social network visualizations).

4.2.6 Stage 3: First Workshops, Beta Test Preparation, and Continuing Development

Stage 3 constituted the summer (and end) of Year 1 of the project. The milestones for this stage were the first set of professional development workshops for teachers and preparations for the first test of the full intervention (the beta test), including finalizing the iPad application and the website for the prototype habitat, scheduling participating schools, and finalizing beta test materials.

The content team was focused on preparing for and conducting two sets of professional development workshops for teachers who were interested in participating in the beta test, and scheduling and preparing for the beta test. The workshops were held in June and preparation included producing materials (curriculum notebooks for the teachers and presentation materials to be used in teaching the workshops), ordering supplies, handling the final scheduling, and dealing with administrative details. The workshops themselves were conducted in six days over two weeks. After the workshops the content team shifted its focus to scheduling and preparing for the beta test. This involved many activities, including scheduling classroom visits and field trips for classes from 12 schools, preparing materials (classroom materials such as printable versions of the website educational content, parental consent and student assent forms, and
electronic and paper versions of the student surveys used for pre- and post-intervention tests), and working with the Museum to schedule and design the field trips.

Stage 3 activities for the tech team revolved around finalizing the iPad application and the prototype habitat website for the beta test. Although this type of activity was referred to as “finalizing,” it was really a milestone during the long process of iterative design and development of the technology tools and the iPad application and the websites were “finalized” many times. During the alpha test, and continuing throughout Stage 3, the technology team produced a major redesign of the iPad application based on the alpha test outcomes (for example, making buttons larger, streamlining entry screens, and making the sequences of activities performed on the iPad more clear). The redesign resulted in a major change in look and feel for the application. Website development was continuing, with the major update being a custom analysis tool that walked students through analyzing and creating charts from the observational data collected at the Museum.

![Project Map of the Project Team in Stage 3](image)

In Figure 4.10 the subworlds of the principal investigators and the intersecting subworlds of the principal investigators and the student teams continue from Stage 2, as do the tech team
subworld of CS2, Design1, and IT1. There are three new subworlds in this stage: The cross-team subworld intersecting the content and tech teams IS1, LIS1, TeachEd1, CS2, Design1, and Design2 reflects interdisciplinary work on finalizing the system for the beta test; the subworld of CoPI2 and TeachEd1 represents their teamwork in preparing for the beta test classroom work, and the content team subworld of IS1 and LIS1 represents their work in managing administrative preparations for the test.

Figure 4.11. Project Team's Social Network in Stage 3

In Figure 4.11 the social worlds of the principal investigators, the content team, and the tech team are clear, with the co-principal investigators in the bottom right quadrant, the tech team along the left hand side, and the content team clustered in the middle with PI. Figure 4.11 also illustrates multiple connections among all team members, with stronger connections among the principal investigators and among the content team. In addition, the only social worlds outside the project arena are the Institute and the Museum. The lack of expected e-mail traffic with schools (regarding scheduling and preparation) is an artifact of the data collection, as that communication had moved to a new channel, a project Gmail account that had been created to provide a central projected-branded e-mail address for the schools and TeachEd1, the main school contact point, was speaking with teachers by phone during this period as well.
In Figure 4.12, with *PI* removed, ties to the principal investigators become weaker, but the ties with the Institute and the Museum remain. This is due to *ISI*’s and *LISI*’s role evolution to become direct contact points for the Institute and the Museum as Year 1 ended and the administrative focus moved from organizing the project to handling administrative details like ordering supplies and paying invoices (*Institute*) and scheduling meetings and field trips (*Museum*). During Stage 3, *ISI* was playing much more of this role than was *LISI*:

Well, okay, so that, because *LISI* and I worked the closest together, *LISI* and I communicated about everything, and a lot of it was coordination. A lot of it was just coordination of the project, because we didn’t have a project manager, I think *LISI* and I served in that capacity as the administrators. So *LISI* and I coordinated, I thought, very well back and forth of identifying tasks that could have slipped through the cracks, or maybe did, or anyway. So *LISI* and I talked about everything, so coordination, about content, about who’s doing what, about what we need to do with quality control of the products. And then, I would say with *PI*, early on I talked to him about the tasks, but like I said as we got to be more autonomous, we would meet with him and talk to him about, kind of, what the next steps were, we would look at review a lot of the technical aspects. [Interview with *ISI*]

4.2.7 Stage 4: Beta Test and Continuing Development

Stage 4 covers September through April of Year 2. This includes the beta test of the entire system, analysis and follow-up from the beta test, and design and development to extend
the system to cover all the habitats at the museum. The content team was focused on the beta test throughout the stage, scheduling and staffing field trips. IS1, LIS1, and TeachEd1 ran the beta test with PI, CoPI2, and CoPI3—the students were in charge of the day-to-day operations and administrative planning including interactions with the Museum, the schools, and the teachers, while the principal investigators worked on issues such as putting systems in place to track teacher fidelity of implementation of the intervention. TeachEd1 worked with the teachers on intervention implementation in the classroom, spending much of her time traveling to schools to drop off and pick up parental consent and student assent paperwork and to model or help teach the intervention’s nature of science and scientific inquiry curriculum, as well as attending field trips. IS1 and LIS1 attended field trips and focused on scheduling activities and other administrative details. During Stage 4 the tech team was focused on the big push to extend the system to cover the entire museum, while continuing to improve the iPad application based on feedback from the beta test field trips to the Museum, during which team members had observed the students using the iPad application and reported any usability or functionality problems encountered. The content team began some work on the new habitats during the beta test, and then ramped up that effort in the late winter and the spring. IS1 was working on beta test data analysis with IntlEd and TeachEd5 under the supervision of CoPI3. And IS1, LIS1, and TeachEd1 began working on dissemination efforts in the spring, outlining potential papers with PI. Among the principal investigators, PI focused on creating an environment in which the content team had what it needed (e.g., personnel, answers to questions) to run the beta test, and concentrated on the push to expand the system (on the technology and content sides) and on the first efforts to write up results for publication. CoPI1 continued to work with the tech team, now on the expansion. CoPI2 and CoPI3 were focused on the beta test; after the beta test CoPI3 led the analysis efforts, working with IS1, IntlEd, and TeachEd5.

Well, early on the ones [turning points] that stick out in my mind all have to do with the technology and the infrastructure. Because my entire focus early on was, are we going to have a system? What is it going to look like? Are we going to have something where, from the technical side of things students can gather data out at the Museum and analyze the data in the classroom? And getting that together consumed a lot of my time. And so once, a major turning point for me was once we got to the alpha testing stage and we knew at the very least we had a technology that would work, then I focused my efforts on the interface itself and how do we make something that the students want to use. And the next major turning point from my perspective was how do we make this an integral part of the classroom curriculum? Now, fortunately, CoPI2, CoPI3, and TeachEd1 had
already been working on that aspect of it by the time it, so that wouldn't be seen as such a
turning point for them, they would probably see that earlier, would be my guess.
[Interview with PI]

![Project Map of the Project Team in Stage 4]

Figure 4.13. Project Map of the Project Team in Stage 4

All three social worlds (the principal investigators, the content team, and the tech team) experienced membership changes during this stage. Undergraduates TeachEd2, TeachEd3, and TeachEd4 were added to the content team for the fall semester to help with the beta test and to begin writing content for the system expansion. They left in January and IntlEd, a Masters student in the international education department, and TeachEd5 and TeachEd6, undergraduates majoring in a program that combined education classes with a science or mathematics major joined the team. On the tech team, IT2 and IT3 left, and art students Design3 and Design4 joined the team in January. Finally, CoPII left the team (and the University) late in Stage 4 and was replaced by CoPI4.

At this stage, the social worlds of the content team and the tech team had begun separating. The initial push to create the system was over, as were the big staff meetings that had characterized the early part of the project:

And that was one thing that we started doing too, was we started having separate meetings. Which was more beneficial to the team to begin with. We'd have whole
meetings and then we'd break up into the education media, the technology committee. Which, again, I thought worked, because, yeah, there's no sense sitting in a technology meeting when I don't have a clue. Although I liked to know what was going on, there was some times where I really wished I knew more about what was going on. I was unclear if that was because I just wasn't there because I was in the field, or if I was working from home, or it that just wasn't really my thing. So that was probably more isolated towards my position. [Interview with TeachEd1]

Figure 4.14. Project Team's Social Network in Stage 4

Now the tech team was focused on expanding the system and the content team on the beta test and producing content for the new habitats. With so many habitats to design and build out, the tech team developed a working pattern focused on individual work punctuated by meetings:

I worked, honestly, I worked on a lot of things on my own, but I collaborated with the visual design guys a lot. And we, we would kind of meet and all discuss the process of how things were going, and we would keep each other updated all the time. So we had like one meeting where we would all get, sit together and review what we were doing, but then throughout the rest of the week—these were weekly meetings—and then
throughout the rest of the week we would kind of work on our stuff and check in, and be like, “hey, this is done, do you guys all want to take a look at it?” So we had a shared repository where we put all the work, and so we could take a look at each other, at what each other was doing, and then coming together during the week and then we would explain it more. [Interview with Design1]

The content team had a variation of this work pattern. The Ph.D. students were running the team on the ground, handling upper-level functions and distributing work to the other students, who were creating spreadsheets for data analysis and writing and developing multimedia content, primarily on their own. Figure 4.13 shows this management subworld in the content team. In the social world of the principal investigators, the two initial subworlds remain and a third subworld recognizes the entry of CoPI4 at the end of the stage. Three cross-team

Figure 4.15. Stage 4 Social Network Without PI

subworlds emerged based on changing work needs during the stage. The subworld of ISI, LIS1, CS2, and Design1 represents the contact points between the groups—this subworld continued
throughout the stage. The subworld of \textit{IS1, LIS1, TeachEd1, TeachEd3}, and \textit{LIS2} represents the group that worked field trips during the beta test. And later in the stage, a subworld of \textit{IntlEd, IS1, LIS1, TeachEd6}, and \textit{Design4} emerged as the content team reached out for help with multimedia. Two subworlds intersected the world of the principal investigators and the content team: the beta test classroom support subworld of \textit{CoPI2 and TeachEd1} and the data analysis subworld of \textit{CoPI3, IntlEd, IS1, and TeachEd5}. The subworld of \textit{PI, CoPI2, CoPI3, and the content team}, which had existed through the first three project stages, is now called \textit{PI, CoPI2, CoPI3, IS1, LIS1, and TeachEd1}.

In Figure 4.14 this team focus is depicted, with the content team laid out in the upper part of the figure and the tech team taking up the lower portion. The work style differences are clear as well. In the content team portion of the figure, key members \textit{IntlEd, TeachEd5, and TeachEd6} surround the management core, while the tech team’s individual approach is reflected in a more even distribution across its space. The principal investigators who were on the team throughout the stage (\textit{PI, CoPI2, and CoPI3}) are clustered together near the center of the figure, while \textit{CoPI1} and \textit{CoPI4} function more as satellites of that core group. Figure 4.15 is very similar, but the content team’s weak ties to the tech team are more easily seen.

4.2.8 Stage 5: Second Workshops, Pilot Preparation, and Continuing Development

Stage 5 of the project comprised the final three months (June through August) of Year 2. During this period the team was focused on conducting the second set of professional development workshops for teachers, preparing for the official pilot test of the intervention that would occur in Year 3, and finalizing the expanded system.

In this stage the content team and the education principal investigators were mainly focused on preparing for the pilot test, which involved planning and running a second set of professional development workshops for participating teachers, expanding the intervention’s curriculum, scheduling the intervention at participating schools, scheduling the field trips, preparing materials and forms, and handling the administrative details connected to all of this. The content team also worked with the tech team to finalize the iPad application and website content for the expanded system. Coming out of earlier testing, the principal investigators had decided to run the pilot test with four teachers who had participated in the beta test and to work with the teachers to refine the intervention’s curriculum. Therefore, workshop preparation
involved developing a draft version of the expanded curriculum (process instructions and detailed lesson plans). *CoPI2* and *TeachEd1* took the lead on curriculum revision, with *TeachEd1* and *TeachEd5* constructing the lesson plans and *LIS1* and *IS1* handling production of curriculum notebooks for the workshop (designing and formatting, proofreading, and production). The workshops were held over two weeks in June; *PI*, *CoPI2*, and *TeachEd1* ran the workshops and *IntlEd*, *TeachEd5*, and *TeachEd6* attended and provided support (e.g., taking notes). Coming out of the workshops, the content team produced a revised curriculum, preparing physical and electronic versions, and supporting materials for the curriculum. *IS1*, *LIS1*, and *TeachEd1* scheduled the intervention’s classroom times and field trips, and *IS1* and *LIS1* worked out staffing schedules for the test and worked with *PI* and *TeachEd1* on administrative details. At the same time, the content team was finalizing the iPad and website content.

The tech team was focused on pilot test preparation as well, working with *PI* to finalize the expanded system. A major staffing change had occurred for this team at the end of Stage 4, when *Design1* graduated and left the team and *CS2* moved to a new city (although he continued to work with the team on a reduced-time basis) and *IT4*, a graduate of the information...
technology program and CS3, a computer science undergraduate, joined the team to replace them. Design1 was an original team member and CS2 a long-term member, and the transition had to be quick and seamless; PI and LIS1 scrambled to get the new team members up to speed.

