ABSTRACT

Title of Document: UTILIZING THE TEAM EFFECTIVENESS FRAMEWORK TO EXAMINE HOW SCIENCE EDUCATION CURRICULUM DEVELOPMENT GROUPS WORK TO CREATE TECHNOLOGY-INFUSED CURRICULUM

Megean E. Garvin, Doctor of Philosophy, 2012

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Today, school districts are challenged to create technology-infused science curricula in order to improve the education of our Twenty-first Century workforce. School districts assemble science education curriculum development groups to rise to the challenge. At times, school districts also collaborate with researchers and form groups that include researchers, classroom teachers, and school district administrators. In contrast to studies that focus on technology-infused science curriculum products and teachers' and students' use of those products, this multiple case study examined how three science education curriculum development groups worked to create technology-infused science curricula. The shift in focus on the process of how teachers and researchers collaborated to create curricula products stemmed from limited research that described tensions between teachers and researchers. I utilized the Team Effectiveness Framework, a framework previously employed by government agencies, private

businesses, and military operations, to further explore how tensions emerged during the development of technology-infused science curriculum. The findings revealed that tensions occurred due to how the groups defined technology-infusion, assembled group members, assigned group roles, facilitated dual curriculum audience discussions, addressed multi-level organization norms, and built team cohesion and trust. Within each case, tensions shaped the resultant science curriculum artifacts. Thus, the study highlights ways in which technology was infused into science curriculum and how diverse expertise of team members, multi-level norm discussions, and local technology resources shaped science curricula artifacts.

UTILIZING THE TEAM EFFECTIVENESS FRAMEWORK TO EXAMINE HOW SCIENCE EDUCATION CURRICULUM DEVELOPMENT GROUPS WORK TO CREATE TECHNOLOGY-INFUSED CURRICULUM

By

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Dedication

To my parents, Chris and Judy, who were my first and continue to be my dearest mentors. Thank you for your endless love and support.

To my husband, JP, and my children, Emily and Christopher, thank you for your patience, love, and support.

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Chapter 1: Introduction

After a sweeping twenty-year era of science education curriculum reform in the late 1970s, Wayne Welch (1979) conducted an extensive review of science curriculum studies and highlighted the need to study the process of curriculum development with emphasis on the interactions between scientists and classroom teachers. At the time and still apparent today, science curriculum development decisions occur primarily at the local school district level. In the 1990s, two sets of science national standards, *Benchmarks for Science Literacy* (1993) and *National Science Education Standards* (1995), provided states and local school districts with guidelines of when to teach particular concepts. Then, No Child Left Behind Act of 2001 required states to systematically test students in science, and local school districts responded to both the law and assessment requirements by developing rigorous science curriculum to prepare students for state assessments and enhance overall scientific understanding. To accomplish this task, local school districts continue to partner with universities and research institutes to develop rigorous science curriculum without clear guidelines to support collaborative curriculum development.

Welch's 1979 review also revealed that extensive "modern equipment," or technology of the day, flooded classrooms but had little overall educational impact on student learning (Welch, 1979). Likewise today, merely obtaining technology equipment does not ensure that technology is used in the classroom for its intended purposes (Amiel & Reeves, 2008; Dede, 2000). Nevertheless, the National Academies of Sciences (2007) calls for stronger technology-infused science curricula for American students. Similar to the flurry of curriculum development during the "Sputnik Era" that Welch reviewed, the number of collaborative groups funded to create technology-infused science curriculum across the United States continues to increase today (DeBoer, 2011). Part of the increased funding stems from President Barack Obama's new education initiative, "Race to the Top," in which he parallels the space race of the Sputnik era with today's race for "states to dramatically improve achievement in math and science by raising standards, modernizing science labs, upgrading curriculum, and forging partnerships to improve the use of science and technology in our classrooms" (Obama, 2009). Today, we are no longer racing against one country to get a man on the moon, but we are faced with a global economy that has our country competing with numerous countries in a race to improve the education of our future workforce.

Resources that include grants, group members' work effort and time are expended on science curriculum development groups without careful investigation into how scientists and classroom teachers collaborate during curriculum development and how they integrate technology into science curricula. Although some researchers recently reported tensions within university and local school district collaborations (Carlone & Webb, 2006; Moje, 2000; Penuel, Roschelle, & Shechtman, 2007), the primary focus of most research tends to be on the end product, curriculum artifacts, rather than on the development process itself. If school districts continue to employ such collaborative science curriculum development groups, we must understand group processes and structures to ensure that groups more effectively meet the goal of creating higher quality technology-infused science curricula. Unlike the numerous studies found in the literature that evaluate the end product of the curriculum artifacts (Maldonado & Pea, 2010; Spikol & Eliasson, 2010; Stieff, 2005), this dissertation aims to study three science education curriculum development groups to examine how effectively each group worked to create technology-infused science curriculum.

Study Purpose and Significance

Although individuals readily work in isolation to accomplish goals, groups, if they function effectively, can accomplish larger, more complex tasks collaboratively (Bales, 1950; J. Mathieu, Maynard, Rapp, & Gilson, 2008; Perkins, 1993; Tuckman, 1965). Indeed, organizations rely on collaborative groups comprised of individuals with diverse expertise to create higher quality products in business settings (Hammond, Koubek, & Harvey, 2001), to improve strategic military plans (Adkins, Burgoon, & Nunamaker, 2002) and to enhance communication between government agencies (Nunamaker, Briggs, Mittleman, Vogel, & Balthazard, 1997). In education contexts, students may learn more effectively when they participate in groups (Pea, 1993) and teachers may benefit by collaborating with each other to develop lesson plans and assessments (Edelson, Gordin, & Pea, 1999).

Collaborations in education organizations are not limited to students and teachers in classrooms and schools. During curriculum development, collaborations extend beyond school districts to include diverse partnerships with institutions such as universities or research institutes. Such extended collaborations are increasingly common given federal mandates that require cooperation between these institutions to develop curriculum, improve student achievement, or deliver teacher professional development (No Child Left Behind, 2002). In fact, current national STEM (Science, Technology, Engineering, and Mathematics) education initiatives include efforts to prepare teachers to teach with technology and exploit current technologies within newly revised curriculum materials at all levels in K-12 education (National Science Board, 2007). While other states continue to adopt STEM education initiatives (STEMED, 2010), the Mid-Atlantic state in which each of the three groups in this dissertation were located not only adopted these initiatives, but also included technology training for all teachers and required alignment of rigorous science curriculum with technology across all levels from pre-school through grade 12 (Governor's STEM Task Force, 2009).

Given such mandates and calls for understanding collaborative science education curriculum development groups, a close examination of *how* curriculum development groups rise to the challenge of incorporating technology into science curriculum is warranted. For example, when science teachers progressively become more involved with curriculum development, teachers must move outside their own classroom to collaborate with other professionals. This environment challenges teachers to redefine their role from classroom teacher to professional educator: this act of redefinition is not trivial. Some teachers struggle to assume roles that ask them to engage in reflective practices and critique other teachers' ideas, lessons, or content knowledge (Reiser et al., 2000). Likewise, researchers realize that their presence in the school and during collaborative meetings may invoke tensions (Moje, 2000) and reinforce historical hierarchal relationships during their interactions with teachers and administrators (Carlone & Webb, 2006). These challenges can present barriers to effective collaboration, and understanding how such challenges manifest and how groups overcome them is vital to improving collaborative efforts.

With such tensions documented in science education curriculum development groups, merely assembling a group of individuals does not guarantee success: combinations of group inputs, mediators, and outcomes characterize group effectiveness. An effective group contains inputs (i.e. well-defined goals and group composition with diverse expertise) and mediators (i.e. strong group coordination and participation of members prior to decision making) which may increase group outcomes (Gersick, 1989; Kerr & Tindale, 2004; J. Mathieu, et al., 2008; van Knippenber & Schippers, 2007). Effective groups can improve overall group performance (Kozlowski & Ilgen, 2006) and can create more innovative products (van Knippenber & Schippers, 2007). Conversely, less effective groups are characterized by the inability to clearly define group goals, the formation of strong subgroups, the domination of one individual, or subgroup during group interactions and the completion of decisions prior to group input (Kerr & Tindale, 2004; J. Mathieu, et al., 2008; van Knippenber & Schippers, 2007). Less effective groups produce lower quality products which fail to reflect the input of all group members (van Knippenber & Schippers, 2007).

Science education curriculum development groups are at risk for engaging in less effective group processes due to the same known challenges that groups in other organizations face. Despite shared commitments to education goals, tensions, and hierarchies often form between researchers and teachers during collaborations (Abell, 2000; Carlone & Webb, 2006; D'Amico, 2005; Moje, 2000; Penuel, et al., 2007;

Reiser, et al., 2000). For example, education groups are particularly susceptible to subgroup formation when they include group members from distinct institutions (e.g. school districts and public universities) (Li & Hambrick, 2005). Similarly, such groups are prone to the development of hierarchical structures that recreate historical relationships between institutions within science disciplines (Abell, 2000) when they reaffirm group members' differential expertise (Thomas-Hunt, Ogden, & Neale, 2003) and impose a status difference between professors, researchers, school district supervisors, and teachers.

Researchers within government agencies, private businesses, and military operations have utilized the Team Effectiveness Framework not only to measure outcomes (i.e. curricula artifacts) but also to analyze group inputs and mediators as groups work collaboratively (J. Mathieu, et al., 2008). The Team Effectiveness Framework, derived from the vast literature on teams, provides a lens to examine group effectiveness based on the group's inputs, mediators, and outcomes and to allow for a more in-depth analysis of how each group works during collaboration while also revealing how groups integrate technology.

Although tensions have been documented within science education curriculum development (Carlone & Webb, 2006; D'Amico, 2005; Penuel, et al., 2007), little is known about the group inputs, mediators, and outcomes that actually lead to tensions and hierarchies; an examination of these structures and processes can help identify the origins of known tensions and inform group leaders on how to assemble and lead the group. The recent increase in education collaborations to infuse technology into local science curricula provides the opportunity to study group processes during curriculum development activities and to examine how these groups address the challenges that arise during collaborations. Moreover, this study provides an opportunity to explore the utility of the Team Effectiveness Framework in educational settings rather than the previous business, military, and government agency settings.

Using a multiple case study design, this dissertation examines three science education curriculum development groups that independently pursued the development of STEM curriculum. I explore how effectively science education curriculum development groups work to infuse technology into science curriculum by utilizing the Team Effectiveness Framework and addressing the following overarching research question:

1. According to the Team Effectiveness Framework (including group inputs, mediators, and outcomes), how do science education curriculum groups work to develop technology-infused science curriculum?

This dissertation is not meant to classify each case as more or less effective against each other or on a continuum. Instead, this dissertation begins to explore how science education curriculum development groups assemble and operate and offer guidance on how each group could increase group effectiveness. Effectiveness is determined by examining group inputs and mediators to determine group outcomes (goal attainment and group performance). Each single case is examined first and then further analysis of patterns across all three cases is examined to identify common group processes or structures.

I assume that groups do not all operate the same due to variation in contexts. To that end, I assume *equifinality*. Equifinality acknowledges that multiple combinations of how teams organize and operate conclude in similar outcomes (Smith-Jentsch, Cannon-Bowers, Tannenbaum, & Salas, 2008). Rather than seeking one particular way for all science education curriculum development groups to operate, I intend to examine each group to understand any tensions that might occur within the group and offer suggestions for how each group can alter inputs and mediators during collaboration in order for each team to increase group effectiveness. Thus, my dissertation closely examines how local school districts rise to the challenge of incorporating technology into science curriculum by assembling and organizing collaborative science curriculum development groups and by offering insight into how curriculum development groups can increase group effectiveness by altering group inputs and mediators.

Chapter 2: Focusing on the Curriculum Development Process

Science education curriculum development occurs at the local school district level, but at the National level, curriculum reform has continued to evolve and impact local school district curriculum decisions over the last fifty years. The Sputnik Era of curriculum reform ushered in the challenge for curriculum developers to create curricula which enabled students to do science rather than recite science facts (Welch, 1979). After this era, education researchers focused on how students learn science and what pedagogical practices assisted teachers and students in the classroom. By the 1990s, the Standards Era provided guidance to local school districts of what students should know and be able to accomplish in science classrooms at varying levels (elementary, middle, and high school). Both the National Research Council (1995) and the American Association for the Advancement of Science (1993) published science standards, but it was not until the enactment of No Child Left Act of 2001 that most states were required to either adopt a standards set or develop their own set of standards.

The Mid-Atlantic state in which this study was conducted developed state standards in 1997. The State Department of Education used both sets of national science standards and other in-state documents to create the state science standards. Later, the state developed voluntary state curriculum and assessment limits to assist local school districts in how to interpret the state standards. During this time period, the state tested all public school students in grades three, five, and eight through the state School Performance Assessment Program (SPAP). The assessment included students working through hands-on science investigations. The state administered the last SPAP assessment in May 2002 just before the state moved toward a high-stakes multiple choice and brief constructive response format to comply with the No Child Left Behind Act of 2001. The state again assessed students at the fifth and eighth grade levels for general science, but no longer included a science assessment for third grade students. The state also assessed only biology content at the high school level under the new assessment structure outlined in the No Child Left Behind Act of 2001. More recently, a new framework for K-12 science education guidelines were published and provide additional recommendations for local school districts (National Research Council, 2011) . Today, with additional federal and state recommendations and state student assessments, local school districts continue to write more rigorous science curricula. Local science curricula provide teachers with local guidelines including when (grade level and sequencing of activities) content is covered, how to teach science concepts and what technology and resources are available to teachers and students. To accomplish the curriculum development task, school districts either write curriculum utilizing the expertise within their own organization or partner with universities or research institutes.

Previously Identified Tensions during Collaborative Curriculum Development

Literature focused solely on the process of curriculum development is limited due to the emphasis typically placed on the curriculum product and how teachers and students use the product. While limited, a few studies highlighted tensions between researchers and teachers and offered possible solutions for future groups. The following literature review provides additional insight into known tensions during curriculum development and frames the need for this dissertation.

Previous studies focused on the interactions between teachers and researchers during curriculum development projects and employed a variety of methods to study collaborations. The methods used to study collaborations include participatory research, field observations, and interviews. Having employed varied methodological approaches, education researchers identified several sources of tensions such as replication of historical hierarchies, opposing worldviews of teachers and researchers, and redefining roles of classroom teachers.

Elizabeth Moje (2000) described tensions including perceptions of power and historical hierarchies that surfaced during collaboration between herself, an education researcher, and a secondary English classroom teacher, Diane. The collaboration examined how Diane taught writing and reading to her junior high school students. Moje described in-depth her “messy, troubled collaboration (Moje, 2000, p. 39).” She recognized that the power was hierarchal and that the power sources included freedom of movement and scheduling. She was free to create her own schedule, but Diane was confined to the school building and the classroom for most of the day. Moje asserted that “making nice” only masked the power structure and the two did not confront the differences in order to work through those differences (Moje, 2000, p. 39).

Perception of power hierarchies defined the tensions within Moje’s collaboration with Diane. Diane perceived herself as powerless and Moje as the person with the expertise and also the leader of the study. Moje’s attempt to “make nice” resulted in a loss of empowerment for Diane. They were not able to move beyond the power structure in the collaboration. The organizational hierarchy sets power structures within school districts from the school district to the school administration to the science department chair to the classroom teacher. Understanding how tensions emerge between group members in collaboration reveals sources of tension and a means to confront power structures and empower group members who perceive themselves as powerless in collaboration.

In another study, Carlone and Webb (2006) revealed tensions stemming from opposing worldviews of teachers and researchers. Carlone and Webb (2006) closely examined the discourse between a science education university researcher, graduate assistant and three second grade elementary classroom teachers during curriculum development for Project BLAST (Bringing Literacy and Science Together). The initial intent was to create an affinity group, similar to a Community of Practice, but Carlone and Webb found that the researcher and teachers held opposing worldviews (academic discourse versus teacher discourse) that led to the group being divided. They noted that even within the first meeting the researcher wanted to be seen as a "collaborator, but her language, actions, beliefs, and values were not part of (and oftentimes, were in opposition to) the teacher discourse that framed the meanings and actions of the teachers (Carlone & Webb, 2006, p. 561)." Carlone and Webb reported that after they uncovered tensions between researchers and teachers during group interactions, they also began to examine when tensions did not occur. They planned to apply what they learned about discourse between researchers and teachers from this study to future groups.

Similar to Moje's struggle, Carlone and Webb (2006) reinforced a power structure within their group as the opposing worldviews of group members (teachers and researchers). Teachers and researchers approached the process very differently, and the group struggled to find common discourse. The power hierarchy of the university expertise imposing their worldview of curriculum development during meetings became apparent to the researchers upon studying group interactions. It is important for researchers to monitor team interactions during and between meetings to uncover tensions among group members or subgroups and develop approaches to mediate group tension.

Finally, Reiser et. al.'s (2000) study contained five middle school teachers, who found it difficult to shift between their roles as classroom teachers to curriculum developers, within a design-based research work circle. Science education design-based research work circles form to develop technology-integrated curricular innovations designed to enhance student learning (D'Amico, 2005; Reiser, et al., 2000). The work circle contained five middle school teachers, one education researcher, and two graduate assistants and created software as part of the Center for Learning Technologies in Urban Schools (LeTUS) project. Reiser et. al. (2000) described tensions between the varying perspectives that emerge as work circles formed in that study and cited a shift in roles as difficult for teachers. Teachers in the work circle preferred to provide colleagues with a menu of options and wanted to share experiences and resources, while researchers, who were concerned with the scalability of the final integrated curriculum, preferred to have a more precise recommendation with sequenced activities. Reiser et. al. (2000) noted that teachers were not accustomed to critiquing colleagues' work, and researchers ultimately edited the curriculum in order to create sequenced activities for students to use and understand the technology. The shift in role for the researchers instilled similar power structures seen in the two previous studies. The time needed for curriculum development also required more time than teachers were able to provide and at least one teacher dropped out of the process.

Reiser et. al. (2000) concluded that technology drew classroom teachers to the work circle, but the discussions regarding pedagogy and science content dominated the work circle interactions. Later, Reiser and his research group addressed the time and tension issues and changed the work circle format by hiring a full-time staff member with an extensive teaching background to write the curriculum (D'Amico, 2005). They suspended bringing classroom teachers into the process until teachers made final edits and implemented the curriculum. Changing the process enabled the researches to control the initial iterations of the technology and artifacts before bringing the products in draft form to the classroom teachers. The researchers relied on the full-time staff member who was a former classroom teacher to provide initial modifications, and when the researchers had a draft, they shared the draft with the classroom teachers. The revised process shorten the overall time commitment for the classroom teachers and avoided initial group tensions.

These studies document different, but related, tensions during collaborations and provide similar solutions to solve the tensions and power issues; namely each recommended open confrontation through discussions within the group. Moje stated that in the future she would attempt to “talk openly” about the “embodied and discursive practices” that produce power in the relationship (Moje, 2000, p. 39). Carlone and Webb called for the use of critical discourse analysis “to demonstrate the ways our language and theories are inextricably connected to historical, cultural, social, and institutional meanings" (Carlone & Webb, 2006, p. 562). They also called for increased social interactions through co-participation activities such as conferences, visiting other schools, or workshops in order to increase interactions between researchers and teachers in a variety of formats. Similarly, Cochran-Smith presented another possible solution "to confront controversial issues of voice, power, ownership, status, and role in the broad educational community," meaning that the education community should work together rather than in isolation (Cochran-Smith & Lytle, 1990, p. 10).

Although each solution aims to reduce or eliminate observed tensions, it is not clear whether such tensions within the collaborations may be essential in order to adapt curriculum to local technology needs and use (Barab & Leuhmann, 2003). Researchers may fear "lethal mutations" made by teachers during enactment of technology-infused curriculum (Dede, 2000, p. 298). Teachers used technology innovations in mutations rather than researchers' set learning goals. Therefore, local adaptation of curriculum requires discussions between researchers and teachers in order to develop mutual adaptations for the local context (Reiser, et al., 2000). Tensions during curriculum development may be essential in order to produce innovative technology that is accompanied by rigorous science curricula and aligned with scientific standards.

Integrating Technology into Curriculum via Designed-Based Research

Back when Welch (1979) wrote his review, laboratory equipment and teaching aides such as film loops and overhead transparencies were the types of technologies available to science teachers. Today, technology is broadly conceived as information and communication technologies that include personal computers, the Internet and handheld devices such as the new generation of tablets. Technology at the end of the Twentieth Century and into the first decade of the Twenty-first Century enabled greater access to information which increased international commerce, and in turn, the United States emphasized the use of education technologies in all classrooms in order to compete on an international level in the workforce (National Academy of Sciences, 2007). Despite this emphasis, local school districts do not necessarily utilize technology within science curriculum in the same way.

Within the last decade, researchers began to take technology out of university-based laboratories and into local K-12 classrooms across the United Sates, and the field of design-based research emerged. Design based researchers created technology-infused curricula (and corresponding education research) in classroom settings and increased the number of collaborations between researchers and teachers. In contrast to laboratory-based research, design-based research (Collins, Joseph, & Bielaczyc, 2004) aspired "to improve the initial design [of an educational innovation] by testing and revising conjectures as informed by ongoing analysis of both the students' reasoning and the learning environment" (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003, p. 11). Science education design-based research is, therefore, research that occurs in the naturalistic context of a science classroom and often includes researchers and teachers jointly and even students (Druin, 2002) constructing technology-integrated curricular innovations (Barab & Squire, 2004). Innovation developers, who often include education researchers, create technology for specific content goals and study the use of the innovations by teachers and students in the classroom.

As the field of design-based research progressed, researchers became increasingly aware that teachers are the gatekeepers of the curriculum. Despite the ostensible goal of collaboration between teachers and researchers in this model of research and development, the classroom teacher (not the designers or researchers) ultimately controlled what aspects of curriculum are enacted in the classroom and used by students (Barab & Leuhmann, 2003). Realizing that the teacher's important role in the enactment of a curriculum innovation is as important as a curricular innovation itself, Edelson, Gordin, and Pea (1999) called for improving designs and enactments and including teachers in the very first stages of the design process. Under this model, teachers and researchers collaborated to share expertise and information and to generate artifacts such as new iterations of curricula (Barab & Leuhmann, 2003; Barab & Squire, 2004; Blumenfeld, Krajcik, Marx, & Soloway, 1994; D'Amico, 2005; Reiser, et al., 2000). In fact, studies in various science disciplines, such as biology (Reiser, et al., 2000), chemistry (Stieff, 2005), and earth science (Brown & Edelson, 1998), reported the benefits derived from such collaborations; however, the design-based research literature, as above, lacks studies which examine the characteristics, affordances, and challenges of these collaborations

One notable recent study by Penuel et. al. (2007) attempted to document how a curriculum development group infused handheld computer technology into science curriculum and examined tensions between differing workplace norms. Similar to Reiser et. al.'s (2000) study, they revealed that reconciling the tensions was a constant work in progress throughout meetings that took substantial time. Penuel et. al. divided a larger group consisting of seven teachers, who taught grades fourth through ninth, one psychologist, two cognitive scientists, one mathematician, two software engineers, and a former science teacher who specialized in assessment and technology into three smaller groups. Each smaller group was tasked to create student-centered science classroom assessment software for handheld computers. The researchers interviewed participants, observed interactions, and collected meeting minutes and curriculum artifacts in order to study the process of creating innovative software and curriculum. They analyzed the data, created a case narrative to describe how tensions within the group occurred over time, and offered a process for future groups to consider.

Penuel et. al.'s (2007) single case study illustrated seven key components that defined a *co-design process* to support successful technology infusion. Four components establish common curriculum development processes including 1) taking stock of current practice and classroom contexts, 2) instilling flexibility for curricular modifications in varying classroom contexts, 3) timing the process to fit the school year cycle and 4) including a bootstrapping event to catalyze the team. Researchers in that study described themselves as the group members who entered into the classroom to take stock of current practices and later discussed classroom contexts with the teachers. The "bootstrapping" event involved an initial meeting for group members to share experiences and for the group to begin to establish a common language to help bridge the gap between varying work place norms in the group. Penuel et. al. (2007) noted that despite these efforts, the teachers did not feel ownership in the development process until they were able to use the technology within their own classrooms.

Among the other key components, the co-design process called specifically for 5) the creation of “a concrete, tangible innovation challenge,” 6) well-defined roles for group members, and 7) central accountability for the quality of the innovations created by the group (Penuel, et al., 2007, p. 53). By calling for a specific innovation such as the software developed in this case study, Penuel et. al. (2007) focused the group to infuse a specific technology into the curriculum and to utilize the software on handheld computers in the classroom. Well-defined roles were task roles assigned with the group. For example, researchers assumed facilitator roles and focused the group on the learning goals of the innovations, and teachers assumed implementer roles to test the innovations in the classroom and to provide feedback to the group. They did not note whether roles dynamically shifted or evolved during the process and limited their recommendations to what worked well within the case study itself.

Finally, Penuel et. al. (2007) called for central accountability in which all of the group members must be able to vouch for the quality of the resource created through the process. Central accountably required all of the group members (teachers and researchers) to champion the technology and curricula when interacting with other colleagues outside of the development group. Having all group members champion the technology began the process of technology diffusion throughout the school district (Daly & Finnigan, 2009; Penuel & Haydel DeBarger, 2011).

Since publication of Penuel et. al.'s (2007) case study, other researchers have employed the co-design process to develop new science curriculum (Maldonado & Pea, 2010) and mathematics curriculum (Spikol & Eliasson, 2010). However, like previous studies, the primary focus of the research was on the curriculum product. Consequently, other researchers did not document, replicate, or revise Penuel et. al.'s (2007) co-design process. As mentioned, the co-design process offers recommendations for how to integrate technology into curriculum in the form of the seven key process components.

Although the co-design process offered guidelines for improving collaborative design, the utility of the co-design process for revealing how effectively groups work to create curriculum is limited by the scope of each key component and is not informed by an in-depth analysis of group inputs, mediators, and outcomes. To that point, design-based researchers continue to acknowledge tensions within collaborative curriculum groups and recently called for system and policy changes to address issues (Penuel, Fishman, Cheng, & Sabelli, 2011). It is unclear whether these recommendations are applicable to teams outside of the design-based research community that may or may not focus on developing a concrete technological innovation. Additional insight into group inputs and mediators is needed. This dissertation will utilize the Team Effectiveness Framework to examine each case's inputs, mediators, and outcomes.

Understanding How Teams Operate Effectively

The Team Effectiveness Framework is a culmination of numerous studies by researchers who studied how people work together both in laboratory settings and within the field to better understand the dynamic interactions that occur within collaborative groups. Spanning half a century, the literature on groups contains multiple perspectives and definitions of terms. This literature includes studies conducted within government agencies, military operations, and private companies and with numerous variables (e.g., group size, group composition, leadership styles, conflict management, etc.). Drawing upon this vast literature enabled me to study science education curriculum development groups and to specifically examine how groups worked to create science curricula and how each group infused technology into curricula.