![Project Team's Social Network in Stage 5](image)

The project map (Figure 4.16) depicts a stage in which many subworlds formed as everyone worked toward the goal of a successful pilot test:

Well I think, like about before, I think in Year 1 it became very much when I was involved it was much more like on the leadership team, which was not just the PIs but all of the grad students that were directly involved in that. So everyone would get together, we'd have those, I can't remember if they were weekly or every two weeks kind of meetings, but we would sit down, we would have met at the same time, that set time in [office location] to talk about how things were going on, so that, and that part of that, that was the initial network, right? And then as tasks came up then you would break off into teams based on that task. So, you know, scoring of assessments, who is going to do all of that, you'd bring all those people together, we would have a sub-meeting about that, get that set, milestones, this needs to be done by this date, this needs to be done by this date, and move on from there. So I think it was the organization of groups was very much more of a task-and-time phenomenon, it wasn't so much, “I really want to work with
you,” as it was, “Okay these are the people who are working on this set task right now and we’re working on this one together because this is the one that has to get done at this point.” [Interview with CoPI3]

Figure 4.18. Stage 5 Social Network Without PI

Multiple subworlds emerged as the content team worked with the principal investigators to prepare for the pilot test—the subworld of CoPI2, TeachEd1, and TeachEd5 (work on the curriculum), the subworld of PI, CoPI2, IntEd, TeachEd1, TeachEd5, and TeachEd6 (the teacher workshop), and the subworld of PI, IS1, LIS1, and TeachEd1 (pilot test administrative work) as well as the content team subworld of IS1 and LIS1 (materials production and scheduling). The tech team subworld of CS3 and IT4 represents final work on the website-database connection, and the cross-team subworld of LIS1, CS3, and IT4 represents work that LIS1 did with the new tech team members to get them up-to-speed.

Figure 4.17 depicts strong ties between PI and the core content team members (IS1, LIS1, and TeachEd1) and among PI, CS3, and IT4. Connections among the balance of the content team, among the tech team members, and between content team and tech team members are
weaker, and only one other principal investigator (CoPI3) appears in the figure. Figure 4.18 confirms the weak ties between the content and tech teams in Stage 5.

4.2.9 Stage 6: Pilot Test and Final Development

Stage 6 ran from the beginning of Year 3 through May of that year. This was the final year of the original grant term, and although the project year ran through August, the original milestones had been met by May, and almost all of the students left the project at that time. Stage 6 included the intervention’s official pilot test and analysis of the test; final development of the full system, including work to enhance the project’s sustainability; and a strong push on dissemination of project findings.

In the first three months of the stage, the content team was engulfed in the pilot test. The intervention had been redesigned to run for three consecutive weeks and the principal investigators had decided to have project team members in the classrooms to observe and to aid the teachers as necessary. The intervention was scheduled to run in the four participating schools over a six-week period in September and October. Three new team members were added for the pilot—TeachEd6, an undergraduate education intern, and two Master’s students in instructional systems, IS2 and IS3 (TeachEd5 had left during Stage 5). Six content team members covered the classroom observation during the pilot (IntlEd, IS1, IS2, LIS1, TeachEd1, and TeachEd6) and most of the content team members and tech team members attended field trips (IntlEd, IS1, IS3, TeachEd1, TeachEd6, CS2, Design2, Design3, Design4, and IT4). The content team Ph.D. students (IS1, LIS1, and TeachEd1) continued to manage the team’s work and handled many administrative responsibilities. During the pilot test and immediately afterwards, IS1 supervised IS3 and TeachEd7 as they input test data for analysis, worked with CoPI3, IntlEd, and IS3 on scoring the data, and then completed data analysis. The three students who had been hired to help with the pilot test—IS2, IS3, and TeachEd7—left the team after the pilot and the rest of the content team turned back to revising the intervention curriculum, writing up project results for publication, and working with the tech team on the iPad application and the website. The curriculum went through a final iteration after the pilot based on feedback from its use in the field. Several team members (CoPI2, IntlEd, IS1, LIS1, TeachEd1, and TeachEd6) worked on the revision. IntlEd graduated and left the team in December and TeachEd8, a Ph.D. student in curriculum and instruction, joined the team in January. Efforts toward dissemination continued,
with PI, IS1, and LIS2 and CoPI4, IS1, and LIS1 working on papers. Finally, at the end of Stage 6 the content team began working on follow-up grants with the principal investigators.

Figure 4.19. Project Map of the Project Team in Stage 6

During Stage 6 the tech team was focused on finalizing the full system and enabling sustainability for the project. The vision for sustainability was the development of iPad and iPhone versions of the application that would be available for free in the Apple App Store so that members of the public could make observations at the Museum and have access to the educational content, the observations database, and the analysis tool on the habitat websites. For school-related sustainability, a website was built to support teachers who wanted to run the intervention on their own after the grant was finished. Content team members LIS1, TeachEd6, and TeachEd8 worked with the tech team on these final versions of the system. The tech team also wrote system documentation during this stage.
Three subworlds emerged in the content team (Figure 4.19): a subworld made up of the content team members who were in the classrooms (IntlEd, IS1, IS2, LIS1, TeachEd1, and TeachEd6), the subworld made up of content team members working on data input (IS1, IS3, and TeachEd7), and a subworld of IS1 and LIS1, who were now managing pilot schedules because TeachEd1 was focused on the classroom work and the field trips. Seven cross-team subworlds emerged: the subworld made up of content team members working on scoring and data analysis (CoPI3, IntlEd, IS1, and IS3), the subworld of curriculum revision (CoPI2, IntlEd, IS1, LIS1, TeachEd1, and TeachEd6), two subworlds related to dissemination (PI, IS1, and LIS2 and CoPI4, IS1, and LIS1), the subworld of grant writing (PI, CoPI2, CoPI3, LIS1, and TeachEd8), the subworld of the content team and tech team members who attended field trips (IntlEd, IS1, IS3, TeachEd1, TeachEd6, CS2, Design2, Design3, Design4, and IT4), and the subworld of the content team members who worked with the tech team on the public apps (LIS1, TeachEd6,
Figure 4.21. Stage 6 Social Network Without PI

*TeachEd8, CS3 and IT4*. Two subworlds continued from the previous stage: the subworlds of the principal investigators (*PI* with CoPI4 and *PI* with CoPI2 and CoPI3). Although there was a lot of intersection across social worlds, many subworlds were working independently of each other:

The first year we all, we were all together, we knew each other. We knew each other the first project year, because we were a small enough team. But I can't remember everybody's name. But by the third year, there were people I never even met. I mean, I was in the field so much and then I was trying, you know, I never even met 'em, I didn't know who they were. I'd come in and say, “Hey, how are you doing?” But we'd at least get e-mails saying, “Hey we just hired this person” so at least I had an idea. So that was good. But it was a lot of changeover. But that's what happens when you have undergrads—we had undergrad students working with us. And so the thing about graduate students, they're, they're pretty much lifers at that point. [Interview with TeachEd1]
The Stage 6 social network visualizations, both with PI (Figure 4.20) and without PI (Figure 4.21) depict strong ties within the three social worlds (the principal investigators, the content team, and the tech team), with multiple weaker ties across the social worlds. There are also very strong ties among College, PI, TeachEd1, and IT4. These represent two sets of e-mail traffic: first, between TeachEd1 and the education college regarding school district policies and procedures for paperwork needed to authorize team members to go into the classrooms, and second, among PI, TeachEd1, IT4, and the information college regarding system outages during the pilot test.

### 4.2.10 Stage 7: Finishing and Moving On

The last stage of the project began in June of Year 3 and ran through the end of the Year 4 no-cost extension (I collected data during this period so the analysis does not cover the entire stage). Although the original grant term ran through August of Year 3, by May of Year 3 the majority of project tasks had been completed. Two students from the content team remained on the project in Year 4 with the four principal investigators, reducing the project arena to two social worlds.

Stage 7 tasks fell into three categories: finishing and closing out the project, continuing dissemination and outreach, and enabling sustainability. Finishing included conducting a third teacher workshop, writing papers for dissemination, and writing the final project report for the funding agency (the final task was to take place after data collection ended for this dissertation and is not included in the analysis). CoPI4 had joined the team to address some of these issues, including using data that had not been conceived as data for the main project—the journal entries written by the students:

> So I had the qualitative analysis piece. So part of the data that had come out of the project, I mean the project was largely quantitative and that's by design, that's how Department of Education projects work. I mean you're looking to measure the efficacy of an implementation, so that's primarily done quantitatively, obviously. But there was some qualitative data coming out of the project, specifically in the journal entries that the students were creating. So it was helpful to have a PI come onto the project who could really take the lead on a qualitative analysis of those data that were coming out. [Interview with CoPI4]
Efforts to enable sustainability focused on creating ways for students and the public to continue using the application and the websites and on submitting grants to fund expansion work on the project. The work to give further life to the application and websites included creating a version of the iPad application and an iPhone application that were uploaded to the Apple App Store and finalizing the teacher website that houses the curriculum and educative material on nature of science and scientific inquiry. The third summer teacher professional development workshop for teachers was also focused on sustainability as it was developed for teachers who might be interested in running the intervention on their own (with support from the teacher website). Multiple subworlds formed to address these tasks: PI, LIS1, and TeachEd8 handled project management and took the lead on writing grant proposals, PI, CoPI2, and TeachEd8 formed a subworld to plan the final teacher workshop, and CoPI4 and LIS1 and CoPI2 and TeachEd8 formed subworlds focused on writing for publication (Figure 4.22).

In figures 4.23 and 4.24 the strongest relationships are among PI, LIS1, and TeachEd8, which represents the core function these three team members played in organizing and developing Stage 7 activities. The ties among these team members, other Stage 7 team members, former team members, and individuals from other social worlds represent activities devoted to dissemination and outreach (e.g., e-mails about a paper that had been accepted for publication) and sustainability (e.g., discussing a teacher’s interest in continuing to use the intervention).
Figure 4.23. Project Team's Social Network in Stage 7

Figure 4.24. Stage 7 Social Network Without PI
4.3 Themes

This section reports on findings from the grounded theory coding of documents and interviews. It is organized by coding categories, with each category representing larger themes constructed from the data in light of my research questions and the sensitizing concepts that inform the study. Open coding was used to begin to identify concepts and categories in the data and these initial codes were arranged into relational groups to narrow and refine the categories. Finally, selective coding was used to identify central themes that are used for further theorizing (see Chapter Five) (Charmaz, 2006; Clarke, 2005; Strauss & Corbin, 1998). This process is explicated further in Chapter Three.

Three sensitizing concepts guided the grounded theory coding; these are summarized here to provide context for the themes:

1. The social worlds perspective (Strauss, 1978, 1982, 1984) is concerned with the ways in which actors define and interpret their social interactions. Social worlds are “characteristic of any substantive area” (Strauss, 1978, p. 122) and through the analysis of social worlds one can understand the ways in which actors collectively create meaning and develop action (Clarke & Star, 2008). The identification and analysis of subworlds and their intersections allows for the analysis of the construction of fluid work boundaries and the segmentation of work activities.

2. Intrinsically transient social worlds (Kazmer, 2002, 2010, 2012) are designed such that “each person’s participation in the world, and sometimes the existence of the world, will end at a specific time or upon completion of a specific goal” (Kazmer, 2002, p. 20). Intrinsically transient social worlds can be colocated or distributed and the features of transience can inform studies of social world involvement, maintenance, or departure.

3. Boundary objects theory (Star, 1989; Star & Griesemer, 1989) extends the social worlds perspective, supporting study of the intersections of social worlds and the discourses in arenas. Boundary objects cross the boundaries between social worlds and have different but overlapping meanings in different worlds. Therefore they cause information mismatches that require negotiation and translation to maintain coherence across the worlds.

The sensitizing concepts are explicated in depth in Chapter Two.
The three sensitizing concepts informed three overarching conceptual process questions that guided this study:

RQ1: What defines the different social worlds of an interdisciplinary team?
RQ2: How do team members view and identify with the social worlds of the team?
RQ3: How do team members bridge the social worlds of the interdisciplinary team?