Within the literature on groups, the term "team" is defined in numerous ways, and for the purposes of this dissertation, I have adopted the following comprehensive definition of a team.

> Teams are "defined as (a) two or more individuals who (b) socially interact (face-to-face or, increasingly, 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 (Kozlowski & Ilgen, 2006, p. 79)."

Teams do not operate in isolation: teams are either embedded within an organization or span between two or more organizations. The difference of contextual boundaries with a team being housed in one organization or a team spanning more than one organization is significant in understanding work place norms and how the organizational context influences interactions within the group. For example, a larger food industry corporation set policies that shaped employee norms, and the norms impacted team level interactions within the organization (Dickson, Resick, & Hanges, 2006). Likewise, group members in curriculum teams make decisions that create and alter science curricula and ultimately impact teachers across the school district.

Mathieu, Maynard, Rapp, and Gilson (2008) reviewed literature on the Team Effectiveness Framework and revealed challenges that characterized effective teams and solutions to increase group effectiveness. The Team Effectiveness Framework aimed to identify and understand group inputs, mediators, and outcomes and to allow for a more in-depth analysis of how effectively group members interact. I intend to utilize the Team Effectiveness Framework to examine how science education curriculum development groups collaborate and work to develop science curricula and to also reveal how groups integrate technology.

Team Effectiveness Framework: A Developmental Process

The Team Effectiveness Framework provides a means to examine how effectively science education curriculum development teams work to infuse technology into science curriculum. As shown in Figure 1, the Team Effectiveness Framework contains constructs to examine groups as they operate by identifying and characterizing *inputs*, *mediators* and *outcomes*. Inputs are the “antecedent factors that enable and constrain members’ interactions,” and drive how the group interacts (J. Mathieu, et al., 2008, p. 412). Mediators, which include processes and emergent states, describe how the group converts inputs to outcomes. Outcomes are the results of group interactions and work. Two teams with similar inputs and outcomes may utilize different mediators. Conversely, two teams with different inputs and outcomes may utilize similar mediators. The infinite configurations of context-dependent group inputs, mediators and outcomes require an understanding of the equifinality assumption: multiple configurations may yield similar results (Smith-Jentsch, et al., 2008).

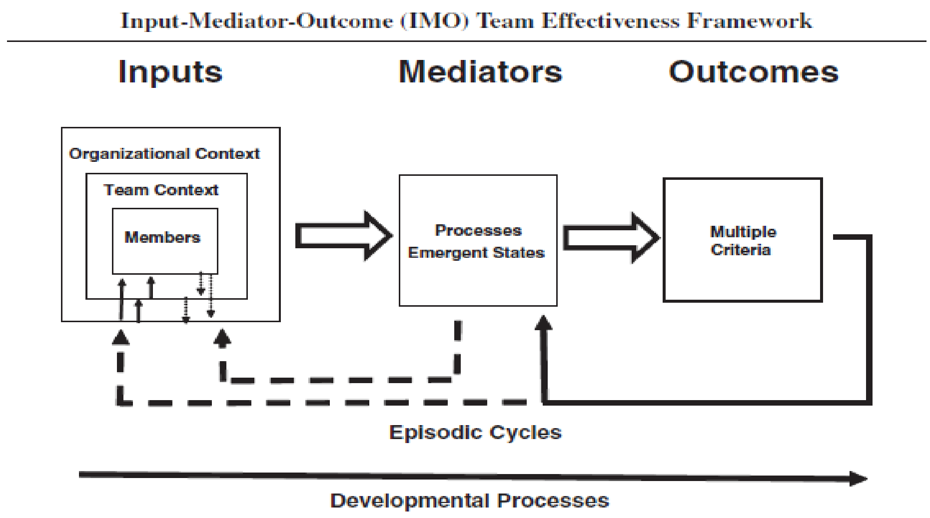

Figure 1: Team Effectiveness Framework (J. Mathieu, et al., 2008)

The Team Effectiveness Framework also contains feedback loops and an overall team developmental process of a group. Group interactions are dynamic over time. In Figure 1, the solid developmental process line indicates that teams mature over time. However, teams often have episodic cycles during interactions in which teams alter how they work together. The episodic cycles reflect the nature of how teams transition from one episode to another over time. The solid line from outcomes to mediators indicates that changes in group mediators is “likely to be more influential” than the connections of dotted lines, which indicate that the feedback is “likely less potent,” from outcomes to mediators and mediators to inputs. (J. Mathieu, et al., 2008, p. 414). Whether examining how a team matures over time (Gersick, 1988, 1989) or the more specific episodic cycles (J. Mathieu, et al., 2008) that a team moves through, both approaches contain a need to establish a team charter (J Mathieu & Rapp, 2009), or also referred to as a team's transition process (Marks, Mathieu, & Zaccaro, 2001) to organize how the team will operate before the first task. In order to understand how each team formed and began to organize, I selected specific inputs (group goals, composition, roles, and norms) to examine for each case.

Utilizing the Team Effectiveness Framework

For curriculum development groups which operate in specified time periods and require member interdependency, recommendations based on the past twenty years of research include selecting and examining particular constructs from the Team Effectiveness Framework (Marks, et al., 2001). I have selected specific constructs for this dissertation to understand known tensions within science education curriculum development groups and the impact on group effectiveness (Table 1). As mentioned, I examined specific inputs in order to understand how teams formed and began to organize. The mediator constructs were each selected based on the previous documented tensions that occurred in curriculum development groups and discussed previously in this chapter. For example, education researchers cited conflict issues in terms of communication (Carlone & Webb, 2006) and workplace norm variation (Penuel, et al., 2007). In addition to the group processes which focus on the actions within the group, I selected emergent states in order to examine how well the group worked together. For example, I selected team autonomy to understand the extent each group was able to make team decisions and team trust to determine if group members relied more on team monitoring behavior (i.e. team member back-up) or if group members lacked trust in other members. The mediators that I selected may or may not be relevant to each case (and are noticeably absent in some cases); however, both the presence and/or absence of mediator constructs within each case reveal valuable information about how the group operated as well as how each might operate more effectively. Below, I provide a more in depth review of each construct.

Table 1: *Team Effectiveness Framework Selected Constructs*

Inputs	**Mediators**		**Outcomes**
	Processes	**Emergent States**	
Group Goals	Monitoring Progress	Group Efficacy	Group Performance
Group Composition	Team Monitoring	Group Cohesion	Goal Attainment
Group Roles	Conflict Management	Team Autonomy	
Group Norms	Coordination	Trust	

Team Inputs: Antecedent and Contextual Factors

Each team input potentially facilitates or limits group interactions. It is important to identify and characterize team inputs in order to understand how the team formed, who is involved with the team and the context in which the team operates. Team inputs with antecedent and contextual factors including group goals, composition, roles, and norms vary from team to team. I selected these specific constructs in order to examine how science education curriculum development groups formed and began to function as a team. *Group goals* refer to the mission of the group's work and the group orientation which effects the mediators and outcomes (J. Mathieu, et al., 2008). Group goals provide the group with a *directive function* and an *energizing function* (Locke & Latham, 2002). The *directive function* focuses the group toward relevant goal tasks and discussions and steers the group away from irrelevant tasks and discussions. The *energizing function* of group goals affects the group motivation.

As the group interacts, group goals continue to impact group decisions and are used within the mediating process to monitor group progress. Group members, often the leaders, not only monitor the group progress but also focus on a potential trade-off between time allotted for work completion and the intensity of group member effort. Group goals affect action indirectly through the discovery or use of task-related knowledge. When group members lack strategies to tackle a goal, they "draw from a repertoire of skills that they have used previously in related contexts, and they apply them to the present situation" (Locke & Latham, 2002, p. 707). Group goals can provide structure and motivation, keep the group on task and ultimately, become an outcome measure of overall group performance.

In order to achieve group goals, groups assemble members and determine the *group composition.* Group leadership can select or recruit group members, or the group can form independently and select group leadership once assembled. Groups that are homogenous or highly heterogeneous in terms of composition, such as expertise or stakeholders, tend to be more successful than moderately heterogeneous groups which suffer from strong subgroup formation (Earley & Mosakowski, 2000). Local school districts contain previously established hierarchies; therefore, leadership within the organization most likely oversees the group either from within the group or at a distance in which the group reports to the school district leadership. As I examine the cases in this study, science education curriculum development groups, which intend to infuse technology, may or may not have a content specialist, a technology specialist, classroom teacher, or scientist as group members. Group composition is an important input to analyze the team effectiveness as the team forms and throughout the development of curricula.

Once the group assembles and sets goals, the group establishes *group roles* and *norms*. By definition, roles are patterns of behaviors (Biddle, 1979); therefore, group roles are patterns of behaviors displayed by group members during group interactions. Group roles contain three broad categories: *task roles*, *socioemotional roles* and *boundary spanning roles*. Well-defined task roles are often assigned within structured institutions, such as schools and universities, in order to establish who is doing what toward the goals of the institution (Wenger, 1998). Within a group, task roles are patterned behaviors directly related to accomplishing group goals while socioemotional roles are patterned behaviors that focus on the interpersonal relationships between group members (Bales, 1950). The final broad category includes boundary spanning roles which are the team members' patterned behaviors external to the group and include group member interactions with other organization members or groups, but are also relevant to the group (Mumford, Campion, & Morgeson, 2006). For example, a group member might seek information or resources from another person who works within the organization but is not a group member. Expanding upon the focus on well-defined task roles within Penuel's et. al. (2007), this dissertation intends to explore all three types of group roles in order to understand how group roles relate to institutional roles and impact team effectiveness.

As group roles and other behaviors become apparent within the group, *group norms* begin to develop. A group norm is defined as "a standard or rule that is accepted by members of the group as applying to themselves and other group members, prescribing appropriate thought and behavior within the group (Postmes, Spears, & Cihangir, 2001, p. 919)." Group norms are not always explicitly stated to the group; rather the actions and behaviors of group members can influence what is acceptable within the group. Penuel et. al. (2007) cite the difference in norms between researchers and teachers in reference to how each perceives curriculum development. Similar to Reiser et. al. (2000), Penuel et. al. (2007) found that teachers tended to focus on the usability of the technology with students, and researchers encouraged teachers to justify concerns. The process of justifying observations and critiquing each other violated the norms of how teachers shared experiences with each other. Taking this perception a step further by studying the group norms within each group explores possible sources of tensions between researchers and teachers.

Team Mediators: Team in Action via Team Processes

Team inputs are converted to outcomes via team mediators including both processes and emergent states within the group. Group processes include two phases, transition and action, and contain interpersonal processes (Marks, et al., 2001). During the transition phase, the group establishes goals and strategies; groups complete tasks, coordinate members and monitor progress during the action phase. Interpersonal processes encompass interactions, such as conflict management, which can be salient across both phases. Processes including monitoring progress towards goals, team monitoring of team roles and norms, conflict management, and coordination provide the construct selection for this dissertation. As each science curriculum development team begins to establish a work process, each construct can uncover possible tensions during group interactions.

Team monitoring, conflict management, and coordination allow group members to work towards goals and assist each other. Team monitoring assistance may occur among group members through (1) verbal feedback or coaching, (2) help in terms of behavioral actions, or (3) task completion for a teammate (Dickinson & Mclntyre, 1997). More effective teams provide continual feedback and assistance within the group and contain little to no conflict while operating. Conflict Management may be needed at any point during group interactions. Groups which are willing to "engage in open discussion of conflict and are prepared to manage it when it arises" tend to be more effective than groups that ignore conflict or isolate group members with concerns (Tekleab, Quigley, & Tesluk, 2009, p. 177). Within science curriculum development teams, conflict between varying group members such as researchers and teachers might be essential in order to produce an artifact with local adaptations (Barab & Leuhmann, 2003). Understanding how researchers and teachers interact and resolve conflict during team interactions can inform other groups on how to navigate group discussions. Coordination of group activities by sequencing and timing of group events is vital to the higher performance and goal attainment of effective groups. Time is a valuable resource for all groups to consider and how the group utilizes time in meetings and establishes deadlines is critical to overall group effectiveness.

Team Mediators: How Team Members Interact via Emergent States

Emergent states differ from processes by representing more cognitive, motivational, and affective states within a team. Emergent states are "constructs that characterize properties of the team that are typically dynamic in nature and vary as a function of team context, inputs, processes, and outcomes (Marks, et al., 2001, p. 357)." Processes describe team interactions and actions, and emergent states reflect team members' experiences during the interactions and actions. Equally important is to understand that all processes and emergent states are dynamic during the time period in which a team operates. Other researchers (Jehn, 1995; Langfred, 2005; LePine, Piccolo, Jackson, Mathieu, & Saul, 2008) have captured data through extensive surveying methods rather than a thick description of how teams operated. I intend to provide the thick description in this case study.

Selected emergent state constructs for this dissertation reflect the need to understand tensions between researchers and teachers. The emergent states include group efficacy, group cohesion, team autonomy, and trust. Group efficacy refers to how well the group works together or specifically it is "defined as a shared belief in a group's collective capability to organize and execute courses of action required to produce given levels of goal attainment" (Kozlowski & Ilgen, 2006, p. 88). Teams in which members think that the team can be successful have higher group efficacy.

Within group interactions, group members' use of pronouns can distinguish if the group is working together and referring to the group as a whole or if subgroups are established within the group thereby dividing the group. Group Cohesion goes beyond a collective belief in the group to examine "the tendency for a group to stick together and remain united in the pursuit of its instrumental objectives" (Tekleab, et al., 2009, p. 174). The cohesion emergent state construct works in tandem with the conflict management process; the two mediators indicate how well group members resolve differences and unite toward task completion and goal attainment. Less effective teams fail to resolve (or ignore) conflict which leads to lower team cohesion (Marks, et al., 2001). By examining team efficacy and team cohesion in science curriculum development teams, I intend to uncover any subgroups that may form in a team and understand how subgroup formation impacted the team interactions over time.

The final two emergent state constructs include team autonomy and trust. Team autonomy is defined as "the extent to which a team has considerable discretion and freedom in deciding how to carry out tasks" (Langfred, 2005, p. 514). Groups may or may not have the flexibility to determine aspects of the curriculum artifacts and may or may not have to confront possible constraints such as format, content, or time allocation for units or lessons. Leaders who do not allow for any flexibility or "micromanage" every aspect of the team's work impede the overall group progress; conversely, leaders who do not provide guidance also impede the group's progress by failing to provide any direction or feedback (Langfred, 2005).

Leaders might be confident in the group members' abilities, but not all group members may feel the same level confidence in each other. Trust is "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party (Mayer, Davis, & Schoorman, 1995,

p. 712). More effective groups establish group trust early and rely on each other through team monitoring to assist each other while less effective teams with lower levels of trust in team member's abilities mismanage conflict which results in lower team performance (Kozlowski & Ilgen, 2006). As the group makes progress toward the group goals, group outcomes on performance and goal attainment provide continual feedback for the group.

Team Outcomes: Beyond Evaluating the Product

Team outcomes for this dissertation fall into two categories, group performance and goal attainment. Group performance outcomes result from team members' actions and behaviors while working towards goals (J. Mathieu, et al., 2008), and goal attainment refers to the extent to which the group achieved its mission (Marks, et al., 2001). A lower performing group that lingers during initial meetings and thus wastes time inadvertently sets a norm for modeling poor time management behavior (Ericksen & Dyer, 2004). High performing teams tend to have three key resources as inputs including enough time, expertise, and clear and compelling tasks that enable the group to mediate successfully and produce high performance outcomes. Unfortunately, lower performing teams who either completely lack at least one key resource or the key resource is inadequate for the group's needs begin down a path too destructive to recover regardless of the mediation within the group (Ericksen & Dyer, 2004). Within science education curriculum development groups, time is essential since the primary responsibility and focus of group members often pertain to their primary occupation outside of the group, such as teachers working with their students within the classroom. Expertise in science content, pedagogical lesson sequencing, pedagogical classroom practices and technology are essential in creating technology-infused science curricula (Barab & Leuhmann, 2003; Reiser, et al., 2000); yet, groups that create science curricula may or may not include the necessary types of expertise or the varied expertise among group members may emerge as a source of tension within group interactions. Studying the group composition, resources, and time allow me to observe each team's overall performance.

Goals are either set for the group or set by the group. Goal attainment in this dissertation provides me with the means to examine what if any changes occurred to the group goals over time and how the groups attained group goals. I am especially interested in how each group sets a technology infusion goal and how that goal manifests in the final artifact through group interactions.

Summary

Previous studies that focused on collaborations during curriculum development revealed tensions between researchers and teachers. Although the studies highlight the need for more study of the collaborations, the studies do not offer more assistance into how to monitor groups in order to reveal how and when tensions emerge and how groups attempt to mediate the tensions. The Team Effectiveness Framework provides me with a lens used by researchers outside of education to analyze group interactions in government agencies, military, and business settings. I intend to employ the framework to analyze science education curriculum development groups.

This dissertation follows outcomes as a cyclical nature within the group as each group operates and as the final overall assessment of how the group worked together. Each case in this dissertation achieved the goal of creating an artifact. The artifacts each vary from each other significantly; *however, evaluating the quality of each product is not the focus of this study*. The Team Effectiveness Framework enables me to study science curriculum development groups as they work to develop technology-infused science curricula. Any tensions that arise during group interactions can be better identified and explained by examining the group inputs, mediators and outcomes. Then, by examining potential patterns with the Team Effectiveness Framework across all three cases, I discuss limitations and implications of how science education curriculum groups work to create technology-infused science curricula.

Chapter 3: Research Methods

Welch (1979) noted that curriculum development issues might stem from, well known (yet poorly researched) interactions between scientists and teachers. Penuel et. al. (2007) provided a single case study and developed the co-design process to understand a design-based research work circle. In this dissertation, I study how effectively science education curriculum development groups work to infuse technology into science curricula. The exploratory nature of this study and the emphasis on the group processes within each case called for a qualitative method.

Qualitative Method Justification

Both Merriam and Yin concurred that case study is a useful research method to study complex social interactions in natural contexts. Merriam (2009) asserted that unlike experimental research questions that seek cause and effect relationships, qualitative research seeks to "delineate the process (rather than the outcome or product) of meaning making" (Merriam, 2009, p. 14). Likewise, Yin (2008) provided three study conditions (i.e., research question, investigator control over behavioral events and focus on contemporary rather than historical events) should be considered when determining the research method of a study.

Yin argued that "how" questions are more explanatory questions that require several research methods including case study. Case study enables a researcher to "deal with operational links needing to be traced over time rather than mere frequencies or incidence" (Yin, 2008, p. 9). My overarching research question meets Yin's research question condition given my aim to understand how science education curriculum groups work to develop technology-infused curriculum. As stated previously, I am not interested in the effectiveness of the curriculum product rather my interest is in the process of the curriculum development itself.

Yin's second condition to determine if case study methodology is appropriate concerns the extent to which the investigator can control behavioral events. As the investigator, I was not in a position to "manipulate behavior directly, precisely, and systematically (Yin, 2008, p. 11)." I did not seek to control behaviors of the science curriculum development group members rather I observed behaviors in natural contexts to understand group interactions and how each group created science curricula artifacts.

Finally, Yin's third condition states that the case study is appropriate when the researcher wishes to focus on contemporary rather than historical events. Although an initial call for a line of research studying teacher and researcher interactions was called for by Welch in 1979 and Penuel and his colleagues used single case study methodology in 2007, a contemporary study is needed to further understand the tensions that emerge between teachers and researchers during curriculum development and how science curriculum development groups infuse technology into science curriculum. Thus, my study examined a contemporary issue of creating rigorous technology-infused science curricula in an area with limited literature regarding the process rather than the curriculum products.

Researchers who employed case study methodology contributed to our understanding of group interactions particularly with groups studied in natural contexts. Gersick (1988) used qualitative methods to study group development and employed case histories for each group. Her findings changed how leaders prepared for initial group meetings and raised awareness for how group norms were established within groups. Multiple case studies are rare in the group interaction literature that contains more laboratory experimental design studies; however, a study focused on team effectiveness in manufacturing organizations utilized a multiple case study design and revealed characteristics that directly influenced manufacturing team effectiveness (Pagell & LePine, 2002). Meriam (2009) explained that in a multiple case study design, cases share a common characteristic. An increase in both the number of cases and the greater the variation across cases allows more compelling conclusions to be drawn. As shown in previous studies, case study is powerful to examine science curriculum development groups as groups interact to create curricula.

Given my research question, meeting all three of Yin's criteria and Merriam's explanation of multiple case study design, I selected a multiple case study design for this study. Without assuming that all science education curriculum development groups engage in identical processes or produce similar artifacts, I employed a multiple case study design to provide a detailed understanding of how different groups set the goal of technology infusion and created technology-infused science curricula. Each case has the potential to reveal possible sources of tensions and how each group worked with any tensions that emerge.

Case Study

For this study, I employed a multiple case study design. In order to recruit cases for the study, I needed to gain access to science education curriculum development groups, set the criteria for case selection, and then, select the cases. Finally, I disclose my biases by providing a thick description of myself as researcher participant and observer.

Case Selection Rationale

I began case selection by defining requisite common conditions across all cases in this multiple case study design. First, each case included a science education curriculum development group that intended to infuse technology into local curricula. In all three groups, the group leadership explained to me that a group goal included technology infusion. How each group carried out the goal of technology infusion allowed me to understand how each group defined and inserted technology into science curricula. Next, each group held face-to-face meetings over an extended time period to attain the goal of creating technology-infused science curricula. I selected this condition on the basis of how curriculum groups tended to operate within this Mid-Atlantic State. As I called local science supervisors, they described curriculum development meetings and the type of group members that assembled to create curriculum. This criterion also provided me with access to observe group interactions. The final selection condition included varied group composition (types of partnerships, expertise, science subject matter, type of technology and leadership style) in order to strengthen interpretation across cases. Varying group composition reflected variation within the real-world setting of science curriculum development. Collaborations occurred with a research institute, with a university, or within a single school district.

Access

In order to study science education curriculum development groups, I needed to first locate groups and gain access to group meetings and group members. In the fall of 2008, I began to work with the first group, chemistry team, as a participant observer while working as a graduate student. Having additional cases within the same state meant that all cases worked under the same State Department of Education and therefore, operated under the same state assessments and state voluntary curriculum. To acquire additional groups for the study, I initially called science supervisors of local school districts in the spring and summer of 2009. Science supervisors in this Mid-Atlantic state tended to lead local science curriculum development projects, and therefore, they were my initial contacts within local school districts to determine if the school district had any current science education curriculum development groups forming. On two occasions, I met the science supervisor in person to discuss the possibility of participation in the study. Initially, I identified four local school districts willing to participate in the study. However, I eliminated one of the four groups that did not meet the conditions for study participation due to a lack of the required technology infusion goal. Another group lost funding for curriculum development and did not assemble a group.

Selected Cases

I selected three groups (chemistry team, biology team, and elementary science team) for this multiple case study. All three groups met the criteria: technology infusion goal, face-to face meetings over an extended period of time, and varied group composition. (See Table 2.)

Table 2: *Case Descriptions*

Groups	*Goal*	*Time-span*	*Number of Meetings*
Chemistry	Create high school chemistry curriculum infused with simulations.	7 months (12/08-6/09)	7
Biology	Create high school biology curriculum infused with non-descript technology.	8 months (12/09-7/10)	9
Elementary	Create elementary science curriculum infused with non-descript technology.	5 months (12/09-4/10)	5

Group composition (types of partnerships, expertise, science subject matter, type of technology, and leadership style) varied across all three groups. The chemistry and biology teams contained partnerships that spanned two organizations. However, the chemistry team differed from the biology team since the leadership included two university researchers and one school district science supervisor. In the biology team, the science supervisor was the overall leader of the group, which contained an external science education research consultant. The science supervisor led the elementary science team, and the group utilized expertise only within the school district.

Group member expertise varied for each case. In particular, each group included members with varying organizational roles (i.e. researcher, teacher, and leadership). These roles (See Table 3.) provided the initial basis to determine the group member composition. Yet, the extent of group member's expertise was not entirely accounted for by their a priori organizational roles. For example, one teacher in the chemistry team was a certified podiatrist. Her expertise in chemistry differed from the expertise of the other two science teachers within that group due to her level of education and the opportunity to apply chemistry in medicine. The teacher's medical expertise was not apparent until after the chemistry team interacted in several meetings. In addition to organization roles, group members varied in the types of leadership roles within the organizations and leadership roles within the group.

Table 3: *Groups' Composition Based on Organization Roles*

Case 1: Chemistry		*Case 2: Biology*		*Case 3: Elementary*	
Education Researcher	* # ^	Science Supervisor	~ # ^	Science Supervisor	~ # ^
Chemist	* # ^	Science Supervisor	~ # ^	Teacher	~ L
Graduate Assistant	*	Science Supervisor	~ #	Teacher	~ S
Graduate Assistant	*	Education Researcher	*	Teacher	~ S
Teacher	~ S L	Teacher	~ S L	Teacher	~
Teacher	~ S	Teacher	~ S	Teacher	~
Teacher	~ L	Teacher	~L		
Science Supervisor	~ # ^	Teacher	~		
Science Supervisor	~ #	Teacher	~		
		Teacher	~		
		Teacher	~		
		Teacher	~		

Key:

~	Local School District Affiliation
*	External Affiliation (i.e. University/Non-profit Research Institution)
#	Institution Leadership
^	Curriculum Design Group Leadership
S	Within each case, these teachers teach in the same school
L	Teachers who hold a leadership position in the school

Researcher as Participant and Observer

My previous experiences both as a student consumer of science curriculum with technology access and later as a teacher who developed science curriculum with limited technology access framed my perceptions of technology infusion and curriculum development and impacted my biases for this case study. My journey as a science educator began as a public school middle science teacher in 1995. The school district supplied me with an outline of topics to teach throughout the year, a few sample lessons, a set of student textbooks and various laboratory supplies. I grew up in a different Mid-Atlantic state, and was shocked that I did not have at least one computer in my classroom. Attending public schools through the 1980s, I had access to at least one Commodore 64 or Apple IIe in each classroom and access to computer labs. In fact as a high school senior, I took a statistics class within a computer lab for an entire school year and learned from the same college level textbook used at my undergraduate school. Even my undergraduate college in 1991 did not provide access to the statistical software program for students. I realized how fortunate and enriched my own K-12 education had been with access to advanced technology tools in school. Most often my previous teachers left the tools for the students to "play with" during free time or after classwork completion. Other technology savvy teachers would purposefully integrate technology into lessons and the classroom culture, and I attempted to emulate this type of integrated approach as a middle school teacher.

In 1996, I married my husband, who is an Information Technology (IT) professional. During the same year, he designed and built the largest wireless local area network in a higher education setting. The following year he built our wireless network at home and assisted in running cable to my classroom and several other science classrooms in my middle school and provided my class with Internet access. (I supplied my own laptop to use in my classroom.) Therefore at school and at home, I continued to enjoy exposure and access to advanced technology.