This section explicates findings from seven major themes that connect to my focus on the processes the team used to work across interdisciplinary boundaries. They cover the iterative design and development process; roles and responsibilities; project management; rules, policies and procedures; technology issues, dissemination and outreach; and finishing the project and planning for the future;

4.3.1 Iterative Design and Development

Because, why didn't we take money and outsource the design and development, and of course, the problem was that the entire research project was building this thing. We didn't know what it was going to be until we built it. And so we didn't have any specs that we could give to someone and say, "Here, go build this thing." But in order to figure out what it was, somebody needed to have their finger on the pulse of the whole project and that was the role that I was playing there. Because we didn't know what it was going to be. We just had a vision and we ended up with something that hopefully matches the vision. [Interview with PI]

The original vision of the project was to design the technology tools iteratively, but iterative design and development became a much broader theme as the design and development of the customized fourth and fifth grade nature of science and scientific inquiry curriculum and the design of the intervention overall were approached iteratively over the course of the project. In an interview, PI spoke of the iterative nature of the project:

So my job was to make sure that all this parallel development that was taking place, on the programming side and the graphic design side, in the education side, and the curriculum side and on the museum side was all vaguely running in the same direction and to keep looping the groups back in together so that we were all going to arrive at the same destination, but we didn't know what that destination was to begin with. [Interview with PI]

The grant proposal was based on an iterative design and development process for the technology tools and the system, and although there was a broad vision for the technology tools and a basic understanding of how they would work, it took the building of multiple, iterative versions for the team to see where they were going. System development (technical and content
development of the iPad application and the websites) proceeded as a series of versions. A new version was finalized for every major project milestone: the prototype habitat (iPad application and student website) for the alpha test, the first teacher workshops, and the beta test; the initial full system (iPad application and student websites) for the second teacher workshops and the pilot test; the final full system after the pilot test; “public” versions of the iPad application and an iPhone application to be uploaded to the Apple App Store; the teacher website; and a final deadline for a website root page that directs visitors to the project website, the teacher website, and all the habitat websites. There were also many intermediate deadlines: The project website was finalized for a kick-off event that was held at the Museum in Stage 1 and the iPad application and the websites were finalized for meetings that PI had with the funding agency program officer and for many conferences and presentations. This stringent schedule and the continual iterations meant that the students (who were handling the majority of development tasks) had to be comfortable with uncertainty:

Because we had too many people working and it was too unclear what had to be done to give precise instructions to everybody. So, everyone needed to basically buy into what we were trying to do, identify the part that they were working on, go off and do it, and then actually do it, and then provide the feedback as to what they learned from it so that they could contribute to what we were going to do next. And not a lot of people are able to buy into that fail quickly, iterate rapidly approach … There was lots of space to fail but they actually had to go and do something. [Interview with PI]

The team strove to apply the best approaches to each part of the development. Generic tools were used and customized where possible and work from scratch was developed where needed. For example, the websites were built on a WordPress platform and the customization work was devoted to creating individual websites that worked together with a look and feel through-line and open access art was customized. This was an area in which specialist disciplinary knowledge was essential. For example, the custom analysis tool used to manipulate observational data was built through the use of an open-access utility:

So I mean initially I think he was struggling with how to do that and I was able to point in the direction of, you know, and that's the modern way with coding is, there's always various utilities out there you can use, like Google maps, and I think that we might have used the Google charts for that, which will, saves you a lot of coding because you just plug in your data to their application and it generates things for you that then you display in your website. So things like that can actually save you a huge amount of development time if you're aware of them. [Interview with CoPII]
The iterative design and development of the curriculum emerged because, as CoPI2 explained, “learning is hard”:

That there's this whole sort of scripted dance that the learner has to go through to construct that knowledge; it's not just a process of giving them information, you have to engage them in constructing their ideas around a topic. [Interview with CoPI2]

The physical experience of the beta test and the outcomes of its pre- and post-intervention testing prompted some rethinking of the experiences that the students were having in the classroom before and after the field trip, and about working in a realistic way with the evaluation tools that were available to the team:

Because that's the hardest thing is, with this project, is we're wanting to teach students about stuff that we don't have fantastic measures for. So the measure that we ended up using was not ability to engage in inquiry or make sense of stuff, it was students' understanding of the nature of this. So it's not procedural or metacognitive kinds of things, it's declarative knowledge. So in order to help students understand declarative knowledge, you have to be explicitly talking about what that, what those target ideas are. Which people don't just pick up by doing science. So there's a difference between doing science and knowing about science, right? So in order—we weren't measuring doing science, so we had to change the thing so we could get more of growth on knowing about science. And those two things are often conflated, right? And it seems, everyday, seems very intuitive that if you do science you'll know about science. By doing science you might get better at doing science, but doesn't mean that you're going to be able to describe things like differences between observations and inferences, between experiments and investigations, and those kinds of things. You just get better at doing, engaging in those practices. It's interesting when you think about measurements and things that we have, and in the education field we don't have a lot of great measures for a lot of things we want to be able to do. [Interview with CoPI3]

And just as the alpha test had provided key information about usability issues for the iPad application that had to be addressed through an iterative development process, the beta test provided similar inputs for an iterative development process for the entire system, including the curriculum:

So whether that would be the redesign of the app itself, of what are they physically engaging with, whether that's layout of information on the website, or the tools that they're using, or how to even tie that together between the online aspects and the face-to-face aspects of that, how do we move in a logical way or a way that promotes learning from the school to the library, back to the app, back to the school, those kinds of things, are we happy with the sequence of those things, are we happy with that? What kinds of non-learning issues are we seeing in the student data and how do we adapt things to increase those, I mean we overall took a, kind of a design-based research on this, which is the idea is you connect learning gains to, or learning to, implementation. So if things aren't producing learning gains, you redesign it and tinker until they do, that's the nature of the kind of research we're doing. [Interview with CoPI3]
The intervention included tools that enabled the co-construction of knowledge—an electronic journal with a commenting function and a discussion board. The journal was incorporated into the curriculum and students did write collaborative journal entries working in small groups. However, the social knowledge construction aspect of the intervention was not truly implemented, as the students did not comment on each other’s journal entries and the discussion board was not used. Teachers were introduced to the knowledge co-construction tools at the first summer workshop, but, as CoPI2 remarked in an interview, “You don't just give things to teachers. It doesn't work. You can't just give teachers things. They'll either sit there, unused, or they'll be used in ways that you really don't understand.” When CoPI1 left the project and the need arose to bring in a new principal investigator, CoPI4 was recruited in part to help the team implement the social learning tools:

The topical area of expertise that in theory I was bringing to the project was the whole online collaboration-facilitation of learning community kind of thing, but it turned out, which you would think would be really obvious because the entire practice of science is collaborative, right? And so the whole, like in real life the practice of science is collaborative. So the idea is that one of the things that we thought, oh, it would be really interesting to facilitate with the students, is to try to figure out how to facilitate their ability to collaborate on scientific activities … . But it turned out that it really wasn't, there was no way to get anybody to conceptualize that as being an important part of the project because it doesn't match up with the standards. … Not because anybody on the team was uncooperative, just because the whole, the whole intellectual environment, from the funding agency, to the way public education works, to the way the education standards work, it was a non-starter everywhere. [Interview with CoPI4]

CoPI2 saw this as partially a structural issue and partially as an outcome of the construction of the team’s social worlds. In discussing that she mostly worked with the content team she explained:

Yes, there was certainly this divide, right? The production and the utility. And, in retrospect that's unfortunate, because we would have, I think, ‘cause, in retrospect we needed to do both in the curricular materials. I don't even know if it's possible in the state of [name of state redacted] to put more of an emphasis on the discursive aspects of what that system could engender, journaling, writing, but you're going to have to get teachers willing to do that, so we would even have had to go in, to not situate ourselves just as science—Common Core would have helped us if it had been around. But this is a way to engage kids in science in doing some of these literacy practices. And if we had somehow highlighted that in the design of the app, and, yeah, if we had highlighted that in the design of the app that would have been good. [Interview with CoPI2]
4.3.2 Roles and Responsibilities

Early on I was involved in every single decision and then as the project went on and we had more people involved, a lot more of the decisions I had to delegate to other people. But the issue is that early on it was my vision that was driving us forward, right, because I knew what I wanted this to be and so if I didn't keep talking with everybody… So, so much of our meetings were, "this is the vision, this is what we're pushing, this is the idea that we're selling," and just keeping everybody moving in the same direction, just like we're doing with this [other project], you know, it's just meeting with people and saying, "this is the direction we're going, this is our vision, this is what we're trying to accomplish," and once everyone is moving in that same direction it's easier to just let them run. [Interview with PI]

The principal investigators had very clear ideas about their roles on the team, from both the team management and the disciplinary perspectives. Early in the project one of PI's main concerns was enabling the implementation of his vision of the project. But as the technology and the educational aspects of the project were built and sustained by the team members individually and in collaboration, the vision of the project began to be constructed and nurtured collaboratively by the team as well:

Because it's not just a matter of other people adopting my vision, it's that the vision evolved as the project went along, and then everybody had their own visionary pieces that they were adding into it. It was all still part of the same vision, but our understanding as to what the technology was going to be when we proposed it was very different from what the technology ended up being and the same thing held true for the curriculum and for the student participation and the online learning modules and all of this stuff. So I was able to step back from a lot of the conversations as other people started to see how all of this fit together and were pushing their own visions as all part of the same thing. [Interview with PI]

CoPI1 believes that it's important to maintain the vision’s coherence while it evolves to ensure that the project stays on task—that while the vision matures it doesn’t mutate:

That was one of the things initially I think that part of my role was to try and help maintain this original vision that myself and PI had, that was written down on paper, we have that in some of the earlier articles, but once you get on the nitty-gritty of doing that specific project, a specific place, developing a specific piece of software, that original vision can get watered down or lost, and so that's a difficult thing with any project that's part of a longer-term goal. [Interview with CoPI1]

Having jointly developed the project, PI and CoPI1 continued collaborating throughout the year and a half that CoPI1 worked on the project. Their joint portfolio included continued brainstorming about the iterations of the system, working with the programmers and designers, coordinating with the other principal investigators, and administering the project. As the project
geared up, PI began focusing more on the design of the system and administration, while CoPI2 and CoPI3 focused on the education side of the project, but he continued to manage the project at an upper level:

Well, I had a lot to do with the design of the systems, in particular, but also in the design of the curriculum early on. The curriculum was one of the first things that I kind of moved off, especially in the second year, off of my plate, but I kept a very tight hand on what we were building, from the technology and the system perspective. So for a while it was divided up where CoPI2 and CoPI3 ran the education content side of things and CoPI1 and I ran the technology side. But I had to be the person who was still bridging all of those concepts. [Interview with PI]

CoPI2 and CoPI3 were part of the management team and focused on the design of the curriculum and its integration into the larger system. Although they worked together, they focused on different areas of the education side of the equation:

If I'm recalling correctly, in our first year it was a lot of big idea planning meetings and leadership, we would get together and talk about what we wanted this, the website to look like, what it needs to be included, how the app we wanted to work, the kinds of experiences we want students to do. Then the following years, we started moving more toward, after that initial development we started moving toward, okay, how are we going assess student learning, how are we going to do the research aspect of that? And then from there it became much more, how do we revise, how do we fix, that kind of stuff. So, for me, the role I ended up taking was more on the assessment side of it, like how do we analyze the student data when that comes in, giving my two cents on functionality, where we want to go for the PD [professional development], where we wanted for the students. And then CoPI2 took more, on the science ed side, took more of a lead on what the nature of the PD for the teachers was going to be and what was going to be in the curriculum under the guidance of TeachEd1, which, or along with TeachEd1, because that seemed to be very, they worked well, they worked so closely together, being student and major professor, that makes sense. And then what I did, is I came in and helped with the analysis of the student responses, scoring, making sure reliability was well, helped with the stats, and those kind of things. And then used that information, “so let's talk about how to fix and tinker” and that kind of stuff. [Interview with CoPI3]

CoPI2 sought to keep the vision connected to the needs of the students who would use the intervention and to the realities of operationalizing the intervention in the elementary school classrooms:

I was a devil's advocate, I think. I also was the one that said, "Remember classrooms, remember classrooms, remember classrooms." Because sometimes, especially early on, it felt like we were getting lost in buttons and fonts and I don't even know the techie words. And I know that was a fear of the project—that was my fear. And it was my job to say, "Remember, this has to be used by kids, it has to have, not just that aahhh." And I was also the little learning wonk, that inputting data is not enough, kids. Inputting data will get us exactly data and noting else. It will get us data on [animals], nothing about
students. I just felt like, every meeting, “Gotta do it, they gotta use it,” just to constantly beat that drum. So in that way it was a really easy role because it was uniform. [Interview with CoPI2]

CoPI4 viewed her place on the team in a different light than did the other principal investigators because she came onto the project mid-way through, after the initial team had gone through the entrainment process:

If working with a group is a five-act play, right, I kind of came in between act three and act four. You know, everything was already on the downward slope. So people's roles were already established, people's relationships were already established; people had already started changing their goal and focus from this project to finishing this and moving onto the next thing. Getting publications out the door or what have you. So I wasn't coming in with a whole, “Let's bring you in on how to shape this project,” it was more of a, “Can you do this particular task?” [Interview with CoPI4]

CoPI4 was brought onto the project when CoPI1 left and had a dual portfolio that was related to her theoretical approach and to her methodological expertise. From a theoretical perspective, she was tasked with enhancing the collaborative knowledge construction aspect of the project and fairly quickly she encountered an issue that many interdisciplinary researchers face—differing priorities in theoretical and practical approaches to work. In this case, it was that collaborative knowledge construction efforts were “a non-starter” due to the priorities of the funding agency and the elementary educational environment. She then began focusing on the other side of her portfolio, bringing her theoretical approach and her qualitative research expertise to the project’s dissemination efforts.

Like the principal investigators, the graduate students were selected for their disciplinary expertise. For example, staffing plans from the beginning included hiring an information graduate student, because PI is an information researcher and because of the specific focus that person could bring:

The fact of the matter is that I wanted to keep a museum informatics emphasis on this particular project, so having a doctoral student who worked in that area was critically important because I didn't want it to just be an education project, or an instructional systems project, or an IT project. [Interview with PI]

ISI was hired to add an instructional design perspective to the team. But her specific role was not as clear at the beginning as was that of a student like CSI, who was brought in to work on the system infrastructure:

I just knew that we needed an instructional design person and I needed someone who had the right kind of vision to figure this out, so she had to figure out what role she was going
to play at the same time we were all trying to figure it out at the same time [Interview with ISI]

The roles of the students on the project evolved as project needs changed and crystalized. This eventually led to a splitting of the types of roles students played. PI connected this split to the project stages in which students were hired:

There's a natural dividing line between the students that worked on the first two years of the project and the students that worked on the final [third] year, because the first two years of the project we were really focused on the development, brainstorming, visioning, trying to figure out what we were actually doing. And the final year of the project was really more of assessment and evaluation. … I think the students who worked on the project during the first two years were more co-conspirators with the co-PIs and less student employees if that makes sense, whereas the people who worked on the third year only were more like, “this is what we're doing and this is what you are going to do.” [Interview with PI]

TeachEd1 connected this development to the differing priorities and focuses of graduate and undergraduate students and illustrated her point by explaining how her dissertation (which was an off-shoot of the project) and personal priorities connected her to the project:

[The undergraduates] were still part time and they had their tasks. Whereas, at that time, by the time they were in there, I was so geared towards my dissertation data and then, of course, I was so invested into the program, into the grant and the research, I wanted it to work … I had a lot of passion for the project. So by the third year I was so about the project. And they were still filling in task, the second year, into the second year and the third year, beginning third year. They were all about fulfilling task, doing a task here and there. Whereas I was looking at the overall, how is this going to affect my dissertation and the project? Are we going to get renewed in three years, that kind of stuff. And they were, you know, working and then going on to the next careers. They were valuable assets, we really needed them in the classrooms and things like that. [Interview with TeachEd1]

An unexpected outcome of this student role evolution was that students were empowered to “figure out what their job descriptions were as they were doing them” [interview with PI]. The ability of students to rise to challenges and the willingness of the principal investigators to give the students room to grow were two keys to a successful outcome:

Of course we didn't really expect that we would have this many students working on the project when it was funded initially. But a lot of students really rose into real leadership roles over the course of the project. And we relied upon them, we really did, because we didn't know what everybody was going to have to do. So a lot of the students really played a key role in figuring out what this was going to look like and where we were going to go. So the students who worked on the project, especially initially on, I wouldn't even think of them as employees, they were all co-researchers, really, on all of this, each
with their own particular area of expertise, all trying to figure this out at the same time. [Interview with PI]

ISI highlighted this aspect of the project and her appreciation of it:

One of the things I loved about the job was that we were treated as professionals and we were given freedom to move and to do, and I just appreciated that so much, to be able to say, "Yeah we need to do these things and to work with you and just to make these things happen." And you're right, I didn't do instructional, very much instructional design work, which I thought I would do—I did other things. But that was also great, because you get more experience doing different things. Yeah, I mean I expected to do more of the curriculum development and the training materials for the teachers, but I didn't have much to do with either of those. I mean I had minimal input and stuff, which is fine, 'cause I enjoyed what I was doing and really enjoyed the people that I worked with, and loved the project, and so I was fine doing whatever was asked of me, a lot of what was asked of me, whatever needed to be done. [Interview with IS]

In light of this, CoPI2 identified a role that was unconnected to the specific project goals—the principal investigators’ role as educators:

But it's been a great experience, I would say it's been particularly useful because it's been a way to apprentice a lot of graduate students in terms of how this work gets done. It's what we are supposed to do at the university, right? [Interview with CoPI2]

4.3.3 Project Management

So the problem with faculty research projects is that there really needs to be some champion to sort of shepherd the project through, so that was my role on this as PI. Because all the other co-PIs have their own projects that they have to keep the ball rolling on and someone has to keep their eye on the finish line and keep the ball rolling and that was really what I was doing. So it was an all-consuming project. Everything that I was trying to work on at the time just kind of fell by the wayside because I had three years to get his project done, and I was pretty much the only one who knew what everyone was working on at any one time because the other co-PIs didn't have the luxury of doing that. So they focused on their particular area of what they were trying to get done. So my role was really one of coordination. In essence, I guess what you could say is that, supported by the GAs, I kind of took on the project manager role because we didn't have a project manager so that's what I had to do. [Interview with PI]

The decision to transform the personnel line devoted to a full-time project manager into funding to hire more students meant that project management activities had to be picked up by team members who officially had other roles. This affected primarily PI, ISI, LIS1, and TeachEd1. PI handled major project management activities such as managing the staff, managing project deadlines, coordinating with the funding agency program officer, conducting outreach to the other social worlds (e.g., school districts, the museum, the university, the
advisory committee), handling human resource activities (e.g., annual appointments, new hires, personnel leaving the project, and salary increases) and managing the budget (e.g., budget tracking). *TeachEd1* took over much of the communication with schools (e.g., setting up professional development workshops and scheduling the intervention in schools), school districts (e.g., drafting and submitting annual school district research applications), and communication with the College (education) about policies and procedures. *IS1* and *LIS1* handled basic project administration activities (e.g., ordering supplies, submitting invoices for payment, arranging to repair broken equipment), creating and maintaining staffing schedules (e.g., scheduling team members to go into the schools, attend field trips, and attend professional development workshops), supervising content team interns, and coordinating activities between the content team and the tech team. *LIS1* worked with *PI* to draft and submit the annual reports on project activities for the funding agency.

And it ends up being just kind of a divide-and-conquer, I think, because everyone is so busy all the time, it's like, “So, who feels comfortable handling this?” “Okay, I'll take this one for right now.” “Go.” And then some of it's just, honestly, who's got the expertise in that, who feels comfortable doing that, who's got the time at that moment when it comes up to do that. I think it's it was never someone assigning jobs of, "You've got this to do, you've got this to do, do it," kind of thing. [Interview with CoPI3]

Early in the project much of the project management activity within the project team arena was handled during meetings. Meeting minutes were distributed via e-mail (meeting minutes were also saved to an internal website for a short time, but it was determined that e-mail was a better channel for distributing meeting follow-up notes):

I think I employed the same communications style, which is basically, "This is what we're all trying to do, this is the direction that we're going. Here is the list of things that we're all working on." And it's just a matter of getting together. And this was certainly true in the beginning phases of the project, right? We would get together once a week and we would all say this is what we've all been working on, this is the direction that we're all going, and half the times we'd realize that we were going in slightly different directions. And so we just kept evolving the direction that we were going and my responsibility was to keep us moving in the right direction. [Interview with PI]

The principal investigator meetings and full project team meetings were supplemented by team meetings and subworld meetings, and as the project progressed the smaller meetings became more of the norm, punctuated with larger meetings. Throughout the project, the process of setting meeting times was problematic due to team members’ other commitments. The
meetings and e-mail to-do lists were essential to keep everyone on track, and the shared office space created a central location for the team and provided structure for the students:

You can't assume that everyone is self-motivating, you have to be having regular meetings and telling people what's expected, communicating clearly what expected of them's important. Also having the right work environment. That working environment we had at [name of Institute redacted], I think that’s a big help, and the open plan working area that, in a professional building is separated from the department where all the students are around, if it was in the department there’s lots of distractions there. … That gives a central for various people to come together, whereas if we had all the different students working besides the professors in different locations on campus, I think that makes it more difficult to keep a project like that working, going along. [Interview with CoPII]

The project’s dedicated workspace also supported subworld and ad hoc meetings, and provided an environment in which the students helped each other and coordinated with each other, although subworld meetings also took place in other locations such as professor’s offices and university conference rooms. The project team maintained a Google calendar in which students were expected to schedule time in the office. They did not have to work all of their hours in the office, but they were expected to maintain regular hours and were encouraged to have overlapping office times when possible in order to facilitate collaborative work. Distributed collaboration was conducted using e-mail and four shared repositories: a College (information) server running WebDAV protocols, Google Drive, Wiggio, and Dropbox (PI, the tech team, and the content team used the WebDAV server; the content team used Google Drive for files related to the alpha, beta, and pilot tests; the tech team used Wiggio to store and share image files; and the principal investigators and the content team used Dropbox during Stage 7 to be able to share files with individuals in the education college with whom they were working on grants):

And that, I'll tell you what, that was one of the biggest things about this team, it was communication. We had excellent communication. I mean, you could text, e-mail, call we would have wireless outages. You could never, there was never a moment that I could not get a hold of somebody. And I think that was one of the things that I found the most impressive about working with the team. Which was good, because we were considered a technology, communication type of grant to begin with, so it was kind of important that we could always communicate. That communication's what allowed me to do my job, to be in the field all the time. [Interview with TeachEd]

Project work was organized around a series of deadlines. Major deadlines connected to project milestones (the alpha test, the first teacher workshops, the beta test, the second teacher workshops, the pilot test, and finalizing after the pilot test), but PI set many intermediate
deadlines connected to occasions such as a project kick-off event at the Museum, meetings with the funding agency program officer, and conferences and presentations.

Content team and tech team staffing levels varied based on project needs. At the beginning of the project PI and CoPII were most concerned about their ability to identify and hire sufficient staff with technology skills, and for the first three project stages the tech team was larger than the content team. As the team prepared for the beta test, PI and LIS1 determined that three content team members could not manage the number of scheduled field trips, and PI worked with CoPI2 to identify education undergraduates to hire as interns and so in stages 4, 5, and 6 the content and tech teams had approximately the same number of members. At the end of April in project Year 3 the majority of the students left the project because the main work was completed, leaving two students on the content team to work on dissemination and future planning with the principal investigators.

4.3.4 Rules, Policies, and Procedures

So we were looking for people to be able to cover our implementation and the research aspect of the implementation during the pilot study, and we needed multiple people to fill spots at all of these different schools during the implementation, and they were selected because IS2 already had clearance to be able to go into the schools, so that was one reason that he was selected. And then IS3 was selected because of his prior work in the school systems and he was able to either, he had clearance or he was able to get clearance quite quickly, so that’s the reason they were chosen. [Interview with IS1]

The rules, policies, and procedures of multiple social worlds (U.S. Department of Education/Institute of Education Sciences, the school districts, the education college, the university, and Apple, Inc.) affected the team.

The team had to work within the rules of the grant and the policies of the funding agency and the U.S. Department of Education. Discussion areas related to the funding agency included procedures for writing and submitting the annual reports, human resources issues (e.g., bringing on CoPI4, changing the level of effort of principal investigators, replacing the program manager with students, hiring undergraduate interns when the grant proposal only included graduate students), the availability of College (information) resources that had been written into the grant, the types of supplies that could be ordered under the grant, altering the number of participants in the research, and rules regarding travel for the grant.
The school districts had policies and procedures related to authorizing the project to do research in the schools and authorizing team members to go into the schools (including doing criminal background checks). The College (education) worked with the school districts to authorize team members to go into the schools; it required that team members provide photocopies of their school district badges, proof of health insurance, proof that team members were named on the university Institutional Review Board (IRB) application, and identification information to obtain verification from the school districts that the team members were authorized. Due to a breakdown in communication, the team learned about these policies just before they were scheduled to go into the schools for the pilot test and there was a subsequent scramble to complete and submit the necessary paperwork (including submitting IRB protocol revisions to the university human subjects committee to add students to the IRB application).

University policies that affected the project team included IRB application procedures, subcontracting rules, budget rules, purchasing and purchase order policies and procedures, policies and procedures related to writing and submitting annual reports to the funding agency, human resources policies (such as staff appointments, staff effort reporting, reporting time worked by interns, and the number of hours per week students were working).

The team encountered Apple, Inc. policies and procedures throughout the project, including the procedures for obtaining an Apple Developer Account (issues related to obtaining and renewing the account), procedures for getting iPads repaired (disconnects between university purchase order rules and Apple invoicing procedures), upgrading to OSX Lion (issues related to the university’s rule for buying software and Apple’s move to the App Store over providing software on disks), and policies and procedures regarding the application to distribute project iPad and iPhone applications through the Apple App Store (rules regarding the minimum number of customers expected to download the applications and procedures regarding the uploading of the applications).

4.3.5 Technology Issues

And so, it was like every piece along the line, the technology, which is supposed to be a tool that you just put it in and it works, it was all just this horrible uphill battle. Like, okay, now we have these iPads, alright, but of course we have to carry these—they have to be stored securely, they have to be carried around, we have to get iPads different places. And then the whole thing with getting the app into the App Store, that's like the biggest nightmare in the whole history of humankind. Programming the app was hard
enough but you at least expect that to be hard, but then just like the act of making it available to people so they could actually get it. So I would say that that's something that we didn't talk about, but that whole piece, from the wireless at the Museum, to the weather stations to the switch from iPods to iPads, to the whole getting the app out there, seemed like it was a whole other layer of blah! [Interview with CoPI4]

The team encountered technology issues and problems throughout the life of the project. Technology issues discussed by the team fell into several themes: installing and maintaining equipment at the Museum, server issues, project management tools, tech administration, and tech availability in schools (this theme does not include technical issues connected with the development of the technologies themselves).