Although I was not aware that I was a curriculum consumer at the time when I was a K-12 student, I remembered particular teachers who taught science differently and sparked my interest in the subject area. Lessons included activities beyond reading the textbook and answering worksheets. As a new teacher and with a minimal curriculum guide, I enjoyed planning lessons and the freedom to develop my own laboratory worksheets and activities. I wanted my students to experience and discover science in similar ways that some of my previous teachers had taught me. Shortly after beginning to teach, I joined the science K-12 state content standards writing team, which mapped the learning progression for students from kindergarten through high school. Upon completion of the standards, I joined the school district's curriculum development team and assisted in writing curriculum to provide more guidance to teachers beyond the few sample lessons that were previously provided. I witnessed and engaged in interesting discussions about how to develop curriculum and what students should learn.

My previous experiences in science curriculum development and technology infusion concluded in my pursuit of a doctoral degree to be able to study science curriculum development. I have two particular biases to disclose. First, I believe that a curriculum artifact is one of many tools used by teachers to develop enacted curriculum or more commonly referred to as lesson plans. Second, I believe that access to technology does not alone ensure successful infusion. When technology with targeted learning goals is infused into curricula, students' learning and understanding of complex scientific concepts increases (Amiel & Reeves, 2008; Dede, 2000). I understand that technology access is not uniform throughout schools and that barriers might be physical (Internet access or computer hardware) as well as skill-based barriers (teachers who lack the skills to use devices or software programs)

(Butler & Selbom, 2002). I enter each case understanding that technology interpretation and implementation is likely to vary within each group.

With my biases, I entered the field and attempted to build a rapport between each group and myself. My role within each group varied in response to how I was received by each group. I did not compromise the data collection process rather I worked to develop trust between study participants and myself. The chemistry team was my first group, and I was introduced as a graduate student interested in learning more about how the team created science curricula. I limited my team roles to coordinating meetings and organizing the teacher manual for the group. I purposefully did not participate in content discussions and was perceived by other group members (two of the three teachers, the other graduate student, and the chemist) as a graduate student who organized the group meetings. Since my scientific expertise was not solely in chemistry and most of the other group members focused on the content, I did not feel that my lack of discussion hurt the team. I felt that I had a strong working relationship with my advisor who was a leader in this group and that I could ask him questions about the team without the fear of losing my graduate assistantship funding.

The second group that I entered was the biology team. The biology team was within the same school district as the chemistry team but had partnered with an external research institute and not a local university. I met with the science supervisor who told me about the group goals including technology infusion and adhering to the high-stakes state assessment. Team members perceived me as a graduate student who was studying curriculum development. Within this team, I was an observer without any team role beyond historian. On several occasions a biology teacher referred to my camera and me and said, “We have it on tape.” I would confirm that a particular topic was covered in a previous meeting, and the team would continue discussions without my input. I quickly realized that group members were more comfortable talking to me one-on-one without the camera recording. Team members knew and pointed out to each other when the red light on the camera was off, and their thoughts and opinions flowed. I arrived at meetings before the beginning and stayed after meetings to discuss what was happening between team members and any other interactions that occurred between meetings.

In contrast to the other two cases, the elementary team was not as welcoming at first. It took a few meetings before teachers were certain that I was not from the State Department of Education. The urban school district had more difficulty meeting the requirements mandated by the state, and the teachers often felt on-guard with state officials. In fact, this was the only team from this school district that permitted me to observe them. Aside from my verbal assurances in attempting to build trust between myself and the teachers, other things such my university email address helped convince teachers that I was really there to see how they developed elementary science curriculum and not to evaluate them within the high-stakes testing and accountability norms set by the state and school district. As teachers on this team struggled with content issues, I wanted to intervene and help, but instead, I observed quietly. A few times when the group struggled just to find a word, such as sterno, a device used to keep food warm in catering, I offered the term. While interactions like this did not help them with any curriculum or content issues, it provided opportunities for me to build trust between the teachers and myself. My past as an elementary trained teacher as an undergraduate also enabled me to hold conversations about science and other subject areas with the teachers. One-on-one discussions with the teachers occurred before, during, and after meetings and through email exchanges.

As a previous teacher, I sympathized with the constraints under which teachers in this multiple case study worked. Having participated in similar curriculum discussions as a teacher, I understood the conversations and tensions within each team. However, as a researcher, I applied a theoretical lens to study group interactions in order to understand how curriculum development groups worked to create technology-infused science curriculum and to provide guidance in how groups can mediate tensions in order to work more effectively.

Data Sources and Data Collection

Merriam (2009) compared triangulation in land surveying, a technique in which three measurement points converge on a single location site, with triangulation in qualitative research to characterize the process by which qualitative researchers employ several strategies to study a phenomenon. Triangulation provides an analysis strategy to ensure internal construct validity of the study. I selected to follow her recommendations of collecting and analyzing multiple sources of data. This data collection technique involved comparing data collected through observations at different times, with different perspectives and with different data sources: group meetings, field notes and artifacts provided me varied data sources that include interactions across time and that provide different group members' perspectives. As I entered the field, I took notes and attended to detailed descriptions of the group members, particular content of conversations, physical meeting settings, events, and activities in the field (Bogdan & Biklen, 2007). I gathered documents in the field and through a server in the chemistry group, Google documents in the biology group and over email with all three groups.

Finally, another recommendation that I adopted from Merriam (2009) was a routine member check. This member check allowed participants to review my analysis for validation purposes and to share with me any additional information or documents that I may not have been privy to during the group interactions (Merriam, 2009; Strauss & Corbin, 1994). In order to maintain contact with participants, I regularly contacted members to update my contact information, and on three occasions, I searched for contact information for participants who left the school district and found employment in different school districts.

The member check for this study involved confirmation, elaboration, and disputation. I sent each case chapter to respective participants via email. Participants provided me with confirmation of my analysis by emailing me comments such as, "You captured what happened." Elaboration was minimal and mostly involved updates with how the science curricula continued to change after the conclusion of the study. Within the biology and elementary teams, I had participants who disputed content. In order to provide further context for the disputed content, I supplied the raw transcripts for the participants to review. In both cases, I expanded the amount of transcript within each case narrative in order to provide further evidence of the discussion context and to satisfy the participants concerns.

Face-to-Face Group Meetings

The chemistry, biology, and elementary teams conducted face-to-face meetings over extended time periods (seven months, eight months and five months respectively). Both the chemistry team and elementary team meetings lasted approximately three hours each meeting. The biology team had six meetings that last from five to eight hours and three meetings that last three hours. I observed and videotaped each meeting with the consent of all group members. I transcribed each meeting in order to capture group interactions during the science curriculum development process.

Field Notes

While working with each team, I had opportunities to talk to group members in order to gain more insight into how each group operated. Most conversations occurred during time periods (before meetings, during breaks, and after meetings) when I stopped the video camera. Group members were free to express opinions with me that they might not have shared while on camera. I recorded content of conversations between group members and myself in field notes. On occasion, I discussed group interactions with group members on the telephone or through email exchanges and also recorded the data in field notes. Immediately following conversations, I recorded specific details that I recalled about conversations with group members and then an overall summary of each conversation.

Artifacts

Artifacts included resources that the groups used during curriculum development, emails between myself and group members, and group generated curriculum documents. The curriculum documents were not evaluated as overall measures of effectiveness of the curriculum as used by teachers or student; rather, content analysis of the curriculum documents triangulated claims regarding the development process. I triangulated content of discussions during meetings and conversations with either the presence or absence of content (i.e. format changes or concepts) within the curriculum document.

Data Analysis

I first employed a constant comparative approach (Strauss & Corbin, 1994) to create an extensive case history (Gersick, 1988) for the developmental process of each case. I analyzed each meeting transcript noting conversation topics, group decisions, and group member interactions within each transcript. I particularly became sensitive to the realization that each group member held his or her own perception of group interactions during meetings as well as after events occurred within a group. I accounted for these variations within side conversations with group members. Then, I triangulated occurrences between group meetings, conversations, and artifacts to determine the presence or absence of Team Effectiveness Framework constructs. I utilized the selected constructs (See Table 1.) in the Team Effectiveness Framework to analyze how group members worked together. As I examined the data sources for evidence of each selected construct, I utilized the analytic questions shown in the Appendix A table to complete a case narrative, which provided the episodic cycles of group interactions (inputs, mediators, and outputs) for each case.

My analysis of each group's inputs, mediators, and outcomes yielded how effectively each science education curriculum development group worked to create technology-infused science curriculum. I did not intend to generalize the results of my work to all science education curriculum development teams. Instead, I intended for this study to provide additional insight into how various combinations of group inputs, mediators, and outcomes impact the incorporation of technology into science curriculum artifacts.

For example, I observed that the emergent state team autonomy enabled a subgroup to form in the elementary team and created tensions between the subgroup and other group members. I began by reading the meeting transcripts and field notes. During the initial team meeting, the teachers collectively asked Claudia, the science supervisor and team leader, if the team could meet away from the school district headquarters. Teachers expressed the need to use classroom resources during the writing process and also to avoid interruption by other groups working on other projects (both in science and mathematics) concurrently at the school district headquarters. Gaining this level of team autonomy to decide their own meeting location enabled the team to focus and work diligently to create the curricula artifacts; however, trade-offs from meeting at other locations included lower meeting attendance by the teachers, the exclusion of an expert resource and less direction and team monitoring from the team leader who remained at the school district headquarters with the other groups. The content discussions during the writing meetings and the content issues within the artifacts provided additional evidence to support the claim that issues and tensions within the team stemmed from gaining this level of team autonomy.

Once each case was analyzed and written, I provided a copy of the analysis for each group member in each case to review. This feedback provided additional validation of group members' perceptions. To my surprise, the study participants who read my analysis and responded thought that I captured issues within each group well. The additional member check feedback strengthened my claims.

Finally, I compared cases across groups to determine if there were any particular patterns of group effectiveness in science education curriculum development groups. I identified themes and overall implications. The implications are meant to assist groups as they assemble, but they are not meant as a prescription for the most effective group given the equifinality assumption that numerous configurations of group inputs and mediators yield similar outcomes. Instead, the cross case analysis provides group members with what to look and listen for during group interactions to increase group mediators such as group cohesion, conflict management, and group trust.

In Chapters 4 through 6, I present the three case studies described above followed by a cross case analysis in Chapter 7. In each case, I first present a case narrative to review each group's history that details the formation of the group, important group interactions, and reflections from team members about the work. Following the narrative review, I then apply the constructs from the Team Effectiveness Framework to analyze episodic cycles of inputs, mediators, and outcomes. In each case, I attempt to demonstrate how these constructs shaped how each group created technology-infused science curriculum products. I offer recommendations on how each group could have increased group effectiveness. In Chapter 7, I abstracted themes within the cross case analysis in order to begin to understand how according to the Team Effectiveness Framework science education curriculum developments groups work to create technology–infused science curriculum artifacts.

Chapter 4: Elementary Science Team

In this chapter, I present the fourth grade elementary science curriculum development team that contained no external collaboration, relied solely on the expertise within its organization, and conducted curriculum development without a goal to select a specific technology innovation. Tensions in the group stemmed from the formation of an elementary teacher subgroup. The subgroup cohesion and subgroup efficacy were both high as the elementary teachers responded to each other and worked well together. Overall team cohesion was low due to the lack of trust in the middle school teachers and the lack of direction from the team leader. Team efficacy was also low due to team members' absences from writing meetings. First, I present the episodic cycles as a thick description in a case narrative, and then I analyze the team with the Team Effectiveness Framework and provide recommendations of how the team could have increased team effectiveness.

Case Narrative

The elementary science team formed on December 10, 2009. Initially, I located the science supervisor's contact information on the school district's website and called the science supervisor, Claudia. We discussed my research interests and the possibility to allow me to follow curriculum development groups in her school district. We met prior to the December 10th meeting in her office at the urban school district's headquarters. Claudia migrated to the United States from an Eastern European country where she obtained a Ph.D. in physics. Her "office" was limited to a single office desk, which was one desk among many desks in a large room populated with other school district curriculum supervisors. Part of the room was used as storage for science and mathematics books and supply boxes that were piled high in rows. The remaining space was filled with desks around the perimeter and conference tables in the middle of the room for staff use. She pulled a chair over to her desk area for me, and we discussed the science curriculum development teams in the school district.

Claudia explained that she assembled elementary grade level teams to write science curriculum units and that the teams were funded by federal and state governments. She directed each team to develop units that aligned with the state's voluntary science curriculum while infusing technology within the curriculum wherever possible. She gave each team a word document template with the embedded format for the curriculum units. She explained that each team needed to use the template to guide their curriculum writing efforts over the next few months. The template included listing big ideas, prerequisite knowledge, state science standards, vocabulary, conceptual understandings, common student misconceptions and learning activities with both descriptions and materials for each activity. She told me that all of the teams met here at the school district headquarters, and she gave me the list of dates that she set for the groups to meet.

Following Claudia, I walked to another floor of the building and into another large room where the curriculum development teachers met. The meeting room was divided into various areas. More books and supply boxes lined the front wall on bookcases. Tables filled with boxes were in front of the bookcases. There were medium-sized conference tables with teachers discussing mathematics curriculum and two side tables with dinner for the teachers in the front of the room. From the middle toward the window-lined back wall of the room were additional storage and meeting areas. Four small conference tables lined each side wall and bookcases filled with books and boxes jutted out from the wall and separated each conference area. Mentor teachers and new teachers who discussed classroom lessons and observations occupied the two small conference areas on each side of the back wall. In the center of the room and between the smaller conference areas, six tables combined to make one long conference table. The teachers who were there to write science curriculum sat at this long table and ate dinner while they waited for Claudia.

Claudia led the entire group of teachers at the beginning of the meeting and introduced me to the group as a graduate student. She directed the teachers into the grade level teams, and each team moved to a different area in the room. Two teams stayed at the center table and the rest of the teams occupied smaller conference tables on each sidewall. I circulated through the teams and asked teachers if they would allow me to observe. Three groups immediately said no and turned to each other to work. Two other teams had a few teachers who were willing to consent, but not all participants were willing to allow me to observe the team. The only team that allowed me to observe with full access was the fourth grade level team.

The fourth grade team teachers consisted of three elementary teachers (Stacey, Cindy, Lilly) and two middle school teachers (Mindy and Nelly)[1]. (See Table 4.) Stacey taught fourth grade and regularly developed curriculum in several subject areas at the elementary level. She previously had a biology-related science career and

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[1] Originally, Dana was an additional teacher, but she moved to another grade level team with fewer members during the first team meeting.

worked in a laboratory before obtaining her education degree. Stacey also has a technology certificate from a local university. Two other teachers, Cindy who taught fourth grade and Lilly who taught fifth grade, taught in the same school in a more affluent area of the urban school district. Cindy taught for many years and was well respected in her urban elementary school, and Lilly taught elementary school for six years. The remaining members of this team included two middle school science teachers, Mindy and Nelly, and the science supervisor, Claudia, who supervised all K-12 science curriculum development. Mindy and Nelly taught middle school and had not taught elementary school, but neither told me how long they taught.

Table 4: *Elementary Science Team Members*

Organization Role	*Pseudonym*	*Leadership Roles*
Science Supervisor	Claudia	Team Leader, School District Leader
Elementary Teacher	Stacey	Sub-leader within group
Elementary Teacher	Lilly	
Elementary Teacher	Cindy	
Middle School Teacher	Nelly	
Middle School Teacher	Mindy	

At first, the teachers were not comfortable with me. I had available two copies of the consent form (one copy for me and the second copy for each teacher to keep), and I asked if I could videotape the first meeting with their consent. After glancing through the form, Nelly and Mindy signed the form. The remaining three teachers read through the form, and Cindy asked me if I worked for the State Department of Education. I answered no and pointed to the university label on the consent form and also provided all of the teachers with my university email address. I would later come to learn that the teachers in this school district had negative interactions with State

Department of Education representatives, and all school district teachers operated under the threat that the State Department of Education would take over the urban school district due to poor annual high-stakes test scores. I felt compelled to stress that I was a graduate student who wanted to observe how the team developed science curriculum. I quickly understood that I needed to work to establish trust between the teachers and myself.

At this meeting, Claudia set meeting dates and times for future work. (See Table 5.) During the fourth grade level team meeting on December 10th, the teachers met with Claudia for about twenty-five minutes. The group divided this time into discussing the units to be developed and another science professional development project.[2] Claudia encouraged the fourth grade curriculum development team to use the existing curriculum first as they created the new curriculum in the formatted template. She asked the team to send her drafts by email, and said that she would provide comments as she reviewed drafts. Claudia established team task roles during this time: Teachers would assume writer roles, and Claudia would assume the editor role.

[2] The professional development project focused on students' science misconceptions and involved Claudia as the leader and Stacey, Lilly, and Cindy as facilitators who led sessions in how to teach elementary science lessons.

Table 5: *Elementary Science Team Meetings*

Date	*Meetings*	*Time-span*	*Attendance*
12/10/2009	Initial meeting at school district headquarters; established goals and team	3 hours	Claudia, Stacey, Lilly, Cindy, Nelly, Mindy
1/21/2010	Collaboratively wrote units at Stacey's school	3 hours	Stacey, Lilly, Cindy, Nelly
2/25/2010	Collaboratively wrote units at Cindy & Lilly's school	3 hours	Stacey, Lilly, Cindy,
3/11/2010	Collaboratively wrote units at Cindy & Lilly's school	3 hours	Stacey, Lilly, Cindy, Mindy
4/19/2010	Final meeting at school district headquarters; handed in units	3 hours	Claudia, Stacey, Lilly, Cindy, Nelly, Mindy

Although Claudia had intended the teachers to continue their work at the school district headquarters, the teachers expressed the need to use resources within the classrooms and the desire to minimize interruptions by other groups or other projects (i.e. science professional development) using that space. With Claudia's consent, the teachers met on the established dates in the schools rather than at the school district headquarters. Claudia corrected scientific concepts for the team and provided advice for the teachers during their brief discussion in December. She referenced another teacher who she interacted with during the professional development project and used her interaction with him as an example of how to interact with colleagues and when to look up science content.

Claudia: There was a teacher who discussed planets and the sun. He sounded very confident but if you listened very carefully to what he was saying, he was scientifically wrong. You will have those individuals who sound as if they know everything and

> then you get intimidated…. The best thing to do if you feel intimated is to look it up right on the spot.

Claudia, the science supervisor and team leader, assembled and organized the team as she provided group goals and roles in this initial meeting. She also granted team autonomy and allowed the team to meet in the schools and not at the school headquarters. Unfortunately, the team lost direct access to Claudia's expertise and guidance during the remaining writing meetings, and the episodic cycles that changed the team dynamics and interactions occurred without her input.

January: Role Confusion

The January 21st writing meeting was held in Stacey's classroom. Stacey's school was not located on a major city road; instead, the school was tucked back into a city neighborhood with narrow one-way streets. The school was difficult to locate and the 4:30 p.m. meeting time placed teachers in early rush hour traffic. Mindy attempted to attend the January 21st meeting, but she became lost. She called from her cell phone, frustratingly gave up finding the school, and went home. Stacey was prepared for the teachers. She pulled out supplies and resource books for the team to use before the meeting. In the middle of her classroom, the students' desks were pushed together and faced each other in one long row of paired desks, and the teachers spread the supplies out along the desks as they began to work. Stacey used her classroom projector and laptop to complete the template, provided by Claudia at the previous meeting, as the team discussed each section. Claudia's consent for the team to meet away from the school district headquarters meant that the team leader was not present; thus, Stacey worked to coordinate the first writing meeting, hosted the team in her classroom, typed the first unit, and corresponded with Claudia at the end of the meeting. In this way, she began to assume a leadership role during this first writing meeting. However, she would later tell me that she did not see herself as the team member "in charge" of the other team members. Rather, she thought that team monitoring of team members' actions was always Claudia's role.

The team utilized the current school district planning curriculum guide, state voluntary curriculum documents, student textbooks, teacher lesson plan books and websites as resources to complete the template for the thermodynamics fourth grade unit. The team began with content discussions regarding potential, kinetic, and thermal energy. The discussion revealed how the teachers initially shared information. Interestingly, the teacher's discourse was saturated with singular personal pronouns, such as I, my, and you, to share information and classroom examples individually. For example, they discussed safety issues and shared how they taught concepts in their own classrooms. Even though Lilly and Cindy taught in the same school, they did not agree on whether students should use open flames in the classroom. Lilly shared how she would not allow her fifth grade students to work with open flames in her classroom.

Lilly: And I would do that [What do you think will happen to a paper cup of water when it's held over an open flame?] as a demonstration not the kids doing it.

Cindy told the team that she allowed her younger fourth grade students to use flames in her classroom, but that she was reluctant to dictate to other teachers what should be done in other classrooms.

Cindy: My kids used an open flame when we were doing it [the activity], but I don't know. I don't want to tell someone else what to do in their classroom.

Ultimately, the team wrote the activity as a teacher demonstration, and the teachers explained after the meeting that they each adapted lessons to their own classrooms. They knew that teachers who wanted to have students use open flames would change the activity to a student-centered approach instead of a teacher demonstration. After the meeting, Stacey referred to her comment during the meeting about writing in a safety precaution note to the teacher.

Stacey: We can do two demonstrations for convection because, like you said, they're gonna involve flames and these are elementary school kids, but for radiation and conduction there are a lot of things that the kids can do themselves, so let's say these are gonna be demonstration, and we can make a note somewhere in here "due to open flames and these should not be done by children." Safety precautions or whatever, so let's do demonstration.

Team discussions regarding the use of other materials continued throughout the first writing meeting. Teachers shared what materials they used or did not use in their own classrooms for different activities. Safety and access to materials were common concerns. Cindy was aware of her fortunate and ample supplies in her classroom and school, and Stacey shared where materials could be found.

Stacey: I'm thinking too if we took them and like if you had the tea lights inside like a Pyrex cup, like those little Pyrex dishes they could do it 'cause there'd be something to buffer it.

Cindy: I guess this is the thing about for the poor teachers and materials, though. Then it gets a little bit – I'm just thinking out loud.

Stacey: But some of our schools now are K to 8. Their eighth grade has gotta have that stuff. I mean I walked outta there and I've got – what are these? – flasks and all kinds of stuff from the –

Cindy: Yeah, that's true.

Stacey: – like you do. You all got –

Cindy: Yeah, we will – yeah, we would have that.

Stacey also shared with the group how she supported her own classroom by buying materials that were not provided by the school district or school. She regularly purchased her own supplies for her classroom as she described her new magnetism supplies.

Stacey: I have to do magnetism now, and I went out and I bought myself – I bought them myself. I bought the kits at Lakeshore Learning and they come with everything.

The group began to organize as a team during the second half of the meeting as Stacey began to take even more of a leadership role during the writing meeting. Stacey also refocused the group to the template, began to use the plural personal pronoun “we” to reference the team, and suggested how the group completed the template.

Stacey: And that’s – I mean I think even though we’re getting a curriculum, my brain doesn’t work that way. I’d be better off saying, “Okay, we’ve done thermodynamics. Let’s fill in the activities. Here’s the whole unit” and be done rather than say, “Oh, we’re gonna go back and plug something in.” We have a scope and sequence. Why don’t we just – because we’ve already got the activities. Why don’t we just type them up and stick them in?

Lilly made another suggestion for the team members to “write them down [activities] and then at a different time we can type them up.” Stacey disagreed with Lilly and wanted the group to divide the work of writing up the lesson activities. Stacey’s frequent interruptions in the flow of the conversation show how Stacey facilitated the conversation. She suggested that each teacher write an activity and send a note to the absent leader Claudia. Nelly and Cindy agreed to the process of writing activities and compiling them together. This decision was an important step for the team to establish a work process that would be used during and between writing meetings.

Stacey: Yeah, and I think what we’ll do here –

Lilly: So that sounds –

Stacey: – in here reference –

Lilly: It’s two of them.

Stacey: – what book we got them from and just make a note to Claudia that we're gonna – maybe each one of us could – like if we were to do something, like you could type up the one that you did on the rice.

Cindy: Okay.

Stacey: I could type up something outta here. If there was another book, maybe Nelly, you could sit and type them.

Lilly: There's two –

Nelly: Yeah.

Stacey: Type the activity up and then we can just file them all together; do it that way. I mean – or we could all go back to computer lab and type right in there, too.

Cindy: Well, I have my stick [flash drive] here if I – you can just transfer them onto yours.

Stacey further established her leadership role by addressing me directly on behalf of the team and giving me permission to ask group members questions at my discretion: "If you have anything you have to stop and ask, go ahead." Despite Stacey's assertion, Lilly responded with concern over who might watch the videotaped meeting, "If you show this to other people they're gonna be like the one in the green shirt's an idiot and shouldn't be teaching." I was aware that they were open and candid with each other, but they were still concerned with my presence. I reassured the teachers that I would talk to them after their meeting and that I did not need to ask any questions during the meeting. I limited my interactions with the group to providing particular material terms (e.g., sterno or glass globe), when the group struggled to recall the material name. In these instances, I would mention the words to be helpful, but did not engage in the team discussions. In this way, I attempted to build trust between the teachers and myself, yet not interrupt the team interactions and discussions.

Tension became apparent in the meeting when the team discussed student misconceptions. At this meeting, the discussion between the teachers involved Cindy and Lilly who asked questions to the team for clarification of science concepts and Stacey and Nelly who answered them with examples. As such, Stacey and Nelly shared a content expert role as they attempted to clarify concepts for Cindy and Lilly. For example, the group discussed kinetic and thermal energy:

Stacey: Well, kinetic is like calories, like kinetic and calories are kinda the same, so it's the amount of energy that can be used, so if – you know like if I never eat any food, eventually my body's gonna die out, you know so it's the actual numeric count of energy that something can hold.

Nelly: Yeah, it's something that has motion, like energy that something has because of its motion. As an example, water loses or gains kinetic energy, so when there's any movement there's a kinetic energy.

Stacey: Kinetic energy and it moves and then it uses it up and then it goes back to zero, so it's a numerical equation basically.

Cindy: Okay.

Stacey attempted to compare kinetic energy to calories. However, scientifically the two were not equivalent. Nelly's statement to the team that kinetic energy is energy of motion was scientifically correct. Stacey repeated Nelly's statement but then incorrectly added that energy is "used up" rather than Nelly's explanation that kinetic energy is gained or lost meaning that energy is transformed. Interactions of this kind between Nelly and Stacey occurred throughout this meeting. As Nelly attempted to offer scientifically accurate explanations, Stacey commanded the discussion even though she was not confident in the content. Within one of the resources, the team found a student misconception that listed the statement, "The temperature of an object drops when it freezes." Nelly and Stacey's explanations of the misconception differed. Lilly also attempted to contribute to the discussion but did not finish her thought.

Stacey: Read it again. What is it?