In order to run the intervention at the Museum, the team had to install and maintain a wireless network and to install four weather stations that were used by students to record weather conditions. The wireless network was installed in two phases: the network was initially installed near the prototype habitat used for the alpha and beta tests, and then was extended to cover all the habitats for the pilot test. Installation involved coordinating with the Museum and the Internet provider and finding an appropriate installation location. The extension of the wireless network was more difficult, with the team needing to locate electrical power and set up repeaters to cover the habitats. Repeated testing of the network was required to cover holes and to create a network powerful enough to support the students on the field trips. The installation of the weather stations involved testing to find the optimum locations to install sensors that would reach four consoles and coordinating with the Museum to install the sensors and consoles. Maintenance of the equipment proved problematic, with team members periodically having to troubleshoot problems at the Museum.

Server issues related to problems running the system in the classrooms. The student websites were hosted on a College (information) server and during the pilot test the team experienced recurring server outages when the website was needed for work in the classrooms. This involved the coordination of efforts among PI, CS3, IT4, the College’s technical support staff, and the content team. Eventually the project’s files were moved to another server, but during much of the six weeks that the content team was in the classrooms for the pilot test the solution was to notify the College’s tech support staff of the classroom schedule so the other operations on the server could be temporarily shut down and for a tech support person to be available as content team members e-mailed and texted about problems logging into the system.
and running it. The content team also created a backup protocol that involved bringing printed versions of the website content and sets of observational data printed from the website.

The team used multiple project management tools: e-mail, the Google calendar with student schedules, the internal site, the College (information) server running WebDAV protocols, Google Drive, and Wiggio. There was no project management plan, and this hodgepodge of systems grew organically. The internal site was used briefly for sharing meeting minutes but this method was abandoned early in the project. The WebDAV server was set up by the College (information) after PI and LIS1 had discussed finding a way to share files. This server had the most complete set of shared files and was used by PI, LIS1, IS1, and the tech team. The content team began using Google Drive (originally Google Docs) to share information and files for the alpha test that were only needed by the content team and then continued to use it for the subsequent tests. This choice was made to ensure that the files were available when they were needed and because several of the content team members had problems logging into the WebDAV server. The tech team used Wiggio to store and share image files, but used the WebDAV server for all other information storage and transfer activities. The organic nature of this tool set meant that the teams used tools that were easiest and most comfortable for them, but it also led to some confusion about where files were located.

Tech administration issues related to administration of the WordPress sites, administration of passwords, creating backups, and uploading the iPad and iPhone applications to the Apple App Store. WordPress administration included creating user permissions for team members, creating logins and passwords for the classes for the alpha, beta, and pilot testing, and problems with using logins. Administration of passwords refers to discussions about collecting and maintaining records of the passwords used for the project—all the passwords created for project computers and the database. The process of uploading the applications to the Apple App Store meant working with the office at the University that handles this activity. This process was completed several times and was time-consuming as it involved much back-and-forth with that office before the team members had the correct developer versions and credentials to upload the applications. Creating backups includes backing up the WordPress sites, the database, and the WebDAV server.

Tech availability in schools refers to the availability of computers for the students to use for classroom work during the intervention. Computers were not always available, as they were
being used for standardized test preparation, and during the pilot test the team had to bring computers to one school for the pre- and post-field trip classroom work.

4.3.6 Dissemination and Outreach

So we [CoPI4, LIS1, and ISI] basically formed a little sub-team to do kind of qualitative analysis. … So we decided to go through and do sort of an open coding on the alpha test journal entries, I'm pretty sure that's what we did first. And so, we worked on getting the data out, figuring out what it looked like. …. We wound up with a really interesting problem where we did a paper proposal and a poster proposal for [name of association redacted]. So, I consider myself an information scientist, I mean, that's where my disciplinary home is, and I've been a member of [name of association redacted] since 1994, right, I've been attending the [name of association redacted] conference regularly since 1995. … So I found it incredibly mind-blowingly irritating that this paper and the poster that we prepared out of the qualitative analysis of the data from this project were rejected from presentation at the [name of association redacted] conference not primarily for their content but because the preponderance of the reviewers that looked at them said they were out of scope for the conference. And, to be told, having been in this discipline since 1993 when I started library school as we called it back in the day, to now, where, you know me and my work are really firmly situated in [name of association redacted], and to be told that the work that I'm doing is not relevant for their conference, I thought was odd. [Interview with CoPI4]

Dissemination and outreach efforts began early in the project and continued throughout its life. These efforts involved stakeholder outreach, public relations, and dissemination.

Outreach efforts took several paths. PI was in regular contact with the funding agency program officer, with the advisory board members, and with the school districts and principals. He also presented at meetings in a variety of venues including school board meetings, local tech club meetings, and multiple meetings of groups connected with the university. In addition, a smaller version of the intervention was run with a local science camp for girls during two summers, and groups from an education association that was meeting locally were taken on a field trip to work with the application. Many of the outreach activities could be categorized as public relations, but some specific public relations activities were undertaken, including getting articles in newspapers and association newsletters, and highlighting the project in the Institute’s annual report. In addition, LIS1 was tasked with keeping the project website up-to-date with news items about project activities, presentations, and publications, and updating the project publications page.
Dissemination included publications and presentations at academic conferences. The project team gave fourteen presentations of project results at academic conferences in the domains of education, information, instructional systems, and information technology and had published two peer-reviewed journal papers (three additional papers were being written during data collection for this dissertation). PI set up a process for this work in which a subgroup would take responsibility for a paper, deciding on the positioning of the paper and writing one or more initial drafts. When the subgroup was happy with the draft, it would be sent around to the principal investigators and content team graduate students. Feedback would then be incorporated into a new draft, which was sent around again. This process continued until all the participants were happy with the final draft and then the paper would be formatted and submitted. This iterative process had two goals: first, the papers and posters included multiple authors so it was important that everyone approve of the final drafts, and second, this process helped the team members work across disciplinary boundaries using the correct vocabulary, methodological approaches, and theoretical foundations:

And also, I would often need clarification, speaking of educational rather than information concepts, is I would need clarification on some of the education stuff. You know, when we say this, what does it mean? How was this, when we measured this, how was that done? That kind of thing, just to see if we were using words wrong. And I didn't always catch those, but that's okay, because all the PIs read the draft manuscripts and the posters, they were able to catch places where we had said things that made perfect sense to us but that didn't make sense from an education perspective. [Interview with CoPI4]

4.3.7 Finishing and Planning for the Future

So it was very much seen as a collaboration between faculty from different disciplines. Toward the end, I think even more collaborations came out as we started talking about new projects or which ways to go with this, because we have the efficacies trial, the issue of kind of taking this and being able to expand to other contexts away from [name of Museum redacted], and what would that end up looking like? So it becomes multiple collaborative projects, figuring out who is best suited to work on those based on what we know of how people work on this one and how, yeah, how people work on this one and what are they interested in doing and where moving forward and who's got time, those kinds of things. [Interview with CoPI3]

During the last part of project Year 3 and the Year 4, the remaining team members focused on finishing and closing out the project, continuing dissemination and outreach, and enabling sustainability. Finishing included conducting a third teacher workshop, writing papers for dissemination, and writing the final project report for the funding agency (the final task was
to take place after data collection ended for this dissertation and is not included in the analysis). Efforts to enable sustainability took two directions: setting up the intervention to run on its own through the public versions of the application and websites and the teacher website, and applying for grants to take the intervention in new directions.

4.4 Summary of Findings

Those sort of three things, innovation, creativity, and entrepreneurship were essential characteristics, because you could think of this as, this was kind of a startup. Because we had that million dollars that was invested from our venture capitalists, and we had sold this idea, but we didn't know what it was going to do, so we had to make it up as we went along, and all we had was the proposal to guide us, but what we said in the proposal was very different from what we ended up making, not in the grand sense of things, at the high level we built what we said we were going to build, but the specifics of how it's going to work was very vague, and it's only when we started working within the constraints of the technology or the classroom curriculum, or the learning goals, or the state standards, or what have you, or the Museum, that you find out what the reality of the situation is. So again, I needed people that I can say to, “here's our vision, this is what we're trying to do. Your piece of it is to build something that fits within these constraints and supports the vision.” [Interview with PI]

This chapter presented findings from analyses of the documentary and interview data. First, the analysis was situated by a situational map that included 10 categories: individual human actors, collective human actors, political/economic elements, nonhuman elements/actants, discursive themes of human actants, concepts, related discourses, temporal elements, spatial elements, and implicated/silent actors. Next, the social worlds of the project team were analyzed using a social worlds/arenas map, seven project maps, and 14 social network visualizations. The social worlds/arenas map is a visualization of three social worlds in the project arena and 10 social worlds that intersect with the project arena. The project maps and the social network visualizations focused on the project arena and analyzed the changing subworlds of the project team over seven project stages that were constructed around major project milestones. Finally, seven themes constructed from the data were explicated: the iterative design and development process, roles and responsibilities, project management, rules, policies and procedures, technology issues, dissemination and outreach, and finishing the project and planning for the future.
In Chapter Five I answer the research questions, discuss the findings in context of the literature and sensitizing concepts, introduce a substantive theory, discuss potential implications of this research, and outline future research directions.
CHAPTER FIVE
DISCUSSION

In this chapter I discuss the findings presented in Chapter Four in light of the research questions and the sensitizing concepts (see section 2.5), offer a substantive theory of interdisciplinary team processes for technology development based on the outcomes of the dissertation research, and discuss implications of and next steps for the research. Section 5.1, Social Worlds of the Team, describes the research team’s social worlds, social world segmentation, and social world change over time and addresses research question 1. Section 5.2, Portrait of an Intrinsically Transient Interdisciplinary Team, describes the roles team members played and discusses challenges faced by the team; this section addresses research question 2. Section 5.3, Bridging Social World Boundaries, discusses boundary objects used by the team members to enable translation and coherence across social world boundaries and addresses research question 3. Section 5.4, Iteratively Designed Teamwork, introduces a substantive theory of interdisciplinary group processes. Section 5.5, Implications and Future Research discusses potential next steps for this research.

The three research questions that guided this study are:

RQ1: What defines the different social worlds of an interdisciplinary team?
   RQ1a: How do social worlds segment?
   RQ1b: How do social worlds change over time?
   RQ1c: How do information researchers fit into the social worlds?

RQ2: How do team members view and identify with the social worlds of the team?
   RQ2a: What role(s) do(es) each team member play in the social worlds and sub-worlds?
   RQ2b: How have each team member’s roles changed over time?
   RQ2c: What challenges emerged at critical points in the project?
   RQ2d: What strategies were developed to address challenges?

RQ3: How do team members bridge the social worlds of the interdisciplinary team?
   RQ3a: What processes and objects enable translation across social world boundaries?
RQ3b: What processes and objects enable coherence across social world boundaries?

5.1 Interdisciplinary Team Social Worlds

This section addresses the team’s social world composition and the traits of the social worlds, and social world segmentation and change over time.

5.1.1 Social World Composition and Traits

The three main social worlds of the team—the principal investigators, the content team, and the tech team—did not emerge organically. They were derived from an organizational structure designed around the roles that were originally envisioned for the members of the social worlds based on responsibilities that were primarily domain-based. At the beginning of the project the social worlds were sparsely populated—the principal investigator world had four members and the content and tech teams had two members each. Among the principal investigators, PI and CoPII had previously been associated as faculty members in the information department; CoPI2 and CoPI3 had been associated as faculty members in the teacher education department and were working together on other grants. CoPI4, who joined the project mid-way through, was a faculty colleague of PI. Over the course of the grant term the team constituted 30 in total—five principal investigators and 25 graduate and undergraduate students. These three social worlds (the principal investigators, the content team and the tech team) remained the substrate of the team throughout the three years of the original grant term; the principal investigator social world always included four members, but the content team and tech team populations varied across time.

The three social worlds evidenced traits detailed by Strauss (1978): at least one primary activity, sites where the activities occur, technology with which activities are performed, and organization to support the activities. Members of the social worlds also worked in different arenas of discourse, with each world employing a specific vocabulary (Maines, 2001). The primary activities of the principal investigator world were team management, dissemination, and management of a portion of the work of the project team. PI and CoPII oversaw technical design and development; PI oversaw the content side of the tech development; CoPI2 and CoPI3 oversaw the educational aspects of the alpha test and the beta and pilot tests, curriculum
development, and measurement development (CoPI2 focused more on curriculum and CoPI3 focused more on measurement); and CoPI4 was brought in to address student collaboration issues. The primary activities of the content team were to design and develop content for the iPad application and the websites; and to support the alpha, beta, and pilot tests; curriculum development; and measurement of test results. The primary activities of the tech team were design of the iPad application and the websites and development of the technical infrastructure for the application and websites (e.g., the observational database and the WordPress installation).