Nelly: The temperature of an object drops when it freezes. Because the lower temperature the like, you know, freezing point is –

Lilly: It's heat is -

Stacey: No, but the heat doesn't drop. What does it- say that again?

Nelly: But in the sentence here they're talking about temperature here. Probably the heat of an object is not –

Monitoring the team interactions during this conversation, Lilly sensed the tension, assumed a team motivator role and verbalized, "We gotta stay focused. We're like challenging each other." Here, Lilly used the pronoun "we" to refer to the entire team as she sought to keep the team united. Lilly added laughter to break the tension and referred back to her own misunderstanding of the term misconception. However, Nelly continued to challenge Stacey's previous explanation.

Nelly: Well, the heat – I think that for that it should be the heat.

Stacey: Well, I think it's we're getting questions.

Nelly: That and its temperature would be – heat would be the best, so then you heat an object, should drop like –

Lilly: I don't know.

Cindy: I don't know.

Lilly: I'm still on misconception, the word. *[Laughter]*

Nelly: Yeah, that was the question.

Lilly: Still on that. *[Laughter]*

Stacey: So we didn't see any more, right? We said energy is a thing, an object that is tangible. [*Reading from the misconception page*]

Nelly: Yeah.

Cindy: Okay. That's all on that-

Nelly attempted to explain that the statement should have referred to a change in heat instead of a drop in temperature that is why the temperature statement was a misconception. Lilly's effort to increase overall team cohesive failed even with her attempt to use laughter and self-deprecation to ease the tension in the team. Nelly attempted to revisit the temperature misconception, but Stacey moved the group onto to the next topic and Cindy reinforced her by stating "That's all on that." I observed that even though Stacey used the pronoun "we" to refer to the team and Nelly agreed, Stacey did not unite the team, rather she redirected the team to the next misconception statement and led the dismissal of Nelly's contribution.

Stacey also led the team's discussion regarding copyright issues. As Lilly referred to an activity in a lesson plan book and said, "I wish we could copy it [the lesson from a book]." Stacey quickly reminded the team "You can't copy…that's illegal." Nelly thought that they could simply reference a lesson that they all agreed was a great student activity called "Heating Up," but Stacey explained "No, you can't do anything like that. No, we have to reword it [the lesson], the whole nine yards. We can take the idea and regurgitate it." Stacey assumed the role of copyright expert and based her comments on her past experiences when she wrote curriculum for the school district. Nelly's suggestion of referencing the lesson was only partially correct. The school district would need to obtain written permission for the lesson. According to Stacey, the school district refused to obtain copyright permission in the past, but she never explained the school district's position to the team.

The copyright issue surfaced again while the team searched the Internet for resources and found what Stacey described as a "public access" site. The website was www.sciencenetlinks.com, and it was supported by the American Association for the Advancement of Science (AAAS). Since Stacey determined that the website was a public access site, she told the group "all we have to do is link on the curriculum." Lilly replied to Stacey's comment and reminded the group "Claudia has said we can do that. We have to do it for people [school district teachers] who don't use the Internet and people who do." But the team still floundered on the copyright issue as they found a Bill Nye the Science Guy video clip about heat that they wanted to reference. The video was found on the website, but the team did not know if the video was copyrighted. Cindy explained how she used and learned from the video. “I actually – the video is how I learned about thermodynamics because these – it’s very good. It’s very thorough.” With Cindy’s recommendation, the team decided to include the video as a link in the template. Stacey thought that Claudia would edit it out if needed.

As a final activity in the unit, the teachers listed toasting marshmallows for students to “experiment with the three types of heat transfer.” They felt that the activity was relatively inexpensive and allowed students the opportunity to show their understanding of radiation, conduction, and convection. Then, the teachers listed a fictitious activity that was an inside joke to Claudia. Lilly said “like take a field trip to the Melting Pot [a local fondue restaurant].” Stacey replied, “That’s a good one, trip to the Melting Pot to watch them make fondue. Let’s see if she [Claudia] even notices.” The team laughed and agreed that Claudia’s reaction would be interesting. The shared inside joke helped to build team cohesion. Stacey sent the template attached to an email at the end of the meeting to Claudia. She also listed the team members who were present and a brief description of what the team accomplished during the meeting. The meeting closed when all of the present teachers volunteered to finish writing activities that were not finished by the end of the meeting

After the meeting, I talked to the teachers without videotaping the conversations. The teachers were more relaxed and discussed their concerns with school level and school district level administrators. They told me more about their schools and issues that they faced. Nelly left quicker than the other three teachers as she had another obligation at her school. She worked on other projects at both her school and at the school district headquarters. I noted that the elementary teachers bonded through sharing information and experiences well during and after the meeting. Although Nelly contributed to discussions at the meeting, it became evident that the elementary teacher subgroup had begun to develop. The subgroup development changed the team dynamics, particularly the team decision-making process.

February: The Elementary Teacher Subgroup Strengthens

Cindy hosted the February writing meeting in her fourth grade classroom. Lilly and Cindy's school is located on a major city road in an affluent area, which was easier to locate. Cindy prepared for the teachers and had supplies and books ready for the team. Her classroom was set up similarly to Stacey's except that her students' desks were pushed together and faced each other in two long rows of paired desks with a cart in between the long rows. The teachers used Cindy's classroom projector on the cart and Stacey's laptop to complete the template as the team discussed each section. Nelly sent an email stating that she had a previous commitment and was unable to attend the meeting. Mindy also did not attend the meeting and did not correspond with the other teachers. Without either middle school teacher present, the three elementary teachers worked together to write the next unit.

As in the first writing meeting, the team utilized the current school district planning guide, state voluntary curriculum documents, student textbooks, teacher lesson plan books and websites as resources to complete the template for the electricity and magnetism fourth grade unit. The team assembled the resources across the student desks. Then, they began to discuss the sequencing of activities for electricity content. Similar to the first writing meeting, the team used the template as a guide to organize their meeting. They followed each section again and listed the prerequisite student knowledge and the voluntary state curriculum indicators, objectives, skills and processes. The team decided under the technology process from the voluntary state curriculum to include the indicator: “Design constraints: develop designs and analyze products.” They decided to include activities in which students built and tested simple, series, and parallel circuits. The use of the term “technology” as stated within the state document is a definition from engineering in which the students use scientific logic to solve problems. Nevertheless, the teachers embraced the inclusion as a way to insert “technology” into the curriculum wherever possible as encouraged by Claudia during the initial meeting at the school district headquarters. Stacey told the group, “Well, we'll put it on there [the template] and then leave it up to Claudia,” and the group assumed that Claudia would edit it if needed.

The teachers discussed the template format during the writing meeting, which prompted them to compare the differences between grade levels and schools across the school district. They again discussed their classroom norms and the use of the developing curriculum artifact by other teachers. Stacey shared that even though a state assessment required students to get a light bulb to light; she went beyond the basic state assessment limit to light a bulb and made her students “bring in shoeboxes” to “make a house that lights light bulbs.” Stacey’s project prompted school schedule comparisons. Cindy and Lilly’s school allowed flexible time for science as Stacey pointed out, “Like you guys are lucky because you get to teach science for 90 minutes. A lot of schools get 30 minutes a day, if they get that." Lilly later added that when students transferred to her class from other school district schools, the students were not well prepared for the state assessment and as a fifth grade teacher she had to try to help those students.

Lilly: And that's the tough thing. Because this school does such a good job with preparing them before they come to fifth grade, but if they [students] came from a school where there's no time to do science ever, they're kind of setting the kid up for failure [on the fifth grade science state assessment].

Lilly also noted that other teachers usually do not even read the state documents and might not even know what else should be taught at the fourth grade level according to the State Department of Education.

Lilly: But you know what's sad? There's going to be people that they're just going to look at this, and they're not going to bother to go look at the VSC [Voluntary Stare Curriculum] themselves and the parts that aren't highlighted. But I guess – you know what? We're making this for people that have the –

Stacey: Least amount of knowledge.

Lilly: And the – a limited amount of time.

The elementary teacher subgroup worked well together and pulled activity ideas from the various resources. They discussed the sequence of activities for simple circuits, series circuits, insulators, conductors, and parallel circuits and exchanged the way and order in which they each taught these concepts in the past. They also discussed how much detail should be included in the activities. Stacey commented, “Because if you think about a brand new teacher who reads that [activity], they're going to give the illustration the kids just made in that series, in that simple circuit.” Stacey was concerned with the curriculum audience: she worried that a novice teacher might not understand how to do the activity with students. On the other hand, both Cindy and Stacey noted that veteran teachers would teach the activities differently over time no matter what they as curriculum developers wrote.

Cindy: Mm-hmm. Well, I guess – well, I guess – well, even myself, I think when I do this the first time, I might not have done all that exciting stuff. You know, but I can see myself experimenting with it more afterwards, and –

Stacey: I mean, like yeah, I mean, you're going to see, you know, the teacher who's been teaching science for 20 years is going to do something entirely different than, you know, Jane who just walked out of the University with her teaching degree, and is so overwhelmed – just think about how overwhelmed you were your first year, just trying to maintain discipline.

Without Claudia or a middle school teacher present, Stacey alone assumed the content expert role at this meeting although the team worked through the activities with little content discussion. One notable discussion involved Stacey addressing the elementary teacher subgroup team’s confusion about a misconception that pure water is a poor conductor of electricity. Following Claudia’s previous advice, Stacey directed Cindy to look it up on Google's search engine. Stacey thought that the term "pure" was the key to this misconception.

Cindy: That's the same as the magnets. They always think the bigger ones – okay? Or a bulb – bulb burn brighter. Okay. And then it says pure water is a good conductor of electricity.

Lilly: No.

Cindy: No, that's a good – it's a misconception.

Lilly: Oh.

Cindy: Like do people think that? People always think when you're swimming, right? But that's because that's got chlorine in it? Is that why?

Lilly: I think any water –

Cindy: Yeah.

Lilly: It's like stay away from water-but doesn't it have to have – there's minerals in it that make it more –

Cindy: That's what I always thought.

Lilly: Like salt.

Cindy: Yeah.

Lilly: Like isn't – like you can have the kids conduct – try to conduct electricity in just water, and then you can stir in salt, and then they should be able to – the light bulb should light up.

Cindy: I don't know.

Lilly: I don't know.

Cindy: I don't know either. Okay.

Lilly: I should do it. I should have my kids do it.

Cindy: So what should I say? What –

Lilly: I should do it myself first.

Stacey: Google 'Why is water a poor conductor?'

Cindy: Okay.

Stacey: I mean, obviously, you know, you're not supposed to use – you know, there's all those warnings. Don't use this, don't blow dry your hair in the bathroom, and –

Lilly: Right.

Stacey: But the keyword might be pure, like you said.

Lilly: Right.

Stacey: But I don't think chlorine is a conductor of electricity. But they tell you not to swim in lakes and you know, you get – when there's a thunderstorm like on the beach –

Lilly: Oh, yeah.

Stacey: – you have to get out of the ocean, so –

Lilly: You have to get out of all –

Stacey: All water. There's got to be a reason. It might be because the – even though it might not be a necessarily good conductor; it might hold the electric charge.

By openly questioning their own understanding of the student misconception, Stacey, Lilly, and Cindy increased subgroup cohesion and trust. The teachers allowed themselves to be vulnerable with each other and display their lack of content knowledge. The Google search listed many websites, and Cindy read content from Wikipedia, which prompted Lilly to observe jokingly, “Which I just modified.” Lilly, Cindy, and Stacey laughed as they knew that Wikipedia was not the best resource for information despite their repeated reference to the website to confirm their content discussion.

Cindy: So it says here – this is Wikipedia. Pure, fresh water –

Lilly: Which I just modified.

[Laughter]

Cindy: Pure, fresh water is a very bad conductor of electricity because there are very few ions in water.

Stacey: That's why. Okay. Because like chlorinated water is going to be full of ions.

Cindy: Okay. So the –

Stacey: So you're looking at like –

Lilly: Okay.

Stacey: They're talking about pure water as being like distilled water, you know, where it's been –

Lilly: How do you make distilled? Like –

Stacey: You filter it.

Lilly: What about our water coolers? Is that filtered water?

Stacey: No, that's spring water.

Lilly: Well, how would I make filtered water? Like a Brita filter?

Stacey: You have to buy it. You have to go buy it. It's the same water you put in a car battery.

Lilly: Oh. Distilled water. Okay.

Stacey: You have to buy it. It's what you make baby formula out of.

Cindy: All right. You guys ready for the next one? Are we going to put that one down?

The elementary subgroup strengthened as Cindy continued to refer to the subgroup collectively as “we.” Assuming a team motivator role, Cindy ended the discussion by drawing the team to collectively make a decision, keeping the group on task and moving the group on to the next topic. Further evidence of the subgroup formation was apparent when Lilly raised the issue of Nelly’s previous written activities. She noted that she was concerned that the activities were not appropriate for the fourth grade level. Stacey and Cindy agreed that the activities written by Nelly should not be included in the packet with all of the other activities.

Lilly: That's how I was telling her that we should go back and look at those, because she teaches middle school science. So we might want to go back and probably modify –

Stacey: Yeah, because like looking at this, I'm going, this isn't stuff we do in – I mean, she's got way too many – we don't even talk about the periodic table.

Lilly: Right.

Stacey: And what is she talking, refer to the Foss teacher guide. There is no Foss teacher – sulfuric acid, you can't use that in fourth grade. Where is she getting these books?

Lilly: Well, must have been at [school district headquarters].

Cindy: Yeah. I have a Foss, but I don't have that one.

Stacey: No, because this has got to be from a middle school curriculum. Classifying elements? This isn't even –

Lilly: Prentice-Hall.

Stacey: Yeah. I mean, that's the middle school curriculum stuff.

Cindy: Okay. So the objective – you guys the objectives now.

Ultimately, the elementary teachers omitted Nelly’s work and appeared to have lost trust in Nelly to produce fourth grade curriculum material. They noted that she used middle school resources, vocabulary, and activities to write a middle school lesson and not a fourth grade lesson.

An off task conversation occurred toward the end of the meeting. The teachers heard and shared rumors that the state was entering President Obama’s “Race to the Top” education initiative. Stacey explained, “If I live in Florida and move to [our state], our curriculum should be almost exactly the same.” Lilly expressed her compensation concern to the teachers, “Well, then, we’re not going to get paid to write curriculum.” Stacey further explained, “Certain teachers are going to get paid a lot more money. You’ve got to be teaching high school sciences.” While this side conversation did not alter the current document, the teachers acknowledged that the units they were tasked to write would not be used in the school district classrooms for a long period of time. The teachers told me after the meeting that new units would probably replace these units quickly. In fact, after she reviewed my analysis, Claudia wrote in an email to me, “We rewrote all those curriculum documents and are now getting ready to toss them as well.” I would later learn that the school district went through two more sets of curriculum documents in two years.

The teachers concluded the meeting by dividing writing tasks that were not completed again. Cindy initiated the conversation, “Who wants to do the activity for this one, parallel circuit?” Stacey reminded them, “They [activities] have to be put into that form.” Stacey once again led and coordinated the group at the end of the meeting and sent the template attached to an email to Claudia at the end of the meeting. Stacey provided meeting attendance and a brief description of what the team accomplished during the meeting Stacey embedded within the template this time a list of who would write which lesson activity; she included only Stacey, Lilly, and Cindy’s names on the list without identifying lessons for Mindy or Nelly.

The change in how writing task roles were assigned and the decision by the elementary subgroup to exclude the middle schools from the writing task role began the next episodic cycle for this team. The subgroup made the decision without consulting the leader, Claudia, or the middle school teachers, Mindy and Nelly. The subgroup cohesion strengthened, and the elementary teachers increased their work productivity in order to meet the outcome of creating fourth grade science units. The middle school teachers had not attended the meeting and did not know that their team roles had changed.

March: It is a Matter of Trust

Once again, Cindy hosted and prepared for the teachers with her supplies and books ready for the team. Her classroom was set up the same as the previous month. All three elementary teachers attended the meeting. For the first time since December, Mindy attended the meeting, but she arrived an hour late. Nelly was absent again, and sent an email message to Stacey that explained she had to stay at her own school for "an after school program in preparation for math state testing next week."

The elementary teachers began the meeting and discussed summer opportunities for teachers in the school district, such as teaching summer school and writing curriculum. They were not sure what Claudia's plans were for the science curriculum. Lilly asked, "Has Claudia given us any feedback?" Unfortunately, although the team had sent multiple units to Claudia, the team did not receive feedback from her. By this point, the only communication that they had received from Claudia was one email comment, "Looks good." Although the teachers assumed that the units were fine as written, they had lost confidence in the team leader to provide timely feedback.

Lilly: So I would imagine if we were doing something completely wrong, Claudia would have told us by now. Because we've emailed her on two different occasions our work.

Stacey: And I mean, I've even got all the stuff that I did, and she just writes back 'looks good.' But I know Claudia. She just kind of throws it somewhere, and she gets back to it later.

The team gained a stronger sense of team autonomy and did not look to Claudia for leadership. This was evident in the team's response to a "mass email" sent from Claudia to all the elementary teacher curriculum writers on the morning of the March meeting. Claudia's email indicated that all teachers must attend a "mandatory" meeting at the school district headquarters. The elementary teacher fourth grade level writers felt that Claudia had already given her consent for their group to meet on their own and that the email did not apply to them. Stacey said, "But she knew that we were meeting here," and she sent Claudia an email on behalf of the group. She read it aloud, "By the time we got the email up, we were already at the school. We began working, and Meg is here. Stacey." Then she asked, "Is that okay?" Lilly replied, "Sounds good."

I was surprised that Stacey put my name in the email, and I asked her about it after the meeting. She told me that she always made sure to let Claudia know when I attended each meeting. I knew that I was copied on all of the emails, but I had not realized that she added my name in the emails. Stacey added that she thought that it did not matter since Claudia knew that the fourth grade team worked through each writing meeting based on their past email team reports. Stacey also commented during the meeting that she "would not want to be in her [Claudia's] shoes at the moment at all." Stacey explained that Claudia oversaw all K-12 science curriculum and regularly observed science lessons in K-12 classrooms across the school district. Stacey explained that Claudia had numerous responsibilities and offered these explanations for why she did not provide timely, detailed comments to the team. Even during the first writing meeting, Claudia only spent 25 minutes of the three hours with the team, because she had to also visit all of the other grade level teams.

The first significant issue that the team began to discuss involved copyright confusion. The school district had purchased Discovery Works, resources such as textbooks published by Houghton Mifflin, and Cindy asked if they could copy the activities since the school district had purchased the material. Stacey assumed the copyright expert role again and told her no. Lilly added that not every school had the resources yet.

Cindy: So – well, everything that comes from Discovery Works, because we purchased this, we can really do it verbatim, right?

Stacey: No.

Cindy: We can't do that?

Stacey: No. Because then it's a copyright infringement. So we have to retype it.

Lilly: And we can't assume that everyone has Discovery Works.

Stacey: Discovery Works. Right. You can't reference like go to Discovery Works, blah, blah, blah because –

Lilly: That's what the old curriculum did.

Stacey: I know because the old curriculum every school had the same book. Now they don't because it's school choice. So the [superintendent] came into a lot of schools that they bought new science materials. Not him, himself, but he made them throw out all the old books –

Lilly: Why?

Stacey: – if they were over ten years old.

An hour into the March writing meeting, Mindy entered Cindy's classroom and Cindy welcomed her. Mindy sat at the long row of student desks next to me and not at the far end of the row by the other teachers. Cindy asked her, "Where do you teach?" She replied, "[Local] Middle school." Mindy had not yet attended a writing meeting away from the school headquarters and had no way of knowing how the team had worked in the past or how her answer would shape the subgroup's interactions with her.

As Mindy settled into her chair, the team's discussion regarding magnets began. Lilly asked, "So what's in a compass? Another magnet?" The team attempted to understand how to use a compass and how a compass works. Lilly asked, "So in a compass, the needle always points North. So that means it points towards Earth's North, right?" Initially, Stacey and Mindy assumed content expert roles and explained the compass to Lilly, who sought clarification from the team.

Lilly: I have a question. Okay. So in a compass, the needle always points north. So that means it points towards Earth's north, right?

Stacey: North. Yes. Mm-hmm.

Lilly: That's [Earth's] a magnet. So what's in the compass? Another magnet?

Stacey: Iron.

Lilly: Iron?

Mindy: Iron. That's a magnet.

Lilly: So does the South Pole not have – it's not magnetic? How does it know to always point north? Is north stronger? How does a compass work *[Laughter]*?

Cindy: What you said is correct. And I don't know the answer. Why doesn't it point south?

Lilly: 'Cause it says it always points north.

Cindy: Points to the north. Yep, it does.

Lilly: But Earth is a giant magnet, right?

Stacey: But it does not always point north.

Lilly: Right.

Cindy: Yeah. Depends on- north is like, yeah, – it moves

Lilly: Is that always the north?

Mindy: It's always north. It depends upon your location.

Lilly: But there's not a magnet in the compass?

Mindy: There's a magnet because iron it can –

Stacey: It charges the iron.

Mindy: Iron yes.

Stacey's explanation confused Lilly, but Mindy understood what Stacey attempted to convey to Lilly when Stacey said, "It charges the iron." Mindy knew that Stacey referred to the charged magnet in the compass. Stacey followed Claudia's advice from the initial December meeting when Claudia told the teachers to look up content and told Lilly to look it up on the Internet.

Lilly: Okay. So is it – so if it's gonna point –

Stacey: Type in how does a compass work

Lilly: – north, it would have to be an opposite charge, right *[Laughter]*?

Cindy: Mm-hmm.

[Stacey and Cindy leave the room. Stacey needs to use the restroom, and Cindy needs to unlock the door for her.]

Lilly: So would it be like opposite of the North Pole so it attracts?

Mindy: The one that's inside a compass?

Lilly: Yeah.

Mindy: No. Because when you're going to hold a compass and then it gives you the direction where you're facing at.

Lilly: Right.

Mindy: So it's not always that it's pointing to north, but it will tell you if you're in the northeast or you're of the northwest.

Lilly: good point

Lilly and Mindy continued to discuss the compass while Stacey and Cindy left the room. Mindy's explanations were scientifically accurate, but the elementary teacher subgroup lacked trust in her expertise and her contributions. Cindy decided to test ideas with compasses and pulled six small, plastic compasses out of her classroom supplies. She placed them on the students' desks around the room.

Mindy: So it depends upon how you hold it to which direction you're facing. But–

Lilly: There's a magnet in the compass?

Mindy: Yeah. Mm-hmm.

Lilly: Okay.

Mindy: The iron –

Lilly: There's a magnet in the compass or is the needle magnetized?

Mindy: Yes. The needle is being magnetized.

Lilly: By iron that's in there?

Mindy: Yes. It's the iron. Try to type how the compass works *[laughter]* 'cause when it tries to move, that means you say the needle is being pulled by the Earth. The direction of the needle is being led or directed, pulled by the earth. The earth tries to work with the needle's magnet. It tries to move it. The thing now is how the needle is being spun

[Cindy reenters the room.]

Lilly: Ok.

Mindy: So that it can pull towards, and it will be pointing.

Lilly: 'Cause you can even make a temporary compass.

Cindy: I'm just putting them on the tables.

[Cindy takes compasses out and places them on the students' desks]

Lilly: That's what they did a long time ago when they were like on their ships. That's how they figured out where to go. They made temporary compasses.

Cindy: And they used the lodestone or –

Lilly: I think they used lodestone.

Mindy: Uh-huh.

Cindy: Mm-hmm.

Lilly: So that's when compasses first –

Cindy: North is that way um because Park runs north and south. So-

Lilly: So I'm guessing the red part is north.

Cindy: That's where I always get – I'm thinking that you're going to –

Mindy: I'm thinking that it is.

Lilly: I think we need a Boy Scout. My husband was an Eagle Scout *[Laughter]*. I think I was asking, and he couldn't explain it. He just knows how to use the compass.

After this experiment, Lilly still did not understand how the compass worked and expressed to the team that she should seek clarification outside of the team. The team continued to experiment with the compasses until Stacey reentered the room and assumed the team monitor role to refocus the team on the template and move on from the compass topic.

Cindy: Yeah. So that's –

Lilly: Okay. So it- So it changed.

Cindy: So if you – right. They should all point the same way. If we put 'em in six different places, they should basically –

Mindy: Yes.

Cindy: – as long as we have 'em away from the computers and everything.

Lilly: Mm-hmm.

Cindy: So if you put ‘em like – just try that. We’ll see if we can get a –

Mindy: If it works? All compasses works.

Cindy: Right. And they are plastic, but –

Lilly: I’m facing that one?

Cindy: Yes.

Mindy: Yeah. That would make sense.

Cindy: The north – oh. You should be able just to set it down, and the red arrow should go to north.

Mindy: Yes.

Lilly: Oh. So it doesn’t matter my north, west, east, south.

Mindy: But you can try to move it, the needle.

Cindy: The needle. Yeah.

Lilly: Always going north.

[Stacey reenters the room.]

Cindy: Yeah. And then what you do is you kind of adjust yourself to be – you know, if you’re really out in the woods, I guess what you do is you adjust yourself to that north so you know – you know what I’m saying?

Stacey: So you can walk north.

Cindy: So you can walk the right way. Yeah.

Stacey: You turn your body in the direction that the needle is.

Cindy: And then the compass will kind of – yeah. Well, it’s meant to do this, actually. So are you guys hitting north like that way or are you hitting north –

Mindy: Right here.

Cindy: Right there.

Mindy: Just a little bit. Not really straight.

Stacey: Are you looking up the vocabulary?

Cindy: I am.

Of note in this interchange, members of the elementary teacher subgroup distinguished themselves as a group by referring to themselves independent of Mindy (i.e., “we”) and questioned Mindy’s explanation of the compass. After all of the questioning, discussion, and experimentation, the elementary teacher subgroup decided not to write a how to use a compass activity lesson for the magnetism unit.

Next, the elementary subgroup determined that static electricity did not fit into the previous electricity and magnetism unit but it was listed in the state assessment limit document, so they created a new unit template. The team worked through the static electricity template with limited input from Mindy until she made a vocabulary word suggestion. Stacey immediately told Mindy that her middle school book contained terms not used in fourth grade curriculum. Lilly recalled that the team used the term conduction in a previous unit, and Stacey justified that using multiple definitions for the same term would confuse the fourth grade students.

Mindy: There's another vocabulary word here for static electricity conduction. It's not conduction, but this is the movement of the electrons.

Stacey: But see, you have a middle school book, and we don't use those words in fourth grade.

Mindy: So we're – oh.

Cindy: Right *[Laughter]*

Mindy: I forgot that.

Lilly: Did you say conduction?

Mindy: Yes.

Stacey: Well –

Lilly: We used that when we did current electricity.

Stacey: Current, but we don't really –

Cindy: I guess we used the term earlier.

Stacey: Because – well, 'cause they're gonna think of conduction as, you know, the movement of heat.