The project team had office space that functioned as the official site of the project, but not all activities occurred there (Strauss, 1978). With the exception of PI, the principal investigators went to the office space only for meetings, and eventually most of the meetings with content team members moved to locations closer to the principal investigators’ offices on campus (tech team meetings occurred in the office space). PI spent more time in the office working with the students, but that amount waxed and waned depending on the need for his physical presence. The students were expected to spend time in the office, but the amount of time each actually spent and the amount of student schedule overlap varied depending on individual student’s school and work schedules and on her or his function on the team (e.g., content team members spent time at schools for the intervention). Project team members also worked at the Museum (for meetings, field trips, and technology installation and testing) and at multiple elementary schools (during the classroom portions of the intervention). This meant that much of the time the team practiced distributed collaboration and its “space and a shaped landscape” (Strauss, 1978, p. 122) were physical and virtual.

The base technology (Strauss, 1978) used for much of the work was e-mail, and the team had server space that used WebDAV protocols on which most of the project documents were saved. However, the social worlds did evolve technology use to serve their own purposes—the content team began using Google Drive (originally Google Docs) to share information and files for the alpha test that were only needed by the content team and then continued to use that platform for the subsequent tests (because several of the content team members had problems logging into the WebDAV server). The tech team used Wiggio to store and share image files (but used the WebDAV server otherwise), and the principal investigators and the content team used Dropbox during Stage 7 to be able to share files with individuals in the education college with whom they were working on applications for new grants. The specialization of technologies by
social world (Strauss, 1978) meant that the social worlds used tools that were easiest and most comfortable for their members, but it also led to some confusion about where files were located. Building a suite of technical tools for the intervention was a main outcome of the project so there was much activity around the building of the technical tools and the infrastructure, and there was a lot of activity involved with team members teaching each other technical skills and helping each other with technology problems (Strauss, 1978).

The organizational work of the social worlds drove much of the social world segmentation (e.g., who would do what, how would they get it done, and with whom they must work to get it done) and subworld intersection (e.g., working with a member or members of another social world to get it done) (Strauss, 1978, 1984).

### 5.1.2 Social World Segmentation and Change Over Time

Most of the subworlds that formed during the seven project stages more closely resemble incipient subworlds. They appeared during a stage, served their purposes, and then disappeared or evolved into new subworlds. Their members did not necessarily see these subworlds as subworlds, but outsiders could recognize them as such (Strauss, 1984). The Stage 6 subworld made up of the content team members who were in the pilot test classrooms (IntlEd, IS1, IS2, LIS1, TeachEd1, and TeachEd6) illustrates this point. The subworld was formed as a result of the iterative design of the classroom side of the intervention. The specific factors that led to the formation of the subgroup were: the decision to increase the proportion of time spent in the classroom during the intervention, the decision to beef up support for teachers in the classroom, and the decision to put observers in the classrooms. Therefore, formation of the subworld and the design of the core activity were driven by factors outside the subworld itself—decisions made by the principal investigators. Several members of the subworld—IS1, LIS1, and TeachEd1—had more agency in the segmentation processes, as they took up the cause, gathered the subworld participants, and developed the processes that defined the subworld’s existence. So while the initial inciting incident for subworld segmentation was the decision of the principal investigators to increase in-classroom support, the members of the subworld participated in the segmentation and in legitimation processes (Strauss 1982, 1984). As the pilot test progressed, the subworld evolved processes for communicating and transferring knowledge, and although its members were distributed among sites (they were primarily in separate classrooms and traveling alone}
between classrooms during the pilot test), they had a physical home base at the project’s offices where they picked up and dropped off materials and a virtual home base in e-mail. A differentiation process can be seen, as the members operated as a group that was aware of itself as a group and aware that its activities were different from the activities of the main social worlds. The members of this subworld participated more in writing than rewriting its history, through their interactions with each other and through the evolution of subworld processes. As with all of the subworlds, the competition for resources was friendly. A need for resources for the activities of the group was identified during Stage 5 by PI, IS1, and LIS1 and three new content team members were hired to work on the pilot. This was a competition for resources in the sense that the money used to hire these content team members could not be used for other purposes (e.g., hiring tech team members), but there is no indication that there was strong competition for these funds at the time (Strauss, 1984). There was more competition for resources in relation to the technology issues that arose during the pilot test (the problems with load on the websites during classroom activities). This problem consumed time resources from College (information) personnel, tech team members (the CS3-IT4 subworld), and the pilot test classroom subworld members (primarily TeachEd1) as they collaborated to create workarounds that temporarily kept the websites running and as they worked to create a long-term solution. For both of these illustrations of resource competition, members of the subworlds engaged in persuasion of a gatekeeper of resources (PI), who in turn negotiated with the gatekeeper of resources at the College (information). This resource problem was also part of the subworld’s process of debating and maneuvering in arenas. The arena of discussion about the place of classroom time in the intervention overlapped with the arena of discussion about the need for the tech team to finish the public version of the iPad application, the public iPhone application, and the work of finalizing the iPad application and the websites. In the end, the subworld did not segment further—rather it disbanded and its members joined new subworlds that were forming. This is a function of the subworld’s formation as a functional unit of the content team that was focused on a specific set of activities that ended at a pre-arranged time (Strauss, 1984).

As was noted above, the main driver of social world change across the stages was function, as subworlds budded off from the main worlds to address functional needs and then died or evolved. But some subworlds were much longer-lived—both subworlds within the social worlds (e.g., IS1, LIS1, and TeachEd1) and those that intersected the worlds. In fact some
subworlds were so permanent that there is a question of whether they should be categorized as evolving social worlds in their own rights (boundary-setting in social worlds is not a clear-cut exercise (Strauss, 1982)). An example of this is the cross-team subworld of PI, CoPI2, CoPI3, and the content team. This subworld technically was intact through all seven stages, but its membership changed as undergraduate education interns came and went from the project. One can also look at this as an evolving subworld that eventually budded off with a core membership of CoPI2, CoPI3, TeachEd1, IS1, and LIS1. This evolution is tied to the growth of the status of the classroom curriculum from being a two-day classroom agenda surrounding the field trip in which the students learned enough about the nature of science and scientific inquiry to use the technology successfully at the Museum to a fully implemented three week curriculum that included the field trip and became part of the infrastructure of the project. So this represents a subworld evolving with a technology, with activities that became more focused over the stages, and with a core membership that became more focused on those activities over the project stages (Strauss, 1984).

5.1.3 Information Researchers in the Social Worlds

The project team included five information researchers over the course of the project: PI, CoPI1, CoPI4, LIS1, and LIS2. These researchers were distributed among the three social worlds—three were principal investigators (PI, CoPI1, and CoPI4), one was on the content team (LIS1), and one was a member of the tech team (LIS2). All five of these researchers had roles that placed them in positions to work across domain boundaries, and two were active boundary spanners (Brown & Duguid, 1998; Cross & Parker, 2004; Levina & Vaast, 2005). CoPI1, while focusing on design and development with the tech team, played project management roles (managing team members with PI and focusing on the original vision of the project) in which he worked beyond technology development. LIS2 was a member of the tech team but had a portfolio focused on multimedia design, which in practice put her in position to work with content team members. CoPI4’s role was in practice more narrowly drawn than she and the PI had originally envisioned, a function of the point at which she joined the project (much of the work was in the service of moving toward finishing the grant) and of issues concerning the ability to create big movement on student collaborative knowledge construction. While these three team members were in position to work across boundaries, in practice they were operating
more as specialists than as generalists. The two information researchers who were operating more as generalists, PI and LIS, were also actively functioning as boundary spanners—linking social worlds and functions by sharing expertise (Cross & Parker, 2004). Museum informatics, the sub-disciplinary background that they brought to the project, accounts for some of the boundary spanning because it works at the intersection of information, technology, and people (Marty, 2000, 2008; Marty, Rayward, & Twidale, 2003). Museum informatics experts bridge technology worlds with subject area worlds and are adept at translating across social world arenas of language. In addition, PI was operating as something of a generalist because, even though he focused more on technology in the later parts of the project, his role as the principal investigator put him in the crosshairs of many boundaries. LIS was also operating as more of a generalist, or possibly as a utility infielder, continually shifting to aspects of the project that needed help. She was also one of the content team members who were most likely to work with tech team members across the social world boundaries.

5.2 Portrait of an Intrinsically Transient Interdisciplinary Team

This section discusses research question 2, which addresses the roles team members played in the project, challenges that emerged, and strategies to deal with the challenges.

5.2.1 Team Member Roles

The majority of team members played multiple roles on a micro level (e.g., writing website educational content and writing lesson plans for the curriculum), but on a meso level most of the team members (including most of the principal investigators) worked primarily on the tech side of the team or on the content/education side of the team. On the tech side the roles primarily related to design and technology infrastructure development and maintenance, and on the content side the main roles included website and iPad content development; curriculum development; test execution, support and evaluation; school and teacher outreach; and student collaborative knowledge production support. Roles that fell into more general categories included sustainability, project management, dissemination and outreach, and future planning. Role change over time was primarily connected to project activities on a micro level, with many team members focusing on broadly the same types of roles across the project stages. The team
members who operated as boundary spanners (primarily PI, ISI, and LIS1) saw the greatest meso-level role changes.

The majority of team members had roles that connected to their home domains (e.g., teacher education, museum informatics, information technology, art). As the literature review notes, there is little agreement about a definition of interdisciplinary collaboration, and the agreement that exists is in broad strokes. Much of the discussion in this area focuses on the extent and nature of theory and method integration (Aboelela et al., 2007; Klein, 2010a; Lattuca, 2001). In the case of interdisciplinary project teams, the discussion is complicated by the problem-based nature of the majority of projects—theories and models may not be driving forces behind such collaborations. At the start of this project I decided to use the term interdisciplinary to describe the research team based on a broad definition from the National Academies (2004) that focused on the motivations of problem solution and knowledge production. The findings of this study support the use of that term, but the definitional complexities were also very much in evidence in the findings. Aboelela et al. (2007) synthesized the literature on this subject to describe the characteristics of multi-, inter-, and trans-disciplinary research by categorizing the types of participants, the problem definition, the research style, and the presentation of findings. In this schema, interdisciplinary efforts have participants from more than one distinct academic field (as opposed to disciplines); the language of the problem definition comes from multiple fields or multiple or intersecting models are employed; the research style draws from the multiple fields and includes multiple data sources and varying analysis of the same data; and dissemination includes shared publications with “language intelligible to all involved fields” (p. 340). The definitional problems are immediately apparent when this schema is applied to the research team in this study. The team included members from several distinct academic fields, including education, library and information science, communication, computer science, and art, so that is not a problem. However, issues that bedevil researchers that attempt to work across domain boundaries considerably affect the other categories. For example, the official problem definition for this project was focused on the language and concerns of the funder. The researchers themselves had a broader vision for the project that went beyond the initial product produced for the grant and integrated disciplinary theories and methods, but the funder’s goals and the likely composition of the peer reviewer panel had to be taken into account in the development of the grant (Langfeldt, 2006; Travis & Collins, 1991). Data analysis was also
affected by the grant’s focus, and the research design for the official pilot study was driven by
the funder’s specifications—in this case, a laser-like focus on quantitative analysis of the
intervention’s outcome. The project team collected and analyzed further data using methods
drawn from other disciplines—for example, a usability study had been planned from the
beginning, and several qualitative analyses were completed—but the quantitative focus of the
grant drove much of the work on the project and other publication projects had to be developed
on the side. The question of publications raises another issue that many interdisciplinary
researchers face—the available outlets for dissemination (e.g., academic journals and
conferences). Publications had multiple authors and attempts were made to include language that
was intelligible to all, but that sometimes led to rejection based on a perception of that the work
was out of scope.

5.2.2 Challenges and Strategies

Few serious unexpected challenges emerged in the findings. The major challenges that
did emerge related to time pressures, the need for more teacher support during the pilot test, and
technology issues. Time pressures were primarily connected to the continuing pressure to hit
project milestones and the iterative rounds of system completion. The pressure to hit milestones
was expected, but the amount of staff hours that were needed to successfully complete the
milestones had not been anticipated. This led to the decision to trade out the planned project
manager position in order to hire more students. PI also managed the time pressures through the
development of continual rolling deadlines (e.g., setting multiple deadlines to complete interim
versions of the system in time for presentations and conferences, rather than setting one or two
major deadlines per year). Therefore, rather than a situation of punctuated equilibrium (Engwall
& Westling, 2004; Gersick, 1988, 1989) or cycling states of inertia and revolution (Gersick,
1988), the project team more resembled the situation of Kazmer’s refined ITSW model (2010) in
which group members were found to have an ongoing awareness of time throughout the project.
The need for more teacher support, which led to the iterative development of the curriculum, was
not unexpected among parts of the project team. Interviews with educators on the team (e.g.,
CoPI2 and TeachEd1) revealed this need was anticipated to a great degree (e.g., TeachEd1’s
description of the iterative rounds of curriculum development as a series of drafts leading to the
final product), but other members of the team were not necessarily aware of that. However, this
situation also required the application of more staff hours, and as the project grew, new content/education staffers were hired to meet that challenge. The most unexpected issues of those detailed here were the technology issues that arose during the pilot test, when server capacity was not meeting the needs for running the websites in the classroom. This was addressed through the coordination of project team members with tech staff from the information college and the dedication of server resources to the project at moments of greatest need.