Between the first conversation regarding the compasses and then the use of vocabulary terms, Mindy struggled to contribute during the rest of the meeting. Many of her comments were limited to simple acknowledgments (e.g., "Mm-hmm"). She shared personal off topic stories about how her laptop became infected by a virus, how she and her husband got lost trying to attend the January writing meeting, and how she and her husband were anxiously awaiting the arrival of their first child.

Throughout the meeting, the elementary teachers also confused Nelly and Mindy by name demonstrating again that neither member belonged to the subgroup.

The elementary teacher subgroup told Mindy why they did not use the lessons written by Nelly and provided a glimpse of the subgroup strength to Mindy. Nelly wrote lessons on her own after the January meeting; however, the elementary teacher subgroup determined that the lessons had to be completely rewritten. Stacey received the lessons in an email and shared them with Cindy and Lilly during the February meeting. They all agreed that Nelly's lessons were too difficult for the fourth grade level. Both Lilly and Stacey explained why prior work done by Nelly was not acceptable to the team after Stacey read the email explaining Nelly's absence and Nelly's request to write lessons on her own.

Lilly: But that might not be so good because the one that she did, remember –

Stacey: It was the one –

Lilly: – we were looking at it –

Stacey: Yeah, it has to be all redone.

Lilly: We were saying it was too middle school.

Stacey: It was too middle school. It was too hard for the kids.

Mindy: Yes *[Laughter]*. Because we-at the middle school-we cannot evaluate what you're doing, the specialty.

Stacey: Right. Yeah. So we have to really do all that.

Mindy: So really – yes. Just like I suggested conduction, and then now – right away you can say no 'cause it's not the right –

Stacey: It's too confusing.

Interestingly, Mindy made clear that she was not part of the elementary team subgroup ("we-at the middle school") as she defended her use of specific vocabulary. This not only represented a lack of overall team cohesion but also a difference in the norms within the school district from the elementary to the middle school levels. Mindy agreed that the middle school teachers should not write the lessons based on not being able to "evaluate what you're doing, the specialty." Although she is not specific, Mindy referred to not being able to evaluate the grade level expertise of the elementary school teachers. The middle school teachers had more experience in teaching science and each had attempted to contribute science content knowledge to the team but their attempts went unnoticed.

As the team concluded the meeting and divided work, Stacey again listed only the elementary teachers in the template to complete activities again. She asked the team what she should send to Nelly to work on alone. She explained further, "I mean, like what she should be doing on her own because there's nothing really she can be doing on her own without us being there." The elementary teacher subgroup lacked trust in the middle school teachers' abilities to write lessons without the subgroup members' assistance in the writing process. Cindy suggested that Nelly "just plan to meet us the next time and give us feedback." Once again, only the elementary teachers assumed writer roles; Nelly and Mindy were not assigned any lessons to write. Cindy also expressed the need for feedback from Claudia. "I think if Claudia has time to give us feedback, I think it would be really important by the 15th because we'll get all our activities done." Stacey wrote the suggestion into the email as the team decided to meet with Claudia at the school district headquarters, “April 15th grade four will meet at [school district headquarters]. We would like to meet with you to discuss what has been done and activities.”

Through their own frustration in creating the fourth grade science units, the elementary teacher subgroup decided to return to the school headquarters. The episodic cycle for this team resulted in a return to guidance from Claudia. The elementary subgroup sought her input through emails and craved constructive feedback on the work completed, but the feedback never came. However, since the teachers met on their own and not at the school headquarters and communication between the leader and group was dismal, the teachers did not know that their time together as a team would end abruptly.

April: Reporting Back to School District Headquarters

On April 19th the team met for the final time with Claudia, who changed the date from April 15th to April 19th, at the school district headquarters. At this meeting, all elementary science curriculum development grade level teams met in a large room with office desks around the perimeter of the room and a few small conference tables along the middle and back of the room as they had in December. In the back left corner by the windows was a small conference table area and next to it was a door into an adjacent smaller conference room with one large conference table. All of the science elementary writing grade level team teachers met in the adjacent room. Claudia introduced Cher, a “master” teacher, who would oversee phase two of the curriculum development for elementary science. Claudia told the teachers that only two teachers per grade level would be hired to work on the units during the next phase. She informed everyone that all interested teachers needed to reapply for the curriculum writing positions, and the new teams would meet twice a week during the remainder of the school year and two full weeks in the summer. She asserted that attendance and commitment were mandatory. The fourth grade team was the only grade level team to produce the template and activities for each unit.

After the whole group meeting, the fourth grade level team met with Claudia and Cher at the small conference table outside of the conference room for approximately 15 minutes. There was another fourth grade teacher named Linda who joined them because she planned to apply for one of the two fourth grade positions. Claudia asked the entire team who planned to reapply. Nelly immediately declined with a firm “No. Thank you.” Mindy was unclear and offered that she was not sure if the amount of time commitment would work for her. Stacey, Lilly and Cindy each acknowledged that they intended to reapply. Stacey mentioned the inside joke about visiting the Melting Pot and acknowledged that Claudia had sent an email about the joke to which Stacey, Lilly, Cindy, and Nelly laughed. The insertion of laughter and a joke was meant to check if Claudia had read the lessons and also lighten the strain between the group and Claudia, but the joke also further isolated Mindy, who did not know what they were talking about.

Claudia and Cher looked through the templates and activities briefly. Cindy asked if the units were sequenced properly and if the order was “logical,” but Claudia provided an indirect response and noted that all of those issues would be taken care of in phase two. Then, Claudia refocused the group to determine who would stay at the fourth grade level. Since the team contained too many teachers and the new teacher

Linda also wanted one of the two positions, Claudia told them that they all must reapply. Claudia concluded the meeting by informing the group how to record curriculum writing hours in order to be compensated.

Finally, Claudia met with all of the other grade level teams individually and then reassembled all of the science elementary curriculum teacher writers in the conference room. She encouraged the teachers to apply for curriculum writing positions and reminded them of the mandatory attendance and commitment stipulations. Since the elementary team had accomplished its goal of creating artifacts and would no longer meet to continue the writing process, I concluded my field observations for this team and did not attend phase two writing meetings. The fourth grade team disbanded.

Team Effectiveness Framework Findings

The elementary science team's contextual and antecedent inputs shaped the team mediators and resulted in the team performance and goal attainment outcomes. As shown in Figure 2, I utilized the Team Effectiveness Framework constructs apparent within this case to examine how the team worked to create technology-infused fourth grade science curriculum. First, I present the findings. Then, I offer suggestions of how this team could have increased team effectiveness.

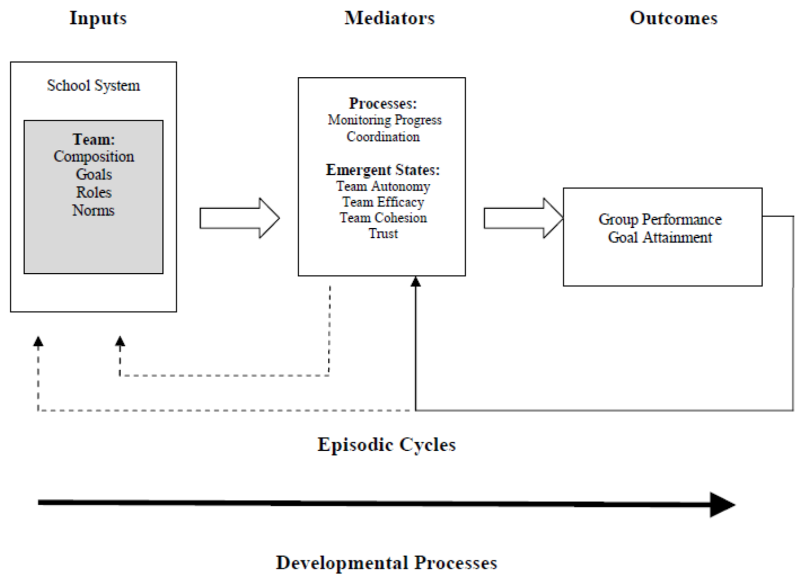

Figure 2: Adapted Elementary Science Team's Team Effectiveness Framework with inputs examined and mediator constructs apparent during team interactions (J. Mathieu, et al., 2008)

Lacking Technology Resources

The fourth grade science elementary curriculum development team's goal to create technology-infused fourth grade science units was set by Claudia, the school district's science supervisor. While the fourth grade elementary science team met the goal of creating unit artifacts, the team minimally infused technology. Technology infusion consisted of listing teacher website resources in the template for lesson plan ideas and teacher science content knowledge. The team listed websites in the template to provide teachers with links to video clips and information websites. While knowing that it was not the best place to verify science content, the elementary science teachers used Wikipedia during the February meeting to support artifact development. The team followed Claudia's request to provide activities with and without technology; however, the elementary teachers' primary concern was the lack of technology infrastructure throughout the urban school district. The concern with the lack of access and infrastructure within urban school districts is consistent with previous technology innovation studies (Marx et al., 2004).

The team not only lacked a specific technology goal and a technology developer but the team also lacked a technology champion (Bielaczyc, 2006) who at least argued for or championed the use of technology within the curriculum whether or not the champion also developed technology tools. The teachers did list a technology state standard in a unit, but the state's use of the term technology referred to designing a simple system and derived this use of the term technology from an engineering perspective. The teachers' attempt to satisfy a technology component resulted in a hands-on activity for students to work with simple electrical currents. Other than the websites and engineering technology state standard, the team did not include additional technology in the fourth grade science units.

Confusing Team Roles

Initially, the teacher team members were all tasked to assume writer roles. Unfortunately, the team required expertise that spanned several different domains (science, curriculum development, copyright, and technology). During each writing meeting, the team members struggled to fill the void of science content expert role, curriculum development role, and copyright role. Claudia, who was the team leader and had a physics background, could have assumed both the science content expert role and the curriculum development expert role during writing meetings, but she did not attend the writing meetings since the team changed the meeting location with her consent. Even though the team sent drafts and sought feedback from her, Claudia did not provide any timely feedback to the team, which resulted in reduced team performance since the team lacked direction and expertise from the team leader (J Mathieu & Rapp, 2009).

The teachers were left to use other resources and other team members' expertise. They read through activity suggestions on the Internet, lesson plan activity books, and textbooks. Within the template, they listed activities, lesson objectives, materials, and Internet links to provide teachers with access to helpful video clips and content pages. Stacey, who taught elementary school, previously worked in a biology-related science career before teaching and attempted to assume the content expert role. She showed her vulnerability to the team in each meeting. For example after the potential and kinetic discussion, she said, "I might as well look this up because I'm gonna need to know it tomorrow anyway." Cindy and Lilly did not attempt to assume a science content expert role, but they did join Stacey in assuming a shared curriculum development expert role. The elementary teacher subgroup worked together and in the end completely assumed all writing tasks for the team.

Claudia assigned two middle school teachers to the team. The middle school teachers held science degrees and taught only science at the middle school level. However, the elementary teachers felt that the middle school teachers' science expertise was too technical for the fourth grade level as shown in the use of "middle school vocabulary" introduced by Mindy at the March meeting. The elementary teachers did not acknowledge the science content expert roles that both Nelly and Mindy attempted to assume in the separate writing meetings that each teacher attended. Instead, the elementary teachers ignored the middle school science teachers' science content expertise, and at the same time they focused on the perceived lack of curriculum development content expertise relevant to the fourth grade units. Ultimately, the elementary teacher subgroup strengthened as a subgroup and made the decision to not allow the middle school teachers to write the fourth grade curriculum.

The copyright issues that surfaced during multiple writing meetings required a copyright expert. Stacey assumed this role and informed the teachers as to which links were allowed and which activities must be rewritten to be included in the fourth grade science units. Cindy and Lilly were confused by what types of copyright resources were protected. The absence of a copyright expert meant that the team relied on Stacey who may or may not have been correct in her copyright information. If the information was correct, Stacey saved the team time from having to edit activities later. If her information was incorrect, she caused the team to increase time and work productivity on activities that could have been simply linked to the units.

Ignoring Multi-level Norms

During writing meetings, teachers regularly engaged in what Reiser et. al. (2000) described as "teacher talk" and shared lesson ideas and resources. Previously, researchers have focused on what teachers discuss about their own classroom level norms and how the classroom level norms shape curriculum (Penuel & Haydel DeBarger, 2011). However, while analyzing norm discussions in the team meetings, I noticed that the conversations moved beyond sharing classroom level norms set by individual teachers to include discussions regarding additional varying norms within the school district as well as norms set by the State Department of Education. Each team member represented multi-level norms. As in Figure 3, each teacher worked within the same school district; however, each school, grade level team, and classroom established varying norms that were set by external groups (i.e. state agencies, school administrators, grade level team leaders, etc.) at each level. Norm sharing enabled teachers to compare norms at various levels and to understand how different levels operated across the school district. For example, even though Lilly and Cindy taught in the same school, they taught different grade levels and were members of different grade level teams within the school. Each level from the State Department of Education to the classroom set norms that influenced actions and behaviors at the next level down to the classroom level. Ultimately, individual teachers set the day-to-day classroom norms. As the teachers wrote the fourth grade science curriculum, they were reluctant to set norms within the school district level fourth grade science curriculum that would dictate how all teachers subsequently set classroom norms. Teachers embedded options for other teachers, such as alternative activities for teachers who did not have access to the Internet or science supplies.

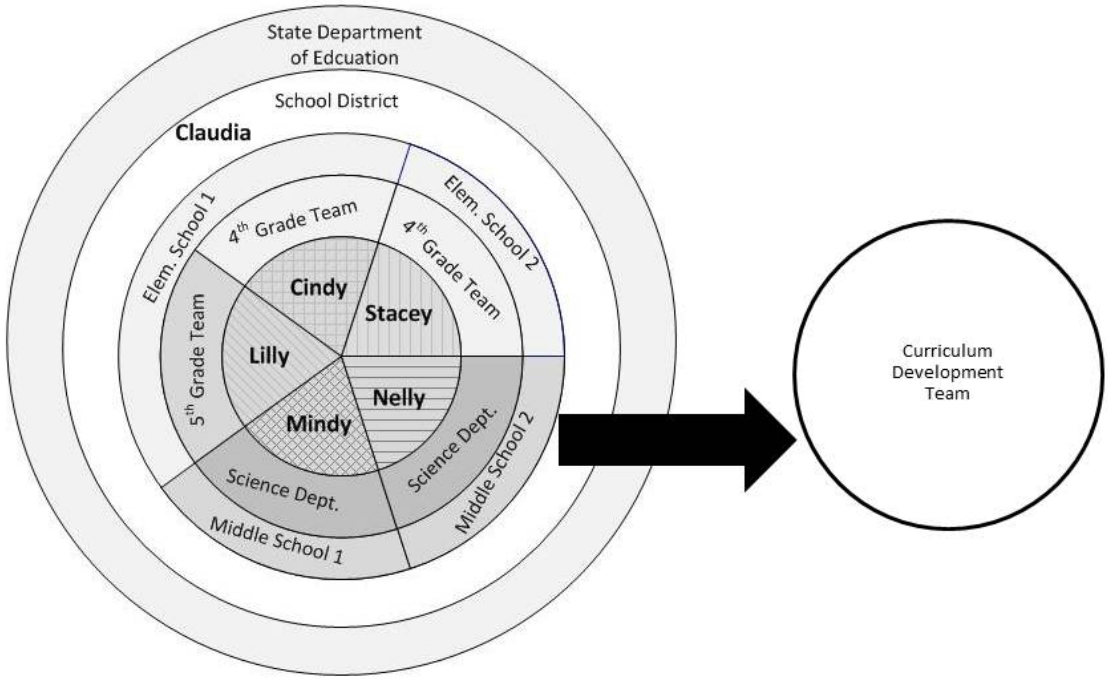

Figure 3: Elementary Science Team Members' Multi-level Norms. This figure illustrates norm levels that each team member brought to the curriculum development team. Each teacher set her own classroom level norms while working under the norms set by the other levels (grade level teams, school, school district and State Department of Education). Lilly and Cindy taught in the same school and shared that level in common, but they were members of different grade level teams within their school. As the science supervisor, Claudia set norms and worked at the school district level.

Classroom level norms included how teachers taught a particular concept, how teachers implemented classroom management techniques and how teachers responded to other norm levels above the classroom level. Despite teaching in the same school, Lilly and Cindy set different classroom level norms regarding whether students could work with open flames in the classroom. During the January meeting, Lilly shared how she would not allow her fifth grade students to work with open flames in her classroom. Cindy told the team that she allowed her younger fourth grade students in the same school to use flames in her classroom, but also explained that she was reluctant to dictate to other teachers what norm should be set in other classrooms. Nelly did not share what she did in her middle school classroom with the elementary teachers during the January meeting, and the teachers did not discuss if there was a particular school district norm or set policy for the use of an open flame in the classroom. Ultimately, the team wrote the activity as a teacher demonstration with the understanding that teachers would modify the lesson as a student-centered activity instead of a teacher demonstration.

The teachers were aware that other teachers would alter what they wrote just as they would alter the activity for their own classrooms. For example during the February meeting, the teachers discussed the audience of the curriculum. They felt that they needed to provide guidance and more details for beginning teachers and understood that veteran teachers would modify the activities before teaching them. For example, Cindy admitted that the first time that she taught a new activity she would follow it carefully before experimenting with alternative methods later.

For the fourth grade science units, the teachers wrote activities that adhered to the state assessment limits, but discussed how they individually departed from the state's voluntary curriculum. Across the Mid-Atlantic State, elementary students were only tested in science at the fifth grade level. Operating under the assumption that students remained within the same school and school district throughout elementary school, teachers below the fifth grade level were expected to teach particular concepts and to prepare students for the fifth grade level assessment. Therefore, the State

Department of Education imposed norms on the school districts to create curriculum that aligned with the state documents. The fourth grade curriculum development teachers did not feel direct pressure to only teach concepts listed by the state at the fourth grade level. For example, Stacey shared a classroom level norm with her shoebox house lesson that also reflected how she departed from the voluntary state curriculum assessment limits during the February meeting.

Likewise, teachers shared norm variation between schools. Teachers were aware that across the school district access to technology, supplies, and textbooks varied significantly. In particular, Lilly and Cindy had access to technology, textbooks, and supplies that were purchased within their school and not widely available to other school district teachers. Lilly explained to the team that her fifth grade level team did not use the same textbooks as other schools in the March meeting and she expressed her frustration as a fifth grade teacher who attempted to prepare new students who entered her school from other schools and who were not well prepared for the fifth grade state science assessment. In contrast, Stacey shared how she purchased her own supplies in order to provide more materials for her classroom to teach science lessons. The elementary teachers remedied the disparity of supplies during writing meetings by listing suggested materials to use for activities as well as alternative supplies in the template. Technology infusion resulted in a list of additional online websites for teachers to use for lesson ideas and content information. The issue with listing external websites is that websites may or may not be active or available to other teachers by the time that the units are distributed to other school district teachers.

Sharing the norms from the classroom, grade team, school, and state assessment limits combined with the consistent attendance by all three elementary teachers enabled the elementary subgroup to form and strengthen during the writing meetings. The elementary teacher subgroup made team decisions based on subgroup consensus, (Postmes, et al., 2001) which resulted in a lack of information sharing with all team members. Unfortunately, the middle school teachers did not participate in the norm discussions at the classroom, grade level team, or school levels. Not only did Mindy and Nelly only attend one meeting, neither teacher previously taught elementary school. The middle school resources, such as textbooks that they brought to the meeting or content contributions during meetings, were not valued by the elementary teacher subgroup. Nelly brought materials with her to the January meeting, but she did not refer to the resources during the meeting. Mindy attempted to use her middle school textbook during the March meeting, but Stacey directly pointed out that the vocabulary was not acceptable for the fourth grade level. Nelly and Mindy were limited in their contributions during norm sharing in meeting discussions, and not able to build team cohesion and trust with the elementary teachers.

Team Trust Barriers

A lack of overall team trust contributed to tension between the elementary teacher subgroup and the other group members. Unfortunately, even after the team sent the units to Claudia, the team did not get any feedback from her. The teachers assumed that the units were fine as written, but lost confidence in the team leader to provide timely feedback. This lack of response from Claudia resulted in a loss of trust between the teachers and the team leader. Embedded within the first unit that the team wrote in January, they jokingly added that they needed a field trip to a local restaurant. Although Claudia acknowledged the joke in an email to Stacey and the team concluded that Claudia had indeed read the unit, further edits and assistance were not given to the team during the five months of writing. The teachers used humor (Marks, et al., 2001) as a litmus test to see if the leader caught the joke while editing, but the desired results of more thorough edits and feedback did not occur.

The elementary teacher subgroup also did not trust the middle school teachers. As shown previously, the subgroup did not initially accept Nelly's or Mindy's scientific explanations until they either located more information or experimented to confirm the content. Nelly wrote her own lessons for the fourth grade science units when she did not attend the February meeting, but the subgroup determined that the lessons had to be completely rewritten. Stacey received the lessons in an email and shared them with Cindy and Lilly. The elementary teachers all agreed that Nelly's lessons were too difficult for the fourth grade level. Of note, Mindy agreed that the middle school teachers should not write the lessons since they were not teaching elementary school and deferred to the grade level curriculum development expertise of the elementary school teachers. The subgroup lacked trust in the middle school teachers' abilities to write lessons without the subgroup members' assistance in the writing process. The elementary teachers were not willing to be vulnerable to the actions of the middle school teachers without directly monitoring or controlling the lesson content. They felt that they would have to rewrite the lessons as they previously rewrote Nelly's lessons.

A final trust barrier was between the team and the external boundary spanning State Department of Education. The teachers were wary of my presence initially and assumed that I represented the State Department of Education. I had to build trust with the team and demonstrate that I was there to observe and learn how they wrote science curriculum. The lack of trust that the State Department of Education might take over the school district due to low-test scores was a burden in the back of the teachers' minds, yet the fourth grade level was not tested by the state in science. The pressure to follow the voluntary state curriculum was not as prevalent as it might have been if this team wrote the fifth grade units which include science content that is tested by the state. The assumption that the fourth grade units were also needed to prepare students who might remain in the same school district required the teachers to list the state assessment limits in each unit, and restricted the range of content that the teachers could cover in the curriculum artifacts.

Recommendations to Increase Team Effectiveness

The fourth grade elementary science curriculum development team struggled with tensions that emerged during curriculum development. The team met for five months, but meeting attendance was low with only the elementary teachers attending each meeting. The low attendance, content role confusion, the lack of leadership during team writing meetings and the lack of team trust resulted in tensions in the team and the formation of an elementary teacher subgroup. The subgroup cohesion and subgroup efficacy were both high as the elementary teachers responded to and worked well together. Overall team cohesion and team trust were low. Thus, team effectiveness was low. Below I provide recommendations for how the team can increase team effectiveness by infusing technology, clarifying team roles, sharing multi-level norms and building team trust.

Infusing Technology

Since the team lacked a specific technology goal, a technology expert and a technology champion, the infusion of technology was minimal in the curriculum artifact. Most websites that were listed were meant for teachers to use for teacher science content information or lesson ideas. If teachers had adequate access to hardware and Internet access, teachers could use the video links listed in the units with their students. A major obstacle for relying on external website links is the lack of content control especially for Wikipedia websites, but also reliable organizations such as government agencies which modify website links rendering the link that the team listed as useless to find the intended information.

Although the school district might not want to take the extra step to work through the copyright process, the teachers and students would benefit if the school district partnered with and gained access to reliable organizations that can maintain and update external Internet resources for teachers that coordinate with the curriculum content. Even without any external partnership, the first step that the school district should take to infuse technology into the elementary science curriculum is to take stock of the resources available in each school district classroom. The inventory listing should include hardware, software, Internet access, and levels of technology use by school personnel (teachers, Information System technicians, school administrators, etc.). This information should be provided to all curriculum development teams in order to assist each team with meeting the goal to infuse technology into the school district's elementary science curriculum.

Clarifying Team Roles

The team suffered from the lack of ongoing direction and feedback from the team leader. If Claudia had provided timely feedback, she could have led the team at a distance and provided science content and curriculum development assistance. Without her direction during writing meetings or another team member to assume a team behavior monitor role and to redistribute roles within the team, the elementary teacher subgroup removed the middle school teachers from writer roles and did not suggest that the middle school teachers assume another role. The middle school teachers attempted to assume the science content roles in writing meetings, but the elementary teacher subgroup associated the middle school teachers' perceived lack of fourth grade curriculum development with their technical science terminology as one in the same issue when the expert roles are actually two different types of knowledge. The confusion with conflating the two expert roles meant that the middle school teachers were left with no roles to assume. At the end of the March writing meeting, Cindy redefine a role for Nelly "to meet us the next time and give us feedback," but she did not specify what type of feedback Nelly could provide. Moreover, the subgroup decided not to send any materials to Nelly after that meeting, which suggests that they did not fully acknowledge a role for Nelly.

To alleviate role confusion within this team, I recommend that the team determine roles for each member and adjust the roles as needed without the exclusion of roles for any given member. The different content expert roles can either be assigned during the initial meeting or adjusted and reassigned during the writing meetings by the team leader. The content expert role can also accompany a content editor role. In this case, the middle school teachers might have increased team effectiveness as content editors who edited the elementary teachers' work for science content accuracy.

For the curriculum development role, the elementary teachers assumed the role but questioned the sequencing of the activities during each writing meeting. They shared how and in what order each teacher had previously taught the concepts. The middle school teachers did not contribute comments during these discussions. In the final April meeting, Cindy asked Claudia if the units were sequenced properly and if the order was "logical," but Claudia had already decided to change the curriculum development process. She added a "phase two" to the project. She downsized each grade level team to two teachers per grade level and required all interested teachers to reapply for the positions. From the fourth grade level team, Stacey, Cindy, Lilly, Mindy and a new teacher Linda all wanted to apply for the two positions. Claudia increased work intensity for phase two by scheduling two writing meetings per week during the remainder of the school year and two full weeks in the summer. Perhaps if the team roles in phase one were better explained or redefined during writing meetings, the team would have had higher team performance with less role confusion or the need for phase two.

Sharing Multi-level Norms

The team did not specifically include time in writing meetings to share norms at varying levels of the school district. The conversations occurred informally and spontaneously during writing meetings as the teachers worked through the template and began to make team decisions of what to include or not include on the template. The elementary subgroup also did not purposely hold classroom, grade level, or school norm discussions to exclude the middle school teachers from the discussions, but the middle school teachers did not feel that they had anything to say or contribute during those conversations. The elementary teachers bonded and strengthened the subgroup through these discussions while inadvertently alienating the middle school teachers. Also, the middle school teachers attended different meetings and did not have each other to talk to or share norms at those levels during any of the writing meetings.

Accounting for classroom level norms of how teachers teach within their own classroom is important to understand while writing curriculum, but attention to the other school district levels and how different norms are set and at times enforced differently across the school district levels is equally as important. Team leaders need to listen for and attend to what level teachers share norms. Discussions can arise naturally during the meeting or can be planned for particular issues such as the open flame safety issue that might develop during a meeting. Facilitating such discussions and eliciting comments from team members who remain silent may assist in building team cohesion and lessen subgroup formation.