5.2.3 Intrinsically Transient Social Worlds

Findings from this study align with Kazmer’s refined ITSW model (2010). The original model (Kazmer, 2002) was developed through the investigation of an online LIS master’s degree program and the model was refined based on work with a distributed, time-limited, grant-funded research project group (Kazmer, 2010). Kazmer’s focus was on the disengagement process, and the model’s 12 dimensions reflect that orientation. Although the 12 dimensions were not specifically used for coding and the focus of this study was not on disengagement, most of the ITSW dimensions were evident in the findings to various degrees:

- Adapting role and identity: This dimension relates to the evolution of role identities based on the shifting needs of the project over time and individuals’ conceptions of project needs. The evolution of role identities is seen most specifically in this work in the changing roles of the students who became “co-conspirators” with the principal investigators and in the evolving activities of the boundary spanners.
- Shifting focus: This refers to focus shifts from internal to external matters as the project ended, such as dissemination to project stakeholders. The concept is a driving focus of two of the themes constructed from this project’s findings: dissemination and outreach, which covers activities related to dissemination of project outcomes and outreach to various stakeholder groups, and finishing the project and planning for the future, which covers the final stage in the project when the remaining team members worked on activities to sustain the intervention and to find funding for future work on the intervention.
- Experiencing intrinsic transience: This dimension focuses on team members’ awareness of the limited time to complete project goals. In this study the concept emerged in multiple codes related to team members’ expressions of the awareness of time, and can
be seen in the *iterative design and development* theme through the idea of finishing multiple iterations of the system and in the project management theme in the laddered deadlines for the iterations.

- **Entrainment with a cohort:** This relates to activities designed to draw in and incorporate members with the group. Entrainment activities for this project were seen in codes for various categories of meetings and “getting [new team members] up to speed”. In the focused coding stage these activities were sorted into the *project management* theme.

- **Disengaging from the cohort:** This dimension relates to variability in team members’ tenure on the project (e.g., leaving early). There was a lot of movement of personnel on and off this project, which is described in section 4.2. The team members themselves initiated some of the departures because they took jobs outside the university or graduated. However, many departures were initiated by the principal investigators during the major staff reshuffling that occurred at the end of the primary project activities during third year of the project, and the final two students left the project late in the fourth year when their funding ran out. The concept of a “natural breaking point” in the project emerged in coding, relating to personnel changes in stages 4 and 5.

- **Preexisting relationships:** This refers to the effect of such relationships on project work and on expectations of continuing relationships. Both of these concepts emerged in the coding. The prior relationships among team members are seen in the social worlds analysis, and continuing relationships are seen in the partnerships of team members in writing for publication and in the *finishing and planning for the future* theme as team members collaborated on new grant applications.

- **Joining next logical worlds:** This dimension refers to disengagement activities such as team members moving on new projects and students looking for work. In this project the concept connects to the work on new grant applications to fund new social worlds focused on further iterations of the intervention.

- **Managing time and money:** This dimension covers aspects of project time and funding, team members working on multiple projects, and changing staff time allocations over the life of the project. On this project, project time and funding connect to the concerns about being able to complete the project goals that led to alterations in the staff budget lines as seen in the *project management* theme (the decision to transform the project
manager personnel line) and the rules, policies, and procedures theme through codes related to the grant’s budget rules. The concept of team members working on multiple projects (as well as having other professional and personal commitments) emerged as the code “mentioning commitments outside the project.” Changing time allocations did not emerge as a concept.

- Pursuing goals and Product: These dimensions are related to the team’s goal of producing a product. In the refined model pursuing goals is a joint activity of the group, as opposed to the individual goals (e.g., graduating) that were the focus of the students in the original study. In this project the team members’ collective focus on the project’s goals can be seen throughout the findings. Interestingly, one team member also mentioned an individual goal that harkens back to the 2002 model, completion of her dissertation. The product dimension relates to a positive impact the existence of the product had on team members’ disengagement processes and the product’s role in coherence on the project. The impact of boundary objects on coherence across social world boundaries in this project is discussed in section 5.3.

- Closing membership and Changing the footing of relationships: These dimensions relate to closing relationships with the group and disengagement from the group as the project ended. These concepts are not a focus of the findings—for this project the focus of the ending stage is more on sustainability and finding further funding. However, the project interviews validated one aspect of the closing membership dimension—all of the team members reported (to various degrees) that they had forgotten details of the project. (This type of forgetting is an expected development as project members begin the disengagement process and represents a refocusing of cognitive load on their next logical worlds (Kazmer, 2010).)

Implications for the affinity between this project and the ITSW model are discussed further in section 5.5.2.3.

**5.3 Bridging Social Worlds**

This section addresses research question 3, processes and objects that enable translation and coherence across boundaries. This research question was informed by boundary objects theory (Star & Griesemer, 1989). A number of nonhuman actants were identified as part of the
sociotechnical system that the project represents: the project websites, the iPad and iPhone applications, the intervention curriculum, the professional development curriculum, the grant narrative, the measurement instruments, the project calendars, and implementation tracking tools. And several members of the team (PI, ISI, and LIS1) have been identified as boundary spanners. In addition, a number of social world and subworld boundaries were identified in the course of mapping the social worlds and subworlds of the project team. Boundary objects can be abstract or concrete, have specific meanings for different social worlds and are the “sites of intense controversy and competition for the power to define them” (Clarke & Star, 2008, p. 121). At the same time, because their structure “is common enough to more than one world to make them recognizable,” (Star & Griesemer, 1989, p. 412) they are able to support translation across social world boundaries by facilitating cooperation without consensus and enabling coherence across the social world boundaries (Clarke & Star, 2008).

Several objects supported translation and coherence across boundaries. The technology-focused PIs and the education-focused PIs did not form a consensus about the best way to integrate the curriculum with the sociotechnical system as a whole until after the beta test. However, this lack of consensus was not clear early in the project, as the education-oriented principal investigators were working with the technology-oriented principal investigators to achieve the original vision of the project. A boundary also existed inside the content team: two of the Ph.D. students (IS1 and LIS1) were not domain experts in curriculum and teacher training, and one (TeachEd1) was. However, the content team was responsible for developing educational content for the websites and the iPad application, and worked with CoPI2 to develop the curriculum. Objects played a big part in translation and coherence across that content team boundary and across the boundary of the subworlds of the principal investigator world (PI-CoPI1 and CoPI2-CoPI3). The student surveys (the measurement instruments for the beta and pilot tests), the iPad application worksheets, and the evolving curriculum supported translation across these boundaries. Team members could have differing views of the role of technology in the project, and the driving vision included connecting field trips to curriculum to support students in conducting their own scientific inquiries. But the surveys represented the outcomes that mattered in the end if the project were to be considered a success by the funding agency. The iPad application worksheets supported translation across social world boundaries through the work on the vocabulary used in the worksheets, with activities in refining the vocabulary
supporting growing understanding of the specific outcomes needed from the project. The iterative development of the curriculum supported translation in a similar way, as the refinements of each iteration helped team members on opposite sides of social world boundaries understand the needed outcomes of the intervention. These objects primarily served to support translation within the content team, within the world of the primary investigators, and across those boundaries. Translation between the worlds of the principal investigators and the content team across the boundaries with the world of the tech team was primarily accomplished through the effort of boundary spanners—primarily PI, ISI, and LISI. The objects that enabled coherence across boundaries supported that coherence directly across the boundaries of the three social worlds. The grant narrative and its explication of the vision for the project served this role. In translating across the main social world boundaries, the narrative’s primary role was its explication of the vision. Within the content team the grant narrative as a document also enabled translation and coherence as the content team Ph.D. students used it on a regular basis to support their activities.

A number of years after boundary object theory was proposed, Star (2010) reflected on questions she had been asked about the nature of boundary objects. She reiterated the characteristics of boundary objects that allowed groups to cooperate without consensus:

- The object (a set of work arrangements that are material and processual) resides between social worlds where it is ill structured.
- When necessary, the object is worked on by local groups who maintain its vaguer identity as a common object, while making it more specific, more tailored to local use within a social world, and therefore useful for work that is not interdisciplinary.
- Groups that are cooperating without consensus move back and forth between the two forms of the object (Star, 2010, pp. 604–605).

She also brought in the concepts of scale and scope—she thought that the concept of boundary objects is most useful at an organizational level and more useful at its most specific. In this sense, the sociotechnical system as a whole (technology, educational content, and curriculum) operated as a boundary object, enabling translation and coherence.
5.4 Iteratively Designed Teamwork

One of the proposed outcomes of this dissertation study was the development of a substantive theory, an explanation of processes, actions, or interactions based on the experiences of study participants that can help guide practice or act as a framework for future research (Strauss & Corbin, 1998). The explanation that I have constructed from the findings of the research is called Iteratively Designed Teamwork (IDT).

IDT is built from the core concept “fail fast, iterate rapidly.” This concept was originally expressed in an interview to describe a work process for the iterative design and development of the technology infrastructure. However, the sentiment also describes a more central concept that continually emerged in different ways—the idea that for the intrinsically transient social worlds of the project team, the key factor for success was for team members to just get things done:

We had too many people working and it was too unclear what had to be done to give precise instructions to everybody. So, everyone needed to basically buy into what we were trying to do, identify the part that they were working on, go off and do it, and then actually do it, and then provide the feedback as to what they learned from it so that they could contribute to what we were going to do next. [Interview with PI]

In other words, there was a lot of room to fail in the service of finding the correct path, but in order to fail, the team members first had to be willing to try things. This theme occurred again and again, with the team using iterative design concepts to build everything in the project. The technology elements were iteratively designed and developed. The curriculum was iteratively designed and developed, growing from a one hour class session that introduced students to the scientific concepts and prepared them for a field trip, to a three week custom curriculum that integrated the field trip into a full sociotechnical system. Content for the technologies was iteratively designed and developed, starting from a set of concepts pulled from the state standards and an information organization scheme, and growing to a suite of 10 websites and 50 observational worksheets for the animals’ habitats. But beyond this, the team itself began to be designed iteratively, a process that was evident throughout the findings. Not enough technology staff to make the milestones? Trade out a project manager position to be able to hire more designers, computer scientists, information technology experts, and an instructional designer. Now there isn’t a project manager? Let the Ph.D. students help you manage the project and eventually take over the day-to-day management of the content team. The original computer scientist who was building the project’s technology backbone leaves? That’s okay, the
undergraduate computer science student you hired to help him will step up. But this pattern isn’t an accident—it’s the outgrowth of a team working within the constraints of time and resources but with role flexibility and an entrepreneurial outlook. It flows out of “the commitments of individual actors to collective action—to work of some kind” (Clarke, 1991, p. 129).

Figure 5.1 Iteratively Designed Teamwork (IDT) Model

Figure 5.1 illustrates the IDT process through elements drawn from the findings. Inputs include the project goals, roles and responsibilities as originally understood by the team, and team member activities. The final outputs are the system, publications, project reports, and applications for new grants (which may lead to the process starting all over again). Two dimensions apply pressure on the process that gets the team from the inputs to the outputs: time, in the form of the grant term, and intervening elements, in the form of rules, policies, and procedures (e.g., from the larger academic organization, from the funder, from other political and economic elements) and technology issues. Strategies to keep progress moving are communication, multiple deadlines, entrepreneurship, and a flexible role structure.

During the forming (Tuckman, 1965) stage of group development activities can be developed because goals are clearly defined through preliminary work. Team members buy into
and support the goals and goal planning leads to the development of sub-goals (Sheard & Kakabadse, 2002). Leadership is essential for effective team processes and faster cohesion of the team—good leaders assign roles, develop and communicate expectations, provide resources, motivate, monitor progress and eliminate obstacles, and act as boundary spanners between the team and its environment. Team leaders also create team interaction patterns that team members can use to work together (Sheard & Kakabadse, 2002; Zaccaro & Klimoski, 2002). The principal investigator sets the tone for the team and is responsible for maintaining focus on the goals (Fernald & Duclos, 2005).