Building Team Trust

Since the elementary teachers strengthened their subgroup and trusted each other, the team accomplished the goal of creating fourth grade science curriculum artifacts. Without direction from the team leader to facilitate and clarify team roles, the team was not able to increase team trust. In order to build team trust, the team needed a team member to work to unite the team, to enforce a mandatory attendance norm and to actively engage team members during and between writing meetings. The team needed all team members to participate in writing meetings in order to utilize all team members' strengths.

In terms of strengthening trust issues between the team and the State Department of Education, the teachers did not interact with any State officials while writing the units. The teachers' perceptions of the negative relationship between the State Department of Education and the school district may have influenced how closely they adhered to the state assessment limits, but my evidence only demonstrated that teachers found areas to move away from the assessment limit list. Since the fourth grade level was not a testable grade level, the state testing discussions were minimal in this team. I recommend that from the school district level down to the classroom level, the school district should make their expectations regarding how closely state assessment limits should be followed consistent and clear.

Case Conclusion Summary

As the team leader, Claudia assigned team members to the fourth grade curriculum development writing team. Then, during the initial meeting, she met with the team briefly and set the team goals. She provided dates, times, the meeting location, the template, and directions to "use the existing curriculum first" and to "infuse technology wherever possible." She also told the team to write technology and non-technology activity options. Finally, she set the intended task roles for the group: The teachers wrote the curriculum, and she was supposed to edit their work.

The team was set to write curriculum. However, the team departed from her initial direction by seeking team autonomy to change the meeting location from the school district headquarters to the elementary schools in which the fourth grade team teachers taught.

Gaining team autonomy to determine writing meeting locations enabled the team to focus and work diligently; however, trade-offs from meeting at other locations included lower meeting attendance, team role confusion, unstructured multi-level norm discussions, and trust barriers within the team. Since Claudia did not attend the writing meetings, Stacey assumed a subgroup leadership role during meetings by taking the lead as the central communicator and monitor within the team. She typed the collaborative write-up for each unit, emailed Claudia at the end of each meeting, and coordinated the meeting places and times. However, Stacey deferred editing and team member activity monitoring to Claudia. Also, Stacey, Lilly, and Cindy all motivated the team in motivator roles during writing meetings. This shared socioemotional role strengthened the elementary subgroup cohesion, but divided the team between the elementary teacher subgroup and the middle school teachers when a middle school teacher attended a meeting.

The elementary science team created fourth grade science curriculum that was minimally infused with technology. Even though tensions emerged within the team, the elementary teacher subgroup persevered throughout the writing meetings to complete unit drafts. Subgroup cohesion and subgroup trust were high and effective in completing the task; however, across the team the overall team cohesion and team trust were low.

Chapter 5: Chemistry Team

The chemistry team contained a collaborative group with a partnership between a university and a local school district and set a goal to infuse a specific technology innovation into high school chemistry curriculum. Tensions emerged within development meetings regarding modifications to the technology and accompanying curricular artifacts, and tensions resolved through open group discussions. One particular tension regarding the selection of the third and final unit topic spanned two months before the group reached a decision. Ultimately, the lengthy decision making process increased team cohesion, but cost the team two months of productivity time and required the group to increase work intensity and to hire a Flash animation programmer as the deadline for unit completion could not be altered. First, I present the episodic cycles as a thick description in a case narrative, and then I analyze the team with the Team Effectiveness Framework and provide recommendations of how the team could have increased team effectiveness.

Case Narrative

The chemistry team leadership formed first and then recruited the other members. For this case, I participated early in the process with the group leadership. Because of this, I observed and participated in the process from before the team formed to the creation of the curriculum artifacts. I first met Paul, an education researcher, while taking two graduate courses with him during the Spring 2007 semester. I expressed my interests in understanding how curriculum development groups worked and how groups infused technology into curriculum. He supported my efforts to pursue this line of research, and I began to work as a graduate assistant supervised by him during the Fall 2007 semester. Paul had several different research projects at the time, and I worked on the Connected Chemistry Curriculum project. I admired Paul's straightforward and high integrity professional approach to working with graduate students, teachers, and other colleagues. During the Fall 2007 semester, I also met Jon, who taught chemistry in a local school district and piloted Connected Chemistry Curriculum units in his high school classes. During the Spring 2008 semester our project team applied for a collaborative state grant with a local school district. I was honored to be a part of the writing process and assisted in obtaining funding for the project. At this same time, Jon applied to our university graduate program and left his local school district to become a fulltime graduate student and graduate assistant on our project. On his own, Jon maintained a personal web page and attempted to integrate more technology into his own classroom wherever possible. The Connected Chemistry Curriculum project provided Jon the opportunity for him to assimilate his personal and professional technology interests.

To fund the teacher professional development and curriculum development project, the team leadership collaborated and wrote a state grant. Per the state grant requirements, the leadership contained an education researcher, Paul, a chemist, Dr. Ridley, and a local school district representative, Steve, who was the school district science supervisor. The team leadership drafted a grant proposal to improve teachers' computer skills in the local school district since the school districts' teachers had limited technology use in the classroom. In their proposal, the leadership team noted that most teachers' technology use was limited to email.

> In the 2006-07 academic year, the district estimated that only 60%-70% of its teachers had attained 'intermediate skill' in computer use and technology integration despite the state's target goal of 100%. Despite the prevalence of new educational technologies that provide exciting curriculum activities, most teachers' technology use appears limited to e-mail programs. The initial inquiry from the LEA [Local Education Agency or local school district] initiated a 12-month exchange of ideas between university faculty and LEA teachers and administrators. Through this exchange, the group generated a plan for a program that would provide high quality professional development in alignment with the objectives of the State Plan for Technology in Education and the professional development goals of the LEA.[3]

During the Fall 2008 semester, the grant funded the team to create high school chemistry units as well as a teacher professional development summer institute. The chemistry team began work to develop the Connected Chemistry Curriculum (Stieff, 2005) to enable high school chemistry students to explore chemical interactions via computer simulations related to laboratory activities or teacher demonstrations. The chemistry team leadership assembled group members with varied expertise from two organizations, a public university and a local school district.[4] (See Table 6) The university representatives included Dr. Ridley, Paul, and two graduate assistants, Jon and I, supervised by Paul. The school district representatives included three science

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[3] The identifiers of the university, school district, and state are not included in this passage in order to preserve anonymity.
[4] Each of the group members selected his or her pseudonym.

classroom teachers, Lady Beetle, G.W., and Sally, and two science supervisors, Steve and Grant. Steve recruited the three teachers and Grant for the project.

Table 6: *Chemistry Team Members*

Organization Role	*Pseudonym*	*Leadership Roles*
Education Researcher	Paul	Group Leader, University Leader
Chemistry Researcher	Dr. Ridley	Group Leader, University Leader
Science Supervisor	Steve	Group Leader, School District Leader
Science Supervisor	Grant	School District Leader
Graduate Assistant	Meg	
Graduate Assistant	Jon	
Teacher	Lady Beetle	
Teacher	Sally	School Science Department Chair
Teacher	G.W.	School Science Department Chair

Through the grant writing process, the group leaders collaboratively established the directive group goals to create technology-infused chemistry curriculum and to plan a summer institute for teacher professional development. Of note, Steve and Dr. Ridley did not plan to attend all group meetings due to other commitments. Therefore, Paul became the principal investigator for the project and assumed numerous roles. Paul was a group leader (group monitor and conflict manager), education researcher, technology developer, chemistry content expert, curriculum writer and curriculum editor. He attended each group meeting, monitored the group's progress, and worked between meetings to rewrite code for the simulations and to edit the curriculum artifacts. Paul also assumed boundary spanning roles with the university and the external government agency, which oversaw the grant. He primarily negotiated the budget for the group and allocated the time and resources available from the university for the team.

The team committed to a dedicated time span of six months to complete the work prior to the planned summer institute to train additional school district chemistry teachers. (See Table 7.) The primary meeting location was the university; however, in order to accommodate the science supervisors, one meeting was held at the school district's science office. Meetings began promptly and usually ended on time with two meetings running late due to lengthy discussions on setting the next meeting date. Each teacher was absent from one meeting, but never the same meeting, which meant that at least two teachers were always present. During the writing and editing meetings, all three group leaders, Paul, Dr. Ridley, and Steve, did not attend the same meeting. Dr. Ridley attended two meetings at the university while Steve and Grant only attended the meeting at the school district's science office. Therefore, Paul assumed the bulk of the leadership role (i.e., facilitator, group monitor, and conflict manager) rather than the previously planned shared leadership model, which was required by the grant.

Table 7: *Chemistry Team Meetings*

Date	*Meetings*	*Time*	*Attendance*
12/5/2008	Initial meeting at the university	2 hours	Paul, Meg, Jon, G.W., Lady Beetle, Sally
1/10/2009	Editing & writing meeting at the university	3 hours	Paul, Meg, Jon, G.W., Lady Beetle, Sally
2/14/2009	Editing & writing meeting at the university	3 hours	Paul, Meg, Jon, Dr. Ridley, G.W., Lady Beetle, other graduate students
3/14/2009	Editing & writing meeting at the school district science office	3 hours	Paul, Meg, Jon, Steve, Grant, G.W. Lady Beetle, Sally
4/18/2009	Editing & writing meeting at the university	3 hours	Paul, Meg, Jon, Lady Beetle, Sally
5/16/2009	Editing & writing meeting at the university	3 hours	Paul, Meg, Jon, Dr. Ridley, G.W., Sally

To prepare for team meetings, Paul, Jon, and I met in Paul's office weekly to discuss the project and prepare for team meetings. Jon began by writing and editing the student manual, but later assumed a graphic artist role and created templates for both the teacher and student manuals and a technology apprentice developer role as he learned how to code within the software platform. Jon assisted Paul with editing submicroscopic representations used in the simulations and in the curriculum artifacts. I assumed a group coordinator role by reserving meeting space at the university, confirming dates and times with group members, and communicating any changes in dates or locations with group members. I also assumed writer and editor roles in which I was primarily responsible for compiling the information in the teacher manual during and between group meetings. Our internal university meetings enabled us to prepare materials for each team monthly meeting. Paul set the agenda for each team meeting based on our discussions and also based on email correspondences from other group members or external representatives from the grant agency, university, or school district.

Lady Beetle and G.W. also held independent meetings in a coffee shop before at least three of the monthly team meetings to discuss the simulations and units alone. Even though they taught in the same school, they met in the coffee shop to minimize interruptions from students and fellow colleagues. Sally did not meet with them, but she often spoke to and emailed Lady Beetle between meetings.

December Meeting: Introducing Connected Chemistry Curriculum

During the initial December team meeting held in a university conference room that had a large table, chairs, and a large whiteboard, Paul indirectly shared the directive group goals by showing the simulations and previously developed curriculum artifacts with the three high school science teachers. I distributed two copies of the study consent form (one copy for me and the second copy for each team member to keep), and all of the chemistry team members signed the form. This group of attendees would eventually become the development subgroup consisting of Paul, G.W., Lady Beetle, Sally[5], Jon, and me. Paul utilized a directive goal setting strategy (Wegge & Haslam, 2005) in order to "show," "tell," and "sell" the innovation to the teachers within the initial meeting, and the group began to establish a common understanding of what they intended to develop. Paul used his laptop and projector to "show" each piece of the simulation to the teachers while he "told" them about how it was designed.

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[5] Sally also brought her toddler son with her to the meeting because her babysitter was not able to watch him.

Paul: Right the files are on everyone's desktop, and I think maybe the best process for us will be to collectively go through just the first lesson together and sort of talk about what the kids will be doing, what the teacher will be doing, and this will give a chance for everyone to sort of get a feel for what the guided inquiry framework is that frames the entire curriculum as well as the use of the simulation in the activity.

Later in the same meeting, he described the simulation interface to the group as he continued to “sell” the teachers on the idea of creating more simulations with accompanying curricula:

Paul: So they're [students are] asked in a simulation like this to make observations about what's going on in the molecular window here, and this simulation doesn't have any graphs or plots on it, but a lot of the later ones do. The activities also direct them to make observations about what is on the plot, which is a macroscopic representation of what's going on.

While Paul presented the overall concepts of the simulations and curriculum, he reinforced throughout the initial meeting that modifications were welcomed and needed in order to adapt the simulations and artifacts to the local school district. For example, the meeting turned from the “selling” phase into how and why the first unit and simulation might change.

Paul: Here, so the way that the code works, and we can choose to change this too, but it's part of a discussion that we’re going to have to come back to again and again. How faithful do we make the simulations to reality? When do we cheat? Right? To make them [molecules] look like we want them to look but they are not really behaving the way that molecules really behave.

Being a programmer and chemistry content expert, Paul clarified the capabilities of the simulation software and the tradeoffs of modifications between the simulation program and the chemistry content represented.

More detailed writer and editor roles assumed by the teachers emerged during meeting interactions. For example, G.W. first introduced the team to the school district's partnership with the Institute for Learning (IFL) early in the December meeting. He explained to the group that the school district planned to infuse the nine IFL principles across all subject areas.

Sally: I was just going to say that's a big thing in the [school district] right now with IFL.

G.W.: Uh-huh.

Lady Beetle: Right.

Sally: It's accountable talk.

Meg: What is accountable talk?

G.W.: Well with IFL what do you think? Accountable talk is one of the nine principles of learning that the [school district] is adopting with the Institute for learning and they're basically nine theoretical statements of I guess what I would call what goes on in a good classroom in a class where learning is occurring, and so what I was mentioning at our last meeting was that we can kind of pair a lot of this up with those nine POL's along with what we've been talking in our groups about disciplinary literacy which is how you take the nine POLs and apply them to a science classroom so just for example very quickly in our last department meaning in [my local] high school we talked about inquiry-based learning and methods to take a lesson from more teacher-centered tones to a more student-centered-

Paul: Right.

G.W.: And so, do you know, we can definitely apply that here I noticed that just jumping back to something that you mention earlier, I can't remember if it was the teacher or the student version, but it said you know definitely have the students understand that there is no correct answer.

Paul: In the student version

The team members welcomed G.W.'s IFL input and recognized that from the school district down to the classroom level the IFL principles needed to be infused into curricula materials. G.W. further explained that he was also a member of the school district science delegation and traveled to Pittsburgh for IFL training.

G.W.: I started with them [IFL team] last year. We have content area teams that travel or started last year traveling to Pittsburgh in bringing information back, and then, we also have consultants from IFL that may come to two of our sessions in a year. In the last TC [science department chair] meeting the consultant from IFL was there talking about aspects of POL [Principle of Learning] and disciplinary literacy.

Indeed, the group acknowledged his IFL expertise later in the meeting when Lady Beetle turned to G.W. and asked. “How, G.W, does this work into claim-evidence-reasoning? How does it, because that's something that we're going to be teaching them [students]?” G.W. reworded questions to align with the IFL principles such as asking students to consider the claim that heating a substance always produces new substances and to provide evidence from observations and drawings to either support or reject the claim.

Sally also assumed a particular writer and editor role beginning in this first meeting. Among other courses, Sally taught general biology classes at her high school and evening biology classes as part of an alternative education program at a nearby high school. She made her first suggested modification to list additional materials for diverse learners in the teacher manual.

Sally: And while you're looking that up Paul, let me just say that in the teacher edition, I think that we can also mention this. Teachers should have available varying markers maybe different colors and color pencils, because when the students are doing observations if you have that available it helps.

G.W.: Yeah.

Jon: That helped in my class.

Lady Beetle: But at the same time, the question becomes do you really want them to think that all oxygen is currently as I said before do we really want them to think that all oxygen really looks red?

Jon: I think that's where the discussion comes up with the teacher like to talk about models.

Sally assumed the differentiation writer role and advocated for diverse learners during this initial meeting. While other team members did not openly acknowledge her expertise in this area as they did with G.W.'s IFL expertise, the team members did make changes to the materials based on her suggestions. During this discussion, Jon also shared his teaching experience and what norms he set in his previous high school chemistry classroom. Since Jon had just left the classroom and taught in another school district within the same state, he discussed and compared norms between his classroom, school, and school district with the group.

Lady Beetle assumed a critic editor role and requested that the group made changes to the student and teacher materials. She usually began by stating, "I have a problem with that" or "that may be an issue." The team members worked through her suggestions during open group discussions. For example, Lady Beetle raised an issue about the size of the sodium representation in the simulation.

Lady Beetle: Okay that may be an issue as well, because I'm looking at this. First of all, most kids don't know that a salt is the result of a neutralization reaction. That's not something that gets covered any time before second semester. So if you're saying sodium, and you want them to know that that’s okay, my kids would notice that the sodium that’s there is bigger than the circle is bigger and lighter [in color] than the one for the salt, and so they would be very confused because not there- the key- in the key- the atomic key.

Rather than challenge, resist, or ignore Lady Beetle’s concerns, the team members discussed and resolved issues she raised. The size and color of submicroscopic sodium was altered in both the simulation and artifacts accordingly.

Acknowledgement and discussion of concerns are important to note for this team, because what could have turned into a group conflict was instead resolved to determine what, if anything, needed to be edited in the materials.

Paul: Yeah. This is- this is a typo that the color is wrong in the legend. This metal should be the same color as this solid.

Jon: It needs to be fixed.

G.W.: Uh-huh.

Paul: See this is why we need people looking at this stuff, because we don't even notice it.

Lady Beetle: I have picky kids.

Sally: No, but that’s something that one kid out of the bunch would actually say.

G.W.: Right.

Sally: Well is that the same color?

Lady Beetle: And it would mess up the entire room that's working-

Paul: *[Speaking at the same time is Lady Beetle]*

And the whole class would go crazy. That's exactly right and since we're putting such an emphasis on making careful observations of these submicroscopic levels somebody's going to point that out.

Lady Beetle shared how she thought her students would respond to scientific content from an everyday student perspective. Her comments sparked team discussions on how to resolve the issues through modifying wording in the artifacts such as clarifying that the term salt referenced table salt.

Lady Beetle: I don't think it should be potassium chloride. I think it should be sodium chloride, because they [students] have never heard of it unless they and I would say this because I use this example all the time when I talk about salts and how the word salt is not a good word to use for sodium chloride, because most of them aren't familiar with Morton's light unless their parent has high blood pressure, because that’s the only way they know about what Morton's light is-

Lady Beetle described her own high blood pressure among other ailments and shared that she was aware how some students would understand the differences between the types of salts, but she thought that most of the students would only think that salt referred to sodium chloride.

At the conclusion of this first meeting, Paul provided all team members with access to a local server where all of the simulations and documents could be accessed at any time. Team members would be able to upload and download simulations and documents as needed. Unfortunately, the teachers would come to find it difficult to log onto the server at times, and consequently, Paul, Jon, and I used the server with little use by any of the other team members. The server enabled us to share very large documents, such as the student and teacher manuals that contained numerous graphics. Each teacher was also given a loaner laptop with the simulations in order to provide them with the resources (computer with adequate processer and software) to evaluate and critique the simulations during and between meetings. The team was set to begin to work together.

January Meeting: Team Norms Set and Development Subgroup Strengthens

The team promptly began the second development meeting at the university in a conference room. Paul, Jon, and I arrived early to set up the projector and to make hardcopies of the unit draft for everyone, and Sally, Lady Beetle, and G.W. arrived on time. Paul again used his laptop and projector to show new simulations while the group discussed modifications. The group reviewed a few details from the previous month's meetings, discussed the upcoming summer institute, and began to edit the next unit.

Because Jon had previously taught in a different school district within the same state, he connected to the teachers with norm sharing from the school district to the classroom levels by comparing his experiences with the teachers' experiences. For example, he prompted a discussion on school time schedules.

Jon: Is [this school district] the same like [my former school district in the same state] just every school has a different like period system? Like-

Lady Beetle: Yes.

Jon: Like some schools have block periods, some schools don't, some schools do it mixed, some schools-

Lady Beetle: Most-

G.W.: For the most part we're on A, B-

Lady Beetle: Yeah.

G.W.: But there are some select schools that are on a-

Lady Beetle: That meet 45 minutes a day or something weird like that *[talking over G.W.]*

G.W.: They're on a hybrid.

School class schedules in the school district varied from school to school. The brief discussion confirmed that the team needed to write the curriculum to account for flexible time periods in which teachers planned to use the different aspects of each lesson.

Group members continued to settle into and define their group roles with explicit discussion among the members. For example, at this meeting G.W.'s ILF expertise role and Lady Beetle's critic editor role is clarified to the team by Lady Beetle and Paul. Lady Beetle stated to the group, "They're using you for IFL (speaking to G.W.), and they are using me for overly critical details." In fact, prior to Lady Beetle's statement, Paul defined G.W.'s IFL expertise task to the group. G.W.

reluctantly assumed the task at first, but he was further convinced by Lady Beetle's encouragement.

Lady Beetle: But it goes back to compare and contrast for me compare and contrast means state the prior-state A state B and then give me words that explain how they compare-

Paul: Right.

Lady Beetle: That's not how everybody interprets compare and contrast and so I have to teach my students that um it's the same thing just because-just because it's something that's instituted by [school district] and instituted by the science department and every TC should have this information, it doesn't necessarily mean that that teacher and all their billions of things that they have gotten in the beginning of the year have been enforcing it

G.W.: Right.

Paul: So I think we can do what Sally suggests though of putting-taking these right they're part of the IFL they're part of what the [school] district is sort of advocating for the teachers to do. They have got some training. We put it in our teacher materials as well-

G.W.: Uh-huh.

Paul: And then, we say very clearly that we are-we are also following this process in Connected Chemistry Curriculum. The same way that you have been- You will see evidence throughout all of the lessons of students being asked to engage in the following claim evidence reasoning practices you know so we put this straight into our materials as well. You know while acknowledging where it comes from. The other thing that I was going to suggest is could you sort of as we move through these lessons and we find these sorts of things that you feel could be reworded to bring them into better alignment redraft it and sort of offer it up to us and say okay here's how I think we could work this particular type of question that will make it align with what we want to be doing in the [school] district.

Lady Beetle: Our IFL expert (looking at G.W.)

Paul: Does that make sense?

G.W.: Well I thought you meant the team.

Lady Beetle: No, I think he really meant you.

G.W.: Oh.

Lady Beetle: I'm sorry.

Paul: No, I meant you.

Lady Beetle: Told you. He totally looked at you when he said it.

G.W.: I tried-I tried.

Paul: I'm making work for you.

Lady Beetle: Well, look G.W., you're the one who noticed that.

Paul: You are the one that noticed that.

Lady Beetle: We would be moving right along-on the lesson three. You were-you were the only one who had the itemized list.

G.W.: Yeah, it could be that.

Paul: Right. So you're already thinking about these things so-

G.W.: Yeah.

Paul: So if you could keep an eye out for them-

G.W.: Sure, sure.

Paul: Then, offer some alternative wording that would bring it into alignment I think that-that could sort of make sure that we're consistent throughout the entire…

Sally: document.

G.W. attempted to have the IFL expertise role shared among all of the group members, but as Paul and Lady Beetle pointed out, he was the group member who noticed areas that the group could modify the curriculum to include the IFL principles. Sally remained silent during most of the discussion until Paul did not finish his thought, and she filled in the word "document" for him. The group support and encouragement of each other into more defined roles in this way increased the team cohesion. G.W. further settled into his role and continued to make itemized lists of how to alter the curriculum to align with the IFL principles. For example, he offered specific semantic changes:

G.W.: It could be as simple as using the characteristics of a quality scientific explanation. Explain whether you think A heating a substance always produces new substances as claim A or choose claim B heating a substance does not always produce new substances. Follow the-and then that's where the teacher would have had to already set up this support. Follow your guidelines in creating a quality scientific explanation so it doesn't have to all be there, but the teacher would have to have some type of support-

Sally and Lady Beetle focused the team on school district and classroom level norms. All chemistry teachers in the school district were supplied with the same textbook, and the textbook shaped the current high school chemistry curriculum. Both Lady Beetle and Sally were members of the school district's high school chemistry curriculum development team. Lady Beetle and Sally both noted areas where the textbook differed in the way terms were used from the Connected Chemistry Curriculum and sought changes in order to avoid confusing the teachers and students.

Sally: All right I wrote some things down here on page 4. I'm just running this through and tell me how it comes back if- okay say the substance is pure as long as it's a single element or compound. Then, it says if the substance is a mixture it contains two or more elements and that could be-

Lady Beetle: That's inconsistent with our textbook. In our textbook, it makes substances only elements and compounds-

Jon: Oh-

Lady Beetle: And it uses an entire different word. It doesn't use the word substance for anything except for pure substances-

Jon: Oh really?

Sally & Lady Beetle: Yes.

Sally: and so --

Jon: That's a Waterman's textbook?

Sally: No, this is the um-

Lady Beetle: Yes, it's Waterman's.

Sally: Yes, Waterman yes.

Even though both Lady Beetle and Sally acknowledged differences between the textbook and Connected Chemistry Curriculum materials, Sally suggested to the group and then takes the lead in correlating the textbook and lab manuals with the Connected Chemistry Curriculum for the teacher manual. Paul acknowledged that the Connected Chemistry Curriculum materials are meant to be flexible for teachers with different resources such as "access to wet lab materials," and Lady Beetle commented that her class size could impact the selection of a wet lab regardless of the types and amounts of materials that she had in her class.

Paul: Yeah, so I mean the idea here is to include this in each of the units too, so if because we want this to be as flexible as possible for teachers with different resources that if they don't have access to do a wet lab or a demo.

Sally: Right.

Paul: There are hands-on activities that will have the same learning objectives. We or I guess I should say- I do not think that that is as high quality as actually doing the wet lab is.

Lady Beetle: Right.

Paul: But some teachers just won't have access to doing a lab.

Sally: Right if they don't have the materials.

Paul: Correct.

Lady Beetle: Actually the biggest issue for me is never not having the materials. It's the size of my class.

Paul: Right

Lady Beetle: Because if you have a class of 37 getting them to do a wet lab would be in the back of the room is-

Sally: Can I um interject here?

Paul: Yup.

Sally: Should we correlate chapters in the textbook along with each you know say okay this lesson would be along with chapter?

Lady Beetle: I think we could do that but I don't think that it should be part of this document I think like it should be a cheat sheet that gets put in

Sally: Well, why not? If you're putting in our [State] core goals and things of that nature, why not, because we have adopted a book for five years we are going to use?

Paul: Right. I'm thinking in terms of-

Lady Beetle: Using this nationally

Paul: Yeah or kind of throughout the state that

Sally: Yeah yeah yeah yeah yeah

Lady Beetle: Right.

Paul: But I like Lady Beetle's idea that we can have sort of an addendum to this

Sally: Okay.

Paul: That says for the Waterman textbook.

Lady Beetle: textbook

Sally: textbook [*All three in unison*]

Paul: Here's the chapters that each of these units-

Lady Beetle: Fall into

Paul: Yeah.

Sally: And that helps with the teacher-

Paul: Yeah.

Sally: You know you're saying having a quick look at

Paul: Yeah that's a great idea.

At the end of the exchange between Paul, Lady Beetle and Sally, the three are talking in unison and finishing each other's thoughts as they brainstorm how to implement Sally's idea of correlating the chapters and labs to the Connected Chemistry Curriculum. G.W., Jon and I were not participating in the discussion but we nodded in support of the idea. Sally's new task to correlate the local resources began with this discussion. Sally also continued to offer suggestions to include modifications for diverse learners as she did in the January meeting. She more explicitly stated to the group, "You have to think too that we adapt our curriculum for level 1, 2, and 3 meaning those who are in groups or special education classrooms."

Sally regularly advocated for diverse learners and wanted all of her students to benefit from using the simulations, but she also pointed out that more wet labs would assist her students to understand the chemistry concepts at the macroscopic level or chemistry apparent in everyday life.

Sally: But see what-I mean, I can understand what you're saying Paul is because you do want to have a wet lab you know you have to have a demo lab there. Because I'm thinking across for my students with IEP's, they sometimes need to see, and then be able to say oh this is what it looks like here. It's like a video game for them. This is what it looks like in reality and this is what it looks like when I'm on a videogame to see the parts.

Lady Beetle’s self-described “critical details” that she shared during the meeting focused on particular issues from the school district level to the classroom level. She allowed herself to be vulnerable and ask content questions to the group. She also sought clarification on what concepts students would be able to understand. Her openness enabled the group to discuss content issues, and sometimes the group found errors in the simulations, as below.

Lady Beetle: Here's the part that I had-that I had confusion on-as a chemistry teacher, there's multiple ways for it [baking soda] to break up, but looking at this I would be confused as a child, because if you look at the baking soda, it changes and when it changes, the carbon and the sodium are exactly the same size in the same color inside the molecule.

Sally: Yeah.

Paul: Yeah, we know.

Lady Beetle: It's breaking up into sodium and carbonate in the solid.

G.W.: Right.

Lady Beetle: It went from sodium bicarbonate to sodium carbonate, which is another issue because there should be two sodiums for every carbonate ion, but maybe I just don't see it. Nonetheless. Then, the other issue is that the carbons and the oxygens are free floating around are actually bigger than the ones inside-

Paul: Yeah, you and I talked about this already.

Lady Beetle: Yeah that's what I was saying-as a child I would make the connection-I would think that I did something wrong. I thought that I actually accidentally added water that's how I figured out that the show water didn’t make a difference, because I thought that I added water and somehow jacked something up that it wasn't actually a physical or chemical change.

Paul: Yeah-yet this is a-there is an error here that needs to be repaired- atoms-this is one of those things that if we don't think about carefully and make sure that it's correct, we end up teaching misconceptions, because the big kids will think that when the reaction occurs atoms change size.

Lady Beetle: Is there another reaction that we can use? Because I feel like this one involves polyatomic ions, and they [students] haven't been exposed to that.

Jon: So we picked baking soda because of the commonness of the like material but having another-we could pick one but then- we were talking about we did potassium chloride last time.

Lady Beetle: That's still a polyatomic ion.

Paul: Right.

Lady Beetle: The kids aren't used to a polyatomic ions- they've never seen something attached like that-that's-do you see what I'm saying?

Sally: But you know what at the same time you're using a substance that you'd have it. The teacher could have it.

Paul: So that's why we picked it.

Another notable discussion involved Lady Beetle sharing the cultural norms of her students that surfaced in her classes as she attempted to use a real-world chemistry example. She explained to the team that a reference of how to make Kool-Aid might not be the best example to include in the Connected Chemistry Curriculum.

Lady Beetle: The only thing I have to mention is on the *What Do You Think*- the Kool-Aid conversation on page 2. Every year when I use the Kool-Aid example, I have to go through- the kids are all confused. I have to explain that when Kool-Aid is really made not when their little sister or brother makes it and then they're

> okay, because for them there is always sugar at the bottom so I don't know.

Her comment sparked a lengthy discussion on varying cultural norms brought by the students to her classroom, which led her to alter her classroom norms in presenting the example to her students. She shared that when she taught in another Mid-Atlantic state, she did not need to clarify that she referenced the directions on the package and not how much extra sugar someone added to the mixture.

The team concluded the meeting and set the date for the next month. The group identified edits for the simulation and student and teachers manuals, which Paul, Jon, and I worked between the meetings. The teachers were given the next unit to review before the February meeting. The workflow became established, and the team began to episodically cycle through each unit until the unit was finalized by all team members, including the peripheral members who did not attend each writing meeting.

February Meeting: Decision Suspended with Tension

The team promptly began the second development meeting at the university in a classroom. Paul, Jon, and I arrived early to set up the tables in the classroom. We arranged the large, black science lab tables into a large square in the middle of the room. Dr. Ridley and several other graduate students arrived on time. The other graduate students were interested in observing the meeting but were not group members and did not attend any additional meetings. Sally did not attend this meeting due to other teaching commitments. Lady Beetle and G.W. arrived on time. Paul used the classroom projector and screen with his laptop to show the simulations while the group discussed modifications. The group divided their time into discussing the summer institute format and content and reviewing more Connected Chemistry Curriculum lessons.

Although the subgroup effectively worked most of the time in resolving issues during curriculum development meetings, one particular issue divided the group and the ensuing conflict was suspended over two months in order for peripheral group members to weigh in on the issue. At issue was the group's inability to decide on a third topic for the final Connected Chemistry Curriculum unit. The initial discussions began in the February meeting when group members Paul and Lady Beetle expressed differing opinions on which unit the group should develop next.

Lady Beetle: And I definitely would go with acids and bases, or thermodynamics. I would not go with equilibrium.

Paul: Okay.

Lady Beetle: I think equilibrium needs to be taught, but in the context of whether it's actually going to be taught and how much –

Jon: How long is it taught in honors?

Paul: Well, so what do we –

Lady Beetle: A half a class.

Jon: A half a class for –

Lady Beetle: Ten minutes, products over reactants. This is the K expression, just so that we can understand acids and bases expressions. That's what I'm trying to tell you. It's not serious or –

Jon: But it's not an honors/regular divide. This is how –

Lady Beetle: Actually, what I do for acids and bases is me showing that K expression is more than I think that the regular chem does.

Paul: That's it. This is a paper, right? Misconceptions around equilibrium is one of the most robust and persistent misconceptions that kids have so – and a lot of the literature points to certain cognitive and representational reasons as to why they have that. I mean this is a pedagogical reason.

Lady Beetle: They're not being taught.

Paul: They're not given any instruction in it-

Lady Beetle: And what makes it really sad is the child who takes regular chemistry truly is not prepared for AP or college chemistry and a child who takes honors is marginally prepared for AP, or honors, or college level chemistry, and you put in the years gaps. If we want to use something that we know is – there was a test on it that's actually backed up and it could definitely be acids and bases and thermodynamics because there's a lot of labs on those topics that are in the book that are actually in the curriculum and the teachers would be most likely to use it-

Paul: So there are two things there to reframe this. One is – which are the ones that we're going to do in the institute, right? What are the lessons we'll deliver because we can't do them all.

Lady Beetle: Right.

Lady Beetle advocated for development of the acids and bases unit or the thermodynamics unit. She justified her selection based on the school district level curriculum documents and reflected on how other school district teachers might refuse to teach an equilibrium unit. Paul justified the selection of equilibrium by providing information based in science education research literature on challenges facing students learning chemistry. However, Paul and the other group members failed to recognize when Lady Beetle also shared that she thought, "Equilibrium needs to be taught." She shifted from the norms at the school district level to her own classroom. While providing her classroom level norm, she agreed with Paul, but when Lady Beetle assumed a school district perspective, they opposed each other. The complexity of Lady Beetle's perspective represented an interaction between her role as a classroom teacher and her role as a school district curriculum developer; her attempts to share the multi-level norms, school district and classroom, went unnoticed by the other group members who solely focused on the school district level norm that she shared. The group members failed to identify her varied perspectives, which led to a lengthy decision making process and loss of team productivity time.

Without a decision, the meeting continued with the group's focus shifting to summer institute issues until eventually the group turned back to the unit selection discussion.

Paul: Okay, yeah, I'm buying it actually. It worked out really well, so what am I hearing? I'm hearing that matter and reactions are very good candidates for the summer institute as definite. I'm also hearing that thermo, KMT, equilibrium, acids and bases, are all possible candidates for a third topic but no definite–

Lady Beetle: Like I said, my vote's for acids and bases and thermodynamics until we can get Steve [school district science supervisor] to support infusing equilibrium into the curriculum, because I don't see the point in teaching something that a teacher's going to say, "Well, there's no room in my curriculum to even do that. Why are you doing that?"

Paul: We can have this conversation with Steve. He's part of this team, so –

Lady Beetle: But even if he were a part of the team, the curriculum is already written, and we're on a three-year cycle supposedly, so it would have to be rewritten and redesigned, and that probably won't happen before the summer so that becomes the – the other issue is that even I love equilibrium and I want it to be there, is it going to be purposeful according to the curriculum that the teachers have to teach the kids because you have to be in –

Paul: We should have this conversation with Steve. We really should.

Lady Beetle: I agree.

Paul: And see what he has to say about it.

Dr. Ridley: Yeah, I was going to say-acids and bases, which are perfectly reasonable, and if he's here next time, then we can say, "Look, we're choosing acids and bases because these others get such short shrift that we really don't feel that this would be worthwhile, and so we would like to do this," and he says, "Oh, well, I didn't even think about this," but we can do this now and in subsequent years, if something happens, then do something else.

Paul: Yeah, I agree, so the good thing about this is matter and reactions are done. They need their final – reactions needs final edits from everybody, which is what – you see it on here. It's a list of where we are right now. The other thing would then be in our – as far as our work plan goes, when we make a final decision about what that third one will be for the summer institute. That's the next one we do, so that way we ensure that by the time June rolls around –

Lady Beetle again explained her selection of the next unit citing norms and constraints at the school district level. Paul postponed the final decision until Steve, the science supervisor, could attend a group meeting. Since Steve had not attended meetings, Lady Beetle shared in a side conversation that she did not see Steve as a curriculum writer at this point in the process, and she did not think that he would agree to such an overhaul to the current school district high school chemistry curriculum. Then, Dr. Ridley, the chemist and third member of the leadership subgroup, added information based on his content role within the team and sided with Lady Beetle to opt for the acids and bases unit. Despite these observations from Lady Beetle and Dr. Ridley, Paul did not support a final decision during this meeting.

Unlike the varying norm levels within in the school district that shaped discussions during the writing meetings, the norm levels within the university had little impact on the curriculum discussions. However, Dr. Ridley shared norms from his chemistry department and classroom with the team with comments such as:

Dr. Ridley: This [referring to mathematics being taken out of the high school chemistry curriculum] is what we see all of the time. I just wrote this section of the strategic plan about the undergraduate curriculum. One of the things that we said is that we see this all of the time in incoming students is that we and biology both now are going to require that you cannot even take Freshman Chemistry or Freshman Biology until you place into Calculus.

Dr. Ridley described to the team how his department conducted a study about how successfully students completed science courses when they were also taking certain mathematics courses. This information and how the norms at the university were shifting became valuable information for the high school teachers to take back to the school district.

Norms within the university shaped more discussions regarding the planning of the summer institute. For example, Dr. Ridley shared his classroom level norms in order to add to the discussion on summer institute projects. He commented:

Dr. Ridley: I mean I teach an online class, and that's exactly the way the thing works. Every student is required to present what we call a TIF project, and that is a lesson plan, a series of activities, and a PowerPoint presentation, and then it gets given to all of the other students in the group, all my other 12 students who then come back and critique it and vote it and grade it."

The university norms had little impact on the format or structure of the Connected Chemistry Curriculum, but did impact the summer institute and were discussed during team meetings.

The final discussion during this meeting focused on assessments. In particular, the research required student lesson assessments, but the school district typically only gave students unit assessments. Lady Beetle asked the group if the assessments should be lesson specific or targeted to the entire unit.

Lady Beetle: But if this is a supplemental curriculum, then I guess here comes the challenge for you guys. If it's a supplemental curriculum, and it's supposed to amplify the current teaching curriculum, then that means that they [students] are being exposed to those things early on because our textbook does, so do we completely remove that representation even though – or does the assessment only serve as an assessment to the activity and not an assessment to the knowledge that's been obtained since day one of the unit? I mean how – I don't know.

Paul: Great questions, so –

Lady Beetle: Because I can tell you, our tests, the honors chemistry test, I didn't put in the graphic into it because we have so many issues with graphics, and so that's just – there's data from a lab that we've done or supposedly done in every unit on every test that they have to graph and/or analyze.

Paul: Yeah, so no. With regard to whatever the teachers would be doing normally in the classroom, we don't touch that at all, so we don't want to make any changes to that other than removing anything that they choose to learn to do in one of our lessons instead. So instead of doing this activity, we'll do the computer activity instead. Your questions are great questions, and there are problems for us with regard to the experimental design and evaluation of the curriculum, so all of these are considered to be confounding variables that the kids are getting exposed to, things that are not part of the curriculum, so how do we parcel out the impact of the curriculum, and we have to worry about this as we go through, so the easy way for us to address that from a research perspective is to tie the assessments very specifically to the lessons, but not to try to use any summative assessment for an entire unit to make claims from, because that entire unit is going to include whatever they do that we make in addition to whatever they would've done in the classroom.

Lady Beetle voiced her concern that if the group used assessment items from the school district's unit assessment bank, the questions were then invalid for the unit assessments. Paul and I explained that we would not use the exact questions, but by reading through the types of school district unit assessment questions, the team can construct questions with similar semantics in order to not confuse teachers and students. The local adaptation to the lesson assessments enabled the team to present documents to the school district teachers and students that appeared similar to the types of assessment questions that both audiences were accustomed.

Lady Beetle: So then why do we need unit assessments?

Paul: I don't, but lesson assessments, so these should be tied directly to the lessons.

Lady Beetle: I thought somewhere in here we were talking about getting a copy of the unit assessments that we wrote last year.

Paul: Maybe one or two pull items that could go onto lessons, I think.

Meg: As examples of items that they would see typically anyway.

Paul: Yeah.

Lady Beetle: Okay, all right, though you have to be careful because if you put the exact same item on your assessment, then you invalidate our assessment – not that we're using it, but that would be invalidated.

Paul: That's exactly right.

Lady Beetle: I would be happy – if I had my other laptop I could give it to you on flash right now. It's in the car and I'm not walking back up the steps, but I can bring it next time.

Paul: Nope, you're exactly right.

Meg: You could place it on the server.

Lady Beetle: Well, see, here's the challenge. The challenge is that I have it on the software, the simulation software, the Exam Free Pro. I have it on that. Because I'm a curriculum writer, I have access to the Word docs. I hate the Word docs though, but I can get those for you.

Paul: I don't think that putting it on all the servers is a good idea seeing –

Lady Beetle: How do I put it on the server?

Paul: – that these assessments are confidential things that totally with the [school] district.

Lady Beetle: Okay.

Paul: But if you were to bring it with you next month, we could then take those, but you're right. We would not want to use the exact items, but Meg is correct in that they will give us an idea of how to include some items that would look familiar to the teachers on lesson assessments but would then be isomers.

The team concluded the meeting and set the date for the next month. Additional edits were needed to the simulation, student, and teachers manuals. Paul, Jon, and I worked on the edits between the meetings. The teachers were given the next unit to review before the March meeting, and the meeting location was changed to Steve's office at the school district's science building. The change in location was an attempt to gain more direct input from both science supervisors, Steve and Grant, and to make the final decision on the content of the third unit.

March Meeting: Science Supervisors Attend and Contribute

The team met in Steve's office in the school district's science building. His office contained his large office desk with computer and a small round conference table with chairs in front of the desk. Paul met with Steve in the office prior to the team meeting to discuss the unit selection conflict that arose in the February meeting. Steve felt that the school district chemistry curriculum could be altered to accommodate the equilibrium unit, which is a topic not covered in the existing school district's high school chemistry curriculum. Paul also asked if school level administrators would hold the new unit against teachers who participated in the summer institute as a teacher who was not following the "official" chemistry curriculum. Steve felt that it would not be a problem and that he could email the administrators, but there were no school level administrators represented in the team.

With the meeting held at the school district building, both Steve and Grant, school district science supervisors, attended the meeting, and all of the curriculum development subgroup members also attended. The decision making process to determine the third and final unit began as Paul described what was discussed during the February meeting including the division between himself and Lady Beetle. Lady Beetle cited similar reasons as to why the students needed the acids and bases unit in chemistry and prior to the next year of curriculum in the AP class. Sally immediately sided with Lady Beetle.

Paul:	Okay. So – and yeah, I know we're doing this out of order, but I need to – I need to personally walk away from this knowing what the last unit is going to be, because that really determines–
Lady Beetle:	I still say acids/bases, but –
Paul:	That determines our work plan for the next two months.
Lady Beetle:	But I understand if other people feel it should be –
Paul:	So at our last meeting, we were – right. So for folks who weren't at the last meeting, you and I [Steve] talked about this right before everybody got here. The – last month's meeting was very much about what the content of the summer institute would be, and what the day to day activities were going to be for the teachers, and not really curriculum modification. So we had come to an agreement that with everything that we're asking the teachers to do, that we cannot cover all of the units that we're developing, and instead just need to focus on three. And with the – which I – which I think is right, the right assumption from G.W. and Lady Beetle, that the three units we cover in the professional development workshop will be the three units that the teachers enact the next year, because they're

not going to pick up activities that we don't cover in the summer institute, even though they'll be available to them.

So we tossed around a lot of ideas, and we came to an agreement that two of those three would be the discovering matter unit and the reaction unit. Discovering matter we've already finished as a group. Reactions we'll finish today, or at least get all the edits done, so that we can write the final draft and send it off to Dr. Ridley. The third one, though, we talked about doing acids and bases. We talked about doing chemical equilibrium, and we talked about doing KMT, I think.

You're [Lady Beetle] a fan of acids and bases. I'm a fan of chemical equilibrium. But we need to figure out collectively what it is that we want to do.

Lady Beetle: My biggest issue is that without rewriting the curriculum, chemical equilibrium would be lost.

Paul: In the current LEA curriculum?

Lady Beetle: In the current LEA curriculum –

[Crosstalk]

Lady Beetle: – chemical equilibrium is all of five minutes, if that.

Sally: Yeah. It is. And we have to go back and rewrite that entire piece.

Lady Beetle: Both honors and regular.

Sally: Right. And I think with acids and bases, we touched base – we went through this before in the revision last year with the honors particularly because we wanted the kids who were going into AP to be prepared, because we want to introduce them, you know, the previous year, so that that way they're not lost.

Paul: Right.

As the discussion continued, Lady Beetle again revealed that her preference for how she operated in her own classroom was to include an equilibrium unit rather than an acids and bases unit. She advocated for the equilibrium unit. Grant began to speak, but then backed off. Interestingly, Steve never shared his opinion, which was most in question prior to this meeting, to the group, and he remained silent on the issue. Steve's lack of participation was strange given that he sided with Paul in their private meeting.

Grant: So are you thinking more acid/bases minimum, or if not –

Lady Beetle: I like the – I like the idea of equilibrium. Teaching the kids equilibrium first year would make –

Sally: It's the majority.

Lady Beetle: – my life easier as an AP chem teacher. But again, unless we're going to add that and pull something away from the document, which I'm all in favor of, if I'm being paid for it.

The discussion turned to assessment, and the group left the unit selection discussion until later in the meeting when Sally, who was still uncertain about the group's final decision and who assumed a socioemotional role to monitor the decision making process, sought clarification.

Sally: I'm making notes for when I come back. I just want to make sure, we did decide on the third unit as being equilibrium?

Paul: I think that happened.

Sally: Both – consensus? Okay.

Paul: Okay.

[Laughter]

Lady Beetle: I think I was the only one holding down the acids and bases block, because –

Paul: We'll do acids and bases next year.

Lady Beetle: Well, I'm okay – no. But I mean, I was only holding down because there really wasn't an equilibrium unit. So once we solved that problem, there was no issue.

The issue is resolved; the open group discussions lasted two months and the team planned to develop the equilibrium unit next.

With the conflict resolved, the team members turned their attention to edit the reactions unit for the remainder of the meeting. The way in which they worked through issues with the simulations demonstrated the high level of team cohesion. Grant, who had not attended a meeting before seamlessly contributed to the discussions and in fact helped the group decide to alter the appearance of the atoms in the simulations. The group brainstormed how to show charges on the submicroscopic level.

Paul: So on the submicroscopic level, you don't see charges.

Jon: You don't see anything.

Paul: Right? You don't see anything. So if I have Na versus Na+, how do we distinguish those two things for the kids in the submicroscopic level?

Jon: One option we thought of was changing the color, like Na starts as green, and then Na+ would turn yellow. Something like that. Right? But then we didn't know if that was going to be like a –

G.W.: The color is all – up to this point, the color has always indicated a different type of –

All in unison Atom

The team discussed additional edits such as changing the shape, size, or adding charges, but each option had problems with student misconceptions of the submicroscopic level. Then, Grant contributed and suggested that they enclose a circle around the polyatomic ions. Jon called it a halo and the group agreed that this option worked best.

Grant: How about if you enclose your polyatomic ions in some sort of circle or a bracket or something.

Lady Beetle: Ooh, that's a great idea. Like a – like a white circle.

Grant: Put a charge –

Jon: Like a halo?

Lady Beetle: Yeah.

Grant: Attach the charge, like your phosphates, for example.

Ultimately, the team created a new submicroscopic representation and provided Paul with the details he needed to complete the simulations. Each group member was pleased with the outcome as Paul began drafting illustrations on the whiteboard in the room.

Paul: A positive would look, the shading would be opposite so this would sort of imply an empty shell, where this implies we have something additional on it.

Sally: Oh cool.

Paul: This is cool. This is easy to draw. Okay. Can you-

Lady Beetle: Yeah Grant! [*cheering*]

Sally: That's good, because look, that outer shell is –

Paul: This is a great idea. And okay, so this, so with this in hand, this means I can now, I can whip out these simulations tonight, now that I know exactly what they're supposed to look like. That's why they don't exist.

Sally and Lady Beetle also contributed to edits that targeted modifications for specific student populations again. Sally advocated for general chemistry students and diverse learners and Lady Beetle advocated for more rigors for her AP (Advanced Placement) students. In addition to their recommended edits, the team used the textbook to guide Connected Chemistry Curriculum modifications. Within the solubility lesson discussion below, the team discussed if the solvation and precipitation lesson should be included in the unit.

Paul: They're going to do a lab with the precipitation plates already, so why are we just recreating this on some microscopic level, I don't get it. And then Jon said, well what about the spectator ions? Seeing what the, seeing what the spectator ions actually do in reaction, and then that actually made me think very carefully, wait a minute they are getting something from looking at the reactions that they wouldn't otherwise get.

Sally: That's the main point in that particular chapter 11. Isn't it?

Lady Beetle: It's not really your main point though.

Sally: But I'm saying, and when you're talking about solubility is that there are spectators, because the kids can't, they don't, they think everything is involved in the precipitation.

Lady Beetle: I guess here, here comes, here's the point where I wonder what's really important. Is it, at this point in the game, is it really important to teach them what the different types of reactions are and the underlying theme that the Law of Conservation of Mass exists, and that we balance the equations accordingly, or is it important to teach that and the fact that some reactions just don't occur? From an AP perspective, if my kids have a full mastery of the types of reactions, reaction predicting, and formula writing, then when they get to AP, I can very easily teach them the solubility rules. But the truth is, that never happens. They usually come in with a very weak understanding of writing and the types of chemical reactions. Then, I rush in and I spend an extra time on precipitants, spectator ions and activity series when really that's not important to first year Chem. If it were up to me, I would choose not to teach this at all, because I have found that it complicates an issue to which they're not already sharp with. And the book that we use doesn't have many examples. It's very, very few examples. In fact, I have to make photocopies of other books because our book is so weak in showing exactly what a spectator ion is and isn't.

Paul: So, so what I'm wondering though is do the kids get something then along those lines out of this that – so it's not really that they're learning the precipitation rules here, but they are hitting on those things that you feel that they're struggling with?

Lady Beetle: My kids, let me say this, I have taught them that if something is AQ, it splits up, and if it's anything else, it stays together. And that if the stuff that's AQ is the same on both sides, it crosses out and it disappears. They get that.

Paul: That's, that's all symbolic.

Lady Beetle: But, right, but the question becomes the solubility rules themselves. They really don't need to know that sulfates typically are insoluble. They really don't need to know that nitrates are typically soluble. That level of memorization in a chapter in a unit that we put right next to the mole for the same test is a, is a lot. It's a lot, and they don't even use it in this school year. So I guess I just feel –

Sally: So your thing with Paul is that really you don't need this, because it's not that much in detail? That's what I'm hearing.

Sally once again moderated the conversation and clarified Lady Beetle's position. Eventually, Paul offered a suggested change with flexibility for teachers. The team left the solubility table at the end of the unit for teachers to decide to include the table or not.

Paul: So one thing we might, I think you're right that it is that, what this is doing is showing spectator ions, and what you're saying is right, but the lesson's about the solubility rules, and that's not really important in the curriculum framework.

So what if we just strike the solubility table from this and make Lesson 4 really about spectator ions and writing chemical equations?

Lady Beetle: I'm happy with that, and then if another teacher wants to bring that up we could incorporate that.

Paul: Right, so we don't strike, but we leave it at the end that teachers could or could not include it here.

The flexibility that the team included here allowed chemistry teachers to decide if the class needed more detail with the solubility table rather than making the table a necessary section of the lesson. This type of flexibility is similar to the correlated lab list that Sally assembled for the team. Teachers had a variety of labs to select that would each correlate with the lessons in the Connected Chemistry Curriculum lessons. The chemistry teachers determined which lab to complete with their classes based on the topics, resources, and time allotment for each lesson.

At the end of the meeting, the teachers were given the next set of lessons to review for the April meeting. Lady Beetle volunteered to be the team teacher who implemented the curriculum in her classroom. Her lesson would be videotaped and used during the summer institute. The group also briefly discussed technology resources in the school district, and Paul explained that he had a class set of laptops with adequate processing that teachers could borrow for the lessons.

Paul: Yeah. What's their technology resources? Because any teachers who work at schools that have really old machines, we've got to worry about. And what we would do in those cases, we would bring laptops for those – for those teachers.

Since the university was able to fill the void of adequate hardware pre-loaded with the software to the summer institute teachers, the team members did not need to worry about the lack of school district technology resources for implementation of Connected Chemistry Curriculum.