Support resources such as a project manager or administrator and management committees help facilitate process and communication across project sub teams (Slatin et al., 2004). Team meetings provide forums for communication and coordination (Slatin et al., 2004). Meetings should be used in the goal planning process (Sheard & Kakabadse, 2002). They should start early in the project and the formats and focus of meetings should evolve to match changing team needs (Fernald & Duclos, 2005). Informal communication has also been shown to be an important factor in group processes and multiple communication and collaboration technologies must be used when groups work asynchronously (Haythornthwaite, Wellman, & Mantei, 1995). The organization should develop criteria by which team leaders will be selected and should support the development of the emerging leaders (Sheard & Kakabadse, 2002). One way in which organizations impede team performance is by directing tactics instead of letting team leaders take control of goals (Sheard & Kakabadse, 2002). Successful team members employ problem-solving skills rather than relying on the leader and exhibit interpersonal skills such as the ability to communicate and negotiate with other members of the team (Arabi & Ahmed, 2006). A positive relationship has been observed between team heterogeneity and team information sharing, learning, motivating, and negotiating. Individual team members in heterogeneous teams may take on accountability for team goal achievement if they see their contributions as unique (Drach-Zahavy & Somech, 2001). Flexible role development enables teams and sub teams to adapt workflows for both short- and long-term demands (Kozlowski et al., 1999).

Teams performing activities that require higher levels of innovation have been observed to have higher levels of participation and support for innovation. Members of such teams interact and share information more frequently and are more likely to exhibit distributed decision making.
processes than teams requiring lower levels of innovation (Curral, Forrester, Dawson, & West, 2001). Finally, professional and other incentives such as authorship on papers are “an essential driving force” for team members (Arabi & Ahmed, 2006).

5.5 Implications and Future Research

This study was exploratory in nature and provides a platform for future research in three areas: refining and expanding the substantive theory, refining the research design and instrumentation, and exploring further theoretical implications.

5.5.1 Validate, Refine and Expand the IDT Model

This study explored the social worlds of one interdisciplinary academic research team. Potential next steps to refine and expand its findings can be approached from a number of different directions. Fundamental work in this area would consist of repeating the study with additional intrinsically transient academic teams to explore the transferability of IDT (e.g., replicate findings), to refine and expand IDT, and to explore multiple types of interdisciplinary collaboration. The influence of other social worlds on the research teams, such as shared connections outside the team (e.g., joint work on other projects and social connections), also should be explored as a next logical step in this research. There was some indication in the coding that researchers’ commitments outside the project may create pressures on their work on the project (cf. Kazmer & Haythornthwaite, 2001) and this may be a fruitful path to investigate. Another potential path to refine and expand the findings is to explore cross-domain collaboration in non-academic settings—for example, project teams in commercial and non-commercial entities or on political campaigns. Finally, a potential new direction for this research is to add an evaluation component by exploring the use of the IDT model to understand factors that may make teams more productive and higher performing. Government and other funders have called for better evaluation of grant outcomes, and this research may add to literature and practice in this area (Dubnick, 2005; Heinrich, 2002; Radin, 2000)

5.5.2 Refine the Research Design and Instrumentation

This study included some work in mixing GTM and social network analysis, and future studies can explore the methodological implications of this design. Further work can also expand
the use of e-mail with grounded theory approaches and employ additional data types, such as surveys, in combining GTM and social network analysis. The current instrumentation (the semi-structured interview schedule) can be refined and new instruments (e.g., a survey) can be tested.

5.5.3 Further Theoretical Implications

Another research stream that can flow from this work is further exploration of the theoretical implications of combining the social worlds perspective with social network analysis, such as using social network analysis to identify social worlds and to help improve team design by describing the trajectories of teams as they evolve over time. Wellman (1988) identifies a power of social network analysis in the ability to analyze connections among clusters that represent individuals’ memberships in multiple clusters or their ties with “foreign” (p. 43) clusters within the network. This can be explored as a connection point with the social worlds perspective. The concept of “membership network analysis” (Breiger, 1988, p. 86), can also be explored to inform social group and subgroup analysis. In addition, the use of structural analysis to chart information and resource flows and competition for resources in a network (Wellman, 1988) might inform the analysis of information flows and resource competition among social worlds and subworlds.

The congruence of this study’s findings with the ITSW model (Kazmer, 2010) can also be addressed further by exploring how IDT might inform work with ITSW. One potentially fruitful area of investigation flows from ITSW’s emphasis on social world departures. Although IDT must still be validated, refined, and expanded, its focus on processes that occur during the lifespan of social worlds might work as a complement to ITSW in studying group processes from beginnings to endings.

5.6 Summary

This dissertation research project explained an intrinsically transient interdisciplinary research team’s process of collaboration across domain boundaries to design an educational technology intervention. It answered three research overarching research questions: What defines the different social worlds of an interdisciplinary team, how do team members view and identify with the social worlds of the team, and how do team members bridge the social worlds of the interdisciplinary team? The questions were informed by the sensitizing concepts of the social
worlds perspective, intrinsically transient social worlds theory, and boundary objects theory. The study found that the main driver of social world change across seven project stages was the development of short-term social worlds based on specific functions but that some subworlds were much longer-lived and covered multiple functions. The majority of team members were found to play multiple roles when viewed on a micro level, but from the meso level most team member roles were fairly stable over time. Three team members (two of whom are information researchers) were found to act as boundary spanners across these roles. Few major unanticipated challenges emerged, but those that did were connected to time pressures, the need for more teacher support during the pilot test, and technology issues. The outcomes of the study were found to align well with Kazmer’s refined ITSW model, with small differences arising from this study’s different focus. Several boundary objects were found to enable translation and coherence across social worlds and within the social worlds of the principal investigators and the content team and the sociotechnical system as a whole was found to work in bridging boundaries. A substantive theory, Iteratively Designed Teamwork (IDT), was proposed to explain the social world processes of the intrinsically transient interdisciplinary team. Future research should be used to validate, refine, and expand the theory; to refine the research design and the instrumentation; and to further explore theoretical implications.
APPENDIX A

SEMI-STRUCTURED INTERVIEW SCHEDULE

1. Tell me about [name of the project]: How did this project come about?
2. How were people selected to participate in [Name of the project]?
3. How would you describe your role or roles within the team? Has that changed / did that change over time?
4. What tasks do you / did you perform related to the project? Has that changed / did that change over time?
5. With whom do / did you work? Has that changed over time / did that change over time?
6. Would you please elaborate on the nature of your relationship [individual team member]
   [Ask for all team members that were placed on the diagram]
7. I notice that you didn’t place [individual team member] on any of your diagrams. Why is that?
8. What kinds of subjects do / did you communicate with other team members about? [Ask the participant to elaborate vis-à-vis different team members]
9. What are / were the opportunities for collaboration? With whom?
10. What are some major turning points in the project? Can you think of any changes that occurred after any of these turning points?
APPENDIX B
INTERVIEW INFORMED CONSENT FORM

FSU Behavioral Consent Form
Mapping The Social World Boundaries Of Interdisciplinary Teams: Processes For Working Across Disciplines

You are invited to be in a research study about the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team. You were selected as a possible participant because you are or have been a member of the team under study. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Nicole D. Alemanne, a doctoral candidate under the supervision of Dr. Paul F. Marty in the Florida State University College of Communication and Information.

Background Information:
The purpose of this study is to learn more about the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team.

Procedures:
If you agree to be in this study, we would ask you to do the following things: Participate in an interview with a maximum duration of 1 hour, complete a social network mapping activity, and possibly participate in a follow-up interview with a maximum duration of 20 minutes. Your interview will be audio recorded in order to help facilitate in note taking and the maps that you draw will be collected for the study.

Risks and benefits of being in the Study:
There are no foreseeable risks to participating in this study. While there are no foreseeable direct benefits to participating in this study, you may gain insight into the process of participating in interdisciplinary research.

Compensation:
You will be offered one $30 gift card. The gift cards will be distributed at the end of the data collection period.

Confidentiality:
The records of this study will be kept private and confidential to the extent permitted by law. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records. The audio files will be stored digitally and the maps that you draw will be stored in a locked filing cabinet. All files will be destroyed 5 years after the completion of the study.

Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to not answer any question or to withdraw at any time without affecting those relationships.

**Contacts and Questions:**
The researcher conducting this study is Nicole D. Alemanne. You may ask any questions you have now. If you have a question later, you are encouraged to contact her at [contact information]. You may also contact the researcher’s advisor at [contact information].

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B, Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at humansubjects@magnet.fsu.edu.

You will be given a copy of this information to keep for your records.

**Statement of Consent:**

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

_________________________________  __________________________
Signature                        Date

_________________________________  __________________________
Signature of Investigator         Date
APPENDIX C

E-MAIL INFORMED CONSENT FORM

FSU Behavioral Consent Form
Mapping The Social World Boundaries Of Interdisciplinary Teams: Processes For Working Across Disciplines

You are invited to contribute emails to a research study about of the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team. You were selected as a possible participant because you are or have been a member of the team under study. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Nicole D. Alemanne, a doctoral candidate under the supervision of Dr. Paul F. Marty in the Florida State University College of Communication and Information.

Background Information:
The purpose of this study is to learn more about the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team.

Procedures:
If you agree to be in this study, we would ask you to do the following things:
Download emails about the project that you have sent and received to a USB drive that will be provided to you. If the USB drive must be mailed, the researcher will provide a stamped, self-addressed envelope to you.

Risks and benefits of being in the Study:
There are no foreseeable risks to participating in this study. While there are no foreseeable direct benefits to participating in this study, you may gain insight into the process of participating in interdisciplinary research.

Compensation:
You will be offered one $30 gift card. The gift cards will be distributed at the end of the data collection period.

Confidentiality:
The records of this study will be kept private and confidential to the extent permitted by law. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records. The audio files will be stored digitally and the maps that you draw will be stored in a locked filing cabinet. All files will be destroyed 5 years after the completion of the study.
Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to not answer any question or to withdraw at any time without affecting those relationships.

Contacts and Questions:
The researcher conducting this study is Nicole D. Alemanne. You may ask any questions you have now. If you have a question later, you are encouraged to contact her at , . You may also contact the researcher’s advisor at , .

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B, Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at humansubjects@magnet.fsu.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:
I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

_________________________________  _______________________
Signature                          Date

_________________________________  _________________
Signature of Investigator          Date
APPENDIX D
MEETING NOTES INFORMED CONSENT FORM

FSU Behavioral Consent Form
Mapping The Social World Boundaries Of Interdisciplinary Teams: Processes For Working Across Disciplines

You are invited to contribute meeting notes to a research study about the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team. You were selected as a possible participant because you are or have been a member of the team under study. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Nicole D. Alemanne, a doctoral candidate under the supervision of Dr. Paul F. Marty in the Florida State University College of Communication and Information.

Background Information:
The purpose of this study is to learn more about the process of collaboration across domain boundaries in an intrinsically transient interdisciplinary team.

Procedures:
If you agree to be in this study, we would ask you to do the following things:
Provide permission for project meeting notes to be downloaded from the project website.

Risks and benefits of being in the Study:
There are no foreseeable risks to participating in this study. While there are no foreseeable direct benefits to participating in this study, you may gain insight into the process of participating in interdisciplinary research.

Compensation:
You will be not be offered compensation.

Confidentiality:
The records of this study will be kept private and confidential to the extent permitted by law. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records. The audio files will be stored digitally and the maps that you draw will be stored in a locked filing cabinet. All files will be destroyed 5 years after the completion of the study.
Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to not answer any question or to withdraw at any time without affecting those relationships.

Contacts and Questions:
The researcher conducting this study is Nicole D. Alemanne. You may ask any questions you have now. If you have a question later, you are encouraged to contact her at . You may also contact the researcher’s advisor at .

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B, Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at humansubjects@magnet.fsu.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:
I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

_____________________________  __________________________
Signature                              Date

_____________________________  __________________________
Signature of Investigator             Date
APPENDIX E

HUMAN SUBJECTS APPROVALS

Office of the Vice President for Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 - FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 11/27/2013

To: Nicole Alemannie

Address: Stones Bldg., PO Box 3062100, Tallahassee, FL 32306-2100

Dept.: COLLEGE OF INFORMATION

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Mapping the Social World Boundaries of Interdisciplinary Teams: Processes for Working Across Disciplines

The application that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and two members of the Human Subjects Committee. Your project is determined to be Expedited per 45 CFR § 46.110(7) and has been approved by an expedited review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 11/23/2014 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to assure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is IRB00000446.

Cc: Paul Marty, Advisor

HSC No. 2013.11547
RE-APPROVAL MEMORANDUM

Date: 09/23/2014

To: Nicole Alemanne - [Redacted]

Address: Shores Bldg., PO Box 3062100, Tallahassee, FL 32306-2100

Dept.: COLLEGE OF INFORMATION

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research:
Mapping the Social World Boundaries of Interdisciplinary Teams: Processes for Working Across Disciplines

Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 09/22/2015, you are must request renewed approval by the Committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chairman of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

Cc: HSC No. 201413586
REFERENCES


BIOGRAPHICAL SKETCH

Nicole D. Alemanne earned a Bachelor’s degree in English and Rhetoric from Binghamton University (State University of New York) in 1984 and a Master’s of Science in Library and Information Science with a certificate in Museum Studies from Florida State University in 2008. She enrolled in the doctoral program at the Florida State University College of Communication & Information, School Information (formerly the College of Information) in the fall of 2008. She has worked as a Graduate Research Assistant, Lead Graduate Instructor, and Graduate Teaching Assistant in the School of Information and has a background in media and marketing research. Nicole’s research interests include the social processes of collaborative knowledge construction, the use of information and communication technologies to support these processes, and the development of social theory to frame this work.