Since the team finally made the third unit content decision, the team had to increase work productivity. With limited time to prepare materials for the Summer Institute and with Paul and Jon already tasked with too many other team roles, the team hired another graduate student who was a Flash programmer. However, the increase in team membership did not alter group interactions during meetings. The newly hired Flash programmer was added as another peripheral team member. He submitted his work to Paul who shared it with the core writing team. Alterations were completed between meetings and resubmitted to Paul. Although the episodic cycle altered the workflow slightly for the team by adding animation review to the meeting schedules, it allowed the team members to focus on other team tasks and continue to operate at an increased pace to meet the summer deadline.

April Meeting: Sally versus Lady Beetle

The team returned to the university and met in a conference room with a projector and laptop. The curriculum development subgroup assembled except for G.W. who had another commitment. Jon, Lady Beetle, and I began the meeting with Paul on time. Sally was ten minutes late because she needed to stop by a youth summit on technology to "make sure the kids got there, and they're going to be fine."

Most of the three hour meeting was spent discussing edits to the equilibrium unit. As in previous meetings, the team worked well together most of the time. However, Sally and Lady Beetle argued during this meeting with each other over various issues that stemmed from advocating for different student populations again. Sally wanted the directions clarified for students and at first Lady Beetle misinterpreted Sally's complaint. Initially, Paul lost track of the argument within the discussion, but later, he mediated the argument, and the group made the correction that Sally sought.

Lady Beetle: Okay, so the one you had complained with was reaction three, correct?

Sally: Right, because at that time –

Lady Beetle: Okay, can we go to reaction three?

Lady Beetle: See, they still can see that at the beginning –

Sally: But that's before you get – that's not at 500. At 500 –

Lady Beetle: You're not – okay, here's the –

Paul: Wait, woah, woah, woah.

Lady Beetle: Here's the concern.

Paul: I don't even understand what the two of you are arguing about?

[Laughter]

Lady Beetle: Here's what we're arguing about. She's afraid that if we word it such that we're saying to sketch it at 500, the child will only focus on the point of 500.

Paul: We solve that by saying bucket.

Lady Beetle: Right, but the graph from 0 to 500 when you run it to –

Paul: But I thought you had a different concern.

Sally: I did.

Lady Beetle: Oh.

Sally: My thing was that's when you are giving instructions like at this point here, we're going back to say look to graph just what you see. When I was running it if I'm the kid and I'm not running it and I run it, I'm gonna stop it. You know how some kids do. The lines actually on this screen looks like it's running on the Y axis.

Paul: Yeah, yeah, yeah, I got it.

Sally: So I said to fix it is to put it at 100 because you can actually see it slope better. Don't go back to page 2.

Paul: So you guys have talked about in the instructions going back to your original graphs, and then re-sketching them from 0 to 100?

Meg: 0 to 500.

Sally: Right, and I'm saying –

Lady Beetle: They were supposed to rerun the simulation.

Paul: They have to rerun the simulation or else Sally's complaint is true. So if they just go back to this, this reaction is so fast from 1 to 100, it almost looks like there's nothing at the beginning because the graph is scaling as the time goes on.

Lady Beetle: Right.

Paul: So if they were to use their original drawings to redraw the 1 to 100, they wouldn't know what they were doing. So they have to redo this again.

Sally: Right.

Lady Beetle: Okay, so that solves the problem.

Paul: That solves the problem.

Sally and Lady Beetle discussed additional differences during this meeting. They shared different classroom and school norms regarding lab materials that are kept in stock, mathematic abilities of students, and directions in the student manual. As shown in the above conversation, Sally advocated for more clarification in directions. Sally also wanted more opportunities for her students to draw answers, which was consistent with her previous contributions in earlier meetings.

Sally: You think words? I think my kids would do drawings, because when we do Chapter 4 and we do atoms and modeling, everything we had to write a description or write your observation, they're all drawing when it comes to atoms.

On the other hand, Lady Beetle advocated for more rigorous activities for her honors and AP students. She felt that graph review would only be necessary for her “less math adept kids.” Lady Beetle noted that teachers who do not set a classroom norm and regularly have students graph in chemistry class would also have a difficult time understanding the graphs in the equilibrium simulations. Again what began as a departure from each other ended in agreement between Lady Beetle and Sally.

Lady Beetle: Because – well, no, because if they haven't discussed it already, what I can see is I can see some of my kids who are in calculus or in pre-cal, they'll be able to look at that and go, wow, that's a really big – that's really steep. There's a big slope change there, so it's happening faster.

But my less math adept kids are not going to be able to do that on their own without some sort of discussion of slope and what that means.

Sally: So maybe they –

Lady Beetle: Change over time, or –

Sally: Well, what I'm saying is that not necessarily within this lesson, but prior to initiating the lesson –

Lady Beetle: Yeah.

Sally: – the teacher needs to have a review of graphs.

Lady Beetle: If –

Sally: You know what I mean?

Lady Beetle: And it depends on the teacher, because if you have already – if you're a heavily graph-based person, you're not going to need as much of the review as someone who doesn't do graphs very often. But I agree.

Next, Sally and Lady Beetle separated team tasks. Sally had assumed textbook correlation in a previous meeting and now expanded her role to include correlating labs or significantly revising the lab protocol in order to highlight particular chemistry content for each Connected Chemistry Curriculum lesson. Sally approached the selection of labs differently than Lady Beetle. She decided which labs to complete and which equations to use as examples based on her chemical stock that apparently was not stocked with as many chemicals as Lady Beetle had in her school.

Lady Beetle: You can actually see if you add more reactives that it goes towards one side, and if you add more products it goes to the other side. I know from personal experience, the cobalt chloride one does. The cobalt tetrachloride one, it goes from clear to fuchsia. You can actually see it go.

Sally: You have those chemicals in stock?

Lady Beetle: Mm-hmm.

Sally: Because I mean what we usually do is make my equations based on what we have in stock.

Even though Sally assumed the task to correlate the labs, she wanted Lady Beetle and G.W. to look through her work. Lady Beetle quickly dismissed G.W.'s input based on the fact that he was not teaching chemistry. Sally expressed her opinion about the quality of the labs from the different resources that all school district teachers were given. Lady Beetle did not agree with Sally's opinions, but she also did not demand changes. Lady Beetle primarily made sure that teachers retained flexibility in lab selection for each lesson.

Paul: This reminds me too, so in the next month we need to know all of the labs that are going to be coming in all of the units.

Sally: This is like a backfill because when I went back through all of the labs, there are some that I think we need to make some changes. I wanted to bump it off of these two guys, Lady Beetle and G.W. about which ones did they actually do?

Lady Beetle: G.W. wouldn't know.

Sally: Okay well yeah-

Lady Beetle: We never do. Okay, I'm sorry. Which?

Sally: For each of the units, I wrote them all out-

Lady Beetle: Oh Okay.

Sally: But I pulled from three different sources that we're constantly using because I think that there's some that are going to–

there's a teacher book that are not – I don't like the lab book. I usually don't pull labs from this book.

Lady Beetle: I do, but here's the challenge that you're gonna have. Are we deciding for teachers what they should do?

Paul: No, we are not deciding for teachers what they should do.

Lady Beetle: Because here's our problem: the curriculum guide is written such that it gives suggestions as to which ones a teacher should do.

Paul: That is what we want to do.

Lady Beetle: So why don't we just use the ones from the book?

Sally: Because they suck, they do.

Lady Beetle: I use them, and I typically don't have –

Sally: But the Honors is better, but I'm saying from our work, they suck. Some of them. The ones in the beginning –

Lady Beetle: Oh, I know what you're saying. You're saying that that way that that lab, the way that the curriculum is written, they didn't select.

Sally: So I'd rather do another list to go with this.

Paul: Yeah, so that's exactly what we want. It's just having a list. Say to the teachers, you need to do a lab.

Lady Beetle: I very rarely do small scale. So I wouldn't know small scale. I can tell you lab manual though.

Paul: Do you have an electronic version of that that we can circulate?

Sally: Yeah, I am. Actually, I just bought a new netbook because my mother board went bad. So I did that last night. So I'm going to rewrite it up and send it.

While Sally was tasked with lab and chapter correlations, Lady Beetle assumed another role within the team during this meeting. As the group discussed the equilibrium lessons, Lady Beetle shared different everyday analogies that she used with her students. For example, to explain equilibrium Lady Beetle described an analogy, "Well, I see this as like *West Side Story*, like a fight scene, where like as one person goes this way, the other one counters, and goes – takes a step back." She shared her norms within her classroom as what her students began to expect from her as she attempted to assist her students' understanding of complex chemistry concepts. Other analogies included baking a cake and observing busy Christmas shopping lines that do not seem to change even though people enter and exit the store. Paul asked Lady Beetle, "Can I make work for you?" She agreed to write up the analogies in order to put them into the teacher manual. Unfortunately, she did not list them out for us, but as I captured the analogies during this meeting and after I transcribed the meeting, I added the analogies to the teacher manual. Unlike G.W.'s and Sally's additional contributions outside of group meetings, Lady Beetle's contributions were limited to her discussions in group meetings and her classroom implementation of a Connected Chemistry Curriculum lesson.

The team cohesion and trust were both high for the curriculum development subgroup. On two occasions within this meeting, Lady Beetle felt comfortable to ask content questions. Paul assumed the expert role and clarified the issues for Lady

Beetle. In the first discussion, Lady Beetle presented the issue as if a student would ask a question that she was not certain how to respond.

Lady Beetle: Okay, I have a question that I know my smart kid who annoys me would ask. I love them, but they are gonna catch me on this one, because I can't answer it. If increasing the temperature increases the pressure, if everything else is held constant, correct? That statement is true?

Paul: Say it again?

Lady Beetle: Increasing temperature increases pressure when everything else is held constant?

Sally: Yes.

Paul: Yes.

Lady Beetle: Okay. If we add heat to this, it moves to the side with more moles?

Paul: Uh, yes. So this is an exothermic reaction, but these are not independent, right, because changing temperature changes the free energy of the system. So you actually change the rate constants.

Lady Beetle: Okay.

Paul: So that's why it shifts in this way. So you can't think of it as the temperature is directly impacting the pressure because the temperature is changing the entire rate equations.

Lady Beetle: Gotcha.

Later in the meeting, Lady Beetle directly asked a content question without the student premise. She allowed herself to be vulnerable to the group and welcomed the clarification from Paul.

Lady Beetle: Wait, I'm having a mental quagmire. When we add more into a four, it goes the other way, not because of a change in pressure.

Paul: That's a concentration change.

Lady Beetle: Right, but when you add an inert gas, according to KMT, the volume of the gas is insignificant to the volume of its container. So the inert gas or any gas for that matter shouldn't – well, not any gas, but anything that wasn't going to react – shouldn't affect pressure.

Paul: No, the pressure of the system will go up just by the fact that you're adding more moles. So even though the volume is small, you're increasing number of collisions of particulars with the walls of the containers, so the pressure goes up; but because the inert gas is not taking place in the reaction, the partial pressures of the reactants and products remain stable.

Lady Beetle: The same, right.

Paul: So they both go down relative to the inert gas, but they don't change relative to one another.

Lady Beetle: Okay, all right.

Paul: All right. Yeah, this is not simple.

G.W. was absent at the meeting, which the group noted by realizing areas where he would have contributed to the discussion. Paul expressed this best when he pointed out a portion of the lesson where he thought that G.W. would have noticed and asked for a modification.

Paul: That's all they do. Right? So if you go – yeah, exactly. If you go to page four-and too bad G.W.'s not here-because this is totally up his alley, right? Page 4 is what are the two pieces of evidence you'd use to conclude that reaction two is reversible or irreversible?

The team ended the meeting by reviewing the tasks for each group member to complete by the May meeting. The teachers were not given any additional lessons to review since the group completed the final equilibrium lessons during the meeting. The May meeting was designated as a meeting for "tying up loose ends" of the curriculum before the curriculum was printed for the summer institute teachers.

May Meeting: Wrapping up the Writing Phase

The team held the final writing meeting at the university in a conference room with a projector and laptop. The curriculum development subgroup assembled except for Lady Beetle who was home sick. Dr. Ridley joined the group, and Paul began the discussion by asking Dr. Ridley if he had reviewed the lessons.

Paul: So today we really need to tie up any loose ends we have over the curriculum materials. Dr. Ridley, have you had a chance to look at the documents that are online? Do you have any recommendations or changes? Then we should talk about that today.

Dr. Ridley: I didn't see anything, I didn't sit down and go through every little detail, but I don't see anything that looks to be particularly out of line.

Since Dr. Ridley did not have any particular issues to discuss with the team, Paul began with an issue that the group briefly discussed in the April meeting. Paul had emailed Dr. Ridley to clarify a content issue, but as of the meeting date, Dr. Ridley had not responded.

Paul: I guess one curricular thing that I'll bring up right now is the catalyst issue. So I e-mailed you about that, what to do. So in the equilibrium unit we have the NO_2 to N_2O_4 conversion to show them and also to help them understand the role of inert gases and catalysts in equilibrium reactions, those are in the simulation, but we don't have catalysts for that reaction and we've been –

Dr. Ridley: We don't know of one for that.

Paul: Right, I know, and so Jon searched the web, searched a couple different sites and couldn't find any. The problem is we need a catalyst to be in there to illustrate that the catalysts is just speeding up the reaction but not shifting equilibrium positions at all, and what we've done in the simulation is just put – it's just a random element that's in there represented as a white circle that we say is the catalyst. I don't know whether that's bad or not bad. All of the units have been designed so that they include actual substances in them and we've gone to great lengths to make sure that the animations look like they are the substances they're supposed to be, and now we have this random dot, and we're saying the random dot is the catalyst.

Eventually, Dr. Ridley suggested using air pollution or smog as an example of the particles in the atmosphere as catalysts.

Other than this content issue, the group revisited the reactions unit to add information into a lesson. The brief discussion enabled Dr. Ridley and Paul to discuss classification of reactions, which was a content item normally, found in high school level chemistry curricula materials but did not exist at in college level materials. Paul felt that since Sally and Lady Beetle advocated for the classification of reactions content, which aligned with the school district chemistry curriculum and textbook, the team would leave the content in the Connected Chemistry Curriculum materials.

Paul: Okay. So let's talk about this issue in the reaction unit and then work on the assessments. Okay, so on the agenda is says adding mass conversions and mole conversions into the reactions unit, so right now if you remember the reaction unit, the learning objectives there are basically for the students to understand how to classify different reactions based on the types of products that are created. So, they see the simulations of all different types of reactions, they group them together, things like combustion reactions and synthesis reactions, which is part of the standards for the school district although I had an interesting conversation with Beth in the chemistry department who said, "Why are you teaching this?"

[Laughter]

Dr. Ridley: Which is the same thing that we get at REACTS [an annual teacher professional development workshop]. They have all of these things that they apparently teach in the school district, that the school district does that nobody – once you get here [university] nobody ever does anything ever again.

Paul: Right. Beth said, she's like "What's a double displacement again? What is that? Why are you teaching them this?"

Jon: Well it's in the book!

Paul: Right, it's there, it's in it, it's designed, we'll go with it. But the big thing that we realized was – and I'll say-I don't think our curriculum really does much for the kids for this particular learning objective because I think they just memorize what they are, so we're hoping that seeing the reactions gives them more insights into things such as collision theory-Here's what's happening it's not just that you memorize that these symbols went here.

The different content norms at the high school and university was noted and provided a moment of laughter for the group. Paul also acknowledged that the modifications were already agreed upon and that the group would leave the content in the unit. The team made a modification to include stoichiometry to the reactions lesson and did not delete or further edit classification of the reactions.

The writing phase of the Connected Chemistry Curriculum concluded with the May meeting. The last sections of the Connected Chemistry Curriculum that were needed included the information from each of the curriculum development subgroup teachers. G.W. provided more IFL documents, and he worked with me to reworded portions of the teacher manual. Sally provided the list of textbook chapters and lab correlations. Lady Beetle had not listed out the analogies, but her contributions in the previous meeting were captured in my notes and added to the teacher manual. I acted as a backup team member for Lady Beetle's analogy contribution. Paul finalized the simulations, Jon finalized the student manual, and I finalized the teacher manual. The team then focused on reviewing a national standardized chemistry assessment that would be given to the high school chemistry students in the fall for the remainder of the May meeting. The team met the goal of creating high school chemistry units with embedded technology.

Team Effectiveness Framework Findings

The chemistry team's contextual and antecedent inputs shaped the team mediators and resulted in the team performance and goal attainment outcomes. As shown in Figure 4, I utilized the Team Effectiveness Framework constructs apparent within this case to examine how the team worked to create technology-infused high school chemistry curriculum. First, I present the findings. Then, I offer suggestions of how this team could have increased team effectiveness.

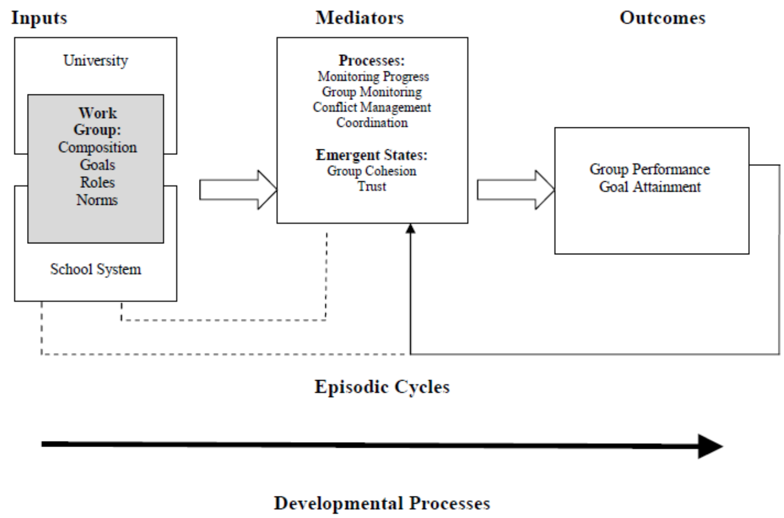

Figure 4: Adapted Chemistry Team's Team Effectiveness Framework with inputs examined and mediator constructs apparent during team interactions (J. Mathieu, et al., 2008)

Targeting Specific Technology Infusion

The team met the goal of technology infusion by creating a specific technology innovation for high school chemistry curriculum. They created simulations using software to show how atoms interact at the submicroscopic level. Students were able to control variables and within some of the simulations observe graph plots changing over time. The team targeted particular chemistry learning goals as they created the simulations and accompanying curriculum artifacts. They also mapped the Connected Chemistry Curriculum learning goals to the National Science Education Standards and the Mid-Atlantic State Core Learning Goals. The team created two documents, teacher and student manuals. For the student manual, the team created clear instructions for how the students utilized the simulations and designed student worksheets to maximize learning potential. In the teacher manual, they provided suggested lab activities that correlated with the simulations and provided guidance for teachers as teachers developed lessons using the simulations.

The team contained a technology programmer, Paul, and a graphic designer and technology apprentice developer, Jon. Despite having two team members with technological expertise, the group hired another Flash animation programmer in order to meet the deadline for the summer institute. The extra assistance was needed since the group increased work productivity and both Paul and Jon multitasked with other assumed task roles in the group. The group successfully created specific technology-infused high school chemistry curriculum.

Team Roles: Assigned and Emerged

As noted in the case narrative, team members assumed multiple task roles throughout the curriculum development time period. Paul, Dr. Ridley, Steve, Grant and I began and continued with the same task and boundary spanning roles. Jon began by writing and editing the student manual, but later assumed a graphic artist role creating templates for both the teacher and student manuals and a technology apprentice developer by learning how to code within the software platform.

The teachers also assumed multiple group roles; however, the roles emerged during curriculum development meetings, and each teacher assumed the roles differently within the group. G.W. was not teaching chemistry at the time, but he was involved at the school district level in professional development with the IFL (Institute for Learning), which was an additional partnership with an out-of-state university. He assumed an IFL expert role within the group and assisted in editing portions of the units to align with the questioning techniques used within the IFL framework. The group continuously sought his input in modifying questions throughout the units. Paul tasked him to work with me and write IFL sections within the teacher manual and with Jon to modify questions in the student manual.

Sally, who taught chemistry and was also a certified podiatrist, was concerned with modifications for diverse learners. She repeatedly brought issues to the group about how to edit portions of the lessons to accommodate diverse learners. In addition to the student accommodations, Sally wanted to ensure that the textbook chapters and labs correlated well with the simulations. She suggested the correlation, and Paul supported her assuming the role to align the laboratory activities from the textbook and other resources available to the school district chemistry teachers.

The final teacher in the team was Lady Beetle, who multi-tasked writer, editor, critic, and implementer group roles during the collaboration. Lady Beetle was the only team teacher at the time who taught Advanced Placement (AP) chemistry. Her comments focused on the rigor of the curriculum. She described the advanced math classes that her AP students took and stressed that these students would be able to work effectively with the graphs in the simulations. She also assumed a self-described critic role as an editor. When she jokingly stated to the group, “They're using you for IFL (speaking to G.W.), and they are using me for overly critical details,” Lady Beetle delineated two subgroups within the curriculum development subgroup. Here, “they” refers to the university group members (Paul, Jon, and me). Her comments questioned numerous aspects of the format, content, and sequence of activities throughout the writing process. She felt comfortable openly discussing the issues she brought to the subgroup. Another task role for Lady Beetle included documenting analogies that she used with her students to explain chemistry concepts. She shared her norms within her classroom as what her students began to expect from her as she attempted to assist her students' understanding of complex chemistry concepts. Several of her analogies were then inserted into the teacher manual. Her final significant role within the team was as the initial school district implementer of the curriculum. She volunteered to use the simulations and manuals with her students prior to any other school district teacher to encourage other teachers to join the project.

Although the remaining three group members had distinct roles within the team, Dr. Ridley, Steve, and Grant, only contributed to writing the units when they attended a writing meeting; therefore, the three remaining group members were peripheral members. Dr. Ridley attended two writing meetings and contributed his chemistry content expertise as a content editor. Likewise, Grant and Steve contributed during the March meeting and held the boundary spanning roles between the group and the school district, which became more necessary to organize the summer institute rather than the curriculum development process. However, during the March meeting at the school district, they both assisted in making decisions about the curriculum and simulations.

The group worked well together with clearly defined task roles for each team member. Paul facilitated roles as additional group task roles for Jon and each teacher emerged during meetings.

Group Members' Multi-level Norms Not Acknowledged

The team acted as a bridge spanning between two distinct organizations, the local school district and university. Unlike work place norm differences found in other teams in the literature on military, business, and government agencies (J. Mathieu, et al., 2008), this team faced additional challenges since each group member worked under multi-level norms within each organization (see Figure 5). Norm comparisons from the school district level down to the classroom level enabled team members to understand colleague's contributions and led to key local adaptations to the curriculum. All of the teachers taught within the same school district; however, Jon, who recently left the classroom and taught in another school district located in the same Mid-Atlantic state, engaged in norm comparisons with the three teachers from the school district to the classroom levels.

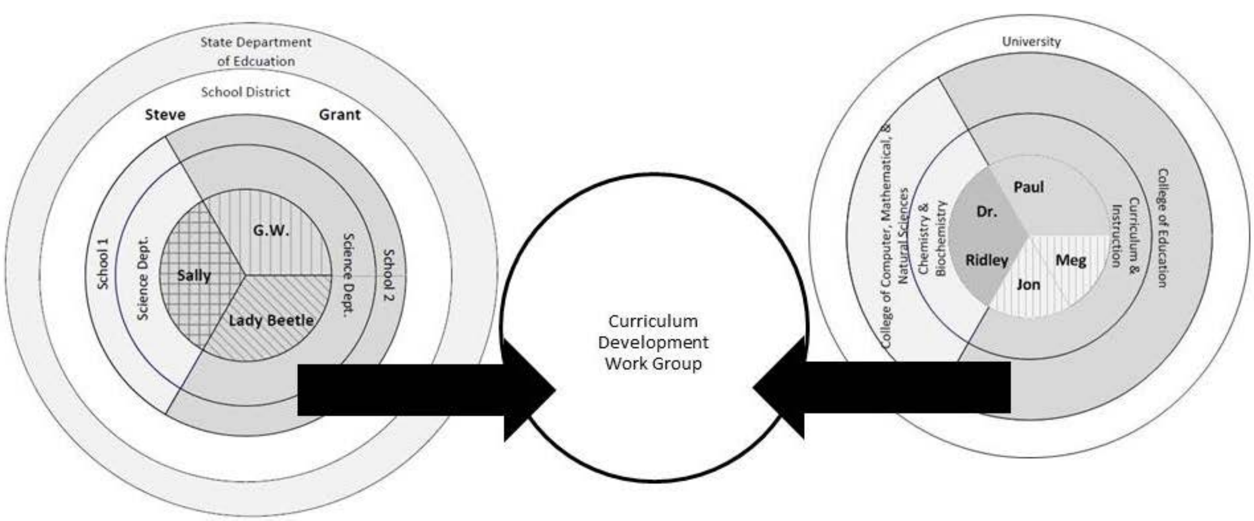

Figure 5: Chemistry Team Members' Multi-level Norms. This figure illustrates norm levels that each team member brought to the curriculum development team. Each teacher set his or her own classroom level norms while working under the norms set by the other levels (science department, school, school district and State Department

of Education). G.W. and Sally taught in the same school. For the university, Dr. Ridley taught in a different college on campus and also shared norm differences with the team.

Norm level discussions during curriculum development meetings included norm level comparisons within the school district. Teachers shared norms from school, science department, and classroom levels. Even though all three teachers taught in the same school district, they taught in two different schools with administrators who set varying norms. Since Lady Beetle and G.W. taught in the same school and G.W. was the science department chair, they shared how their school and science department operated which was oftentimes different from how Sally's school and science department operated. For instance, Lady Beetle described how their science department integrated the new IFL questioning techniques.

Lady Beetle: Our science department anyway made kind of a deal with each other that we are going to try to incorporate two of these in our discussions every week when we come back from break so that were going to use questions like well could you elaborate on that tell us more.

The level discussions enabled team members to understand each other's workplace norms at the school and department levels, which are not set by individual teachers. G.W. and Sally, as department chairs in their schools, did establish norms within their respective departments and shared how they each operated. The variation between schools and departments also provided opportunities for Jon to compare his past experiences and to share information with the teachers in the team. Rather than polarizing the conversation to a teacher subgroup, the norm level discussions provided Paul and me the opportunity to listen and to understand how the Connected Chemistry Curriculum might be perceived and enacted differently in schools. The discussions led to modifications and added flexibility for teachers in the Connected Chemistry Curriculum units.

As described by Reiser et. al. (2000), teachers were most comfortable talking about their own classrooms. Sally advocated for her diverse learners and Lady Beetle advocated for her advanced students. G.W. shared IFL adaptations and on occasion classroom management techniques for the teacher manual. The teachers did not make the only classroom norm comments; Jon shared comments about his former high school chemistry classroom. Such as during a discussion regarding mixtures in January, Jon said, “I always had a bottle [baby oil mixture] next to my desk. Every day somebody would always come and shake it. It never does mix.” Although he had left the classroom, he contributed to the norm sharing discussions with the teachers during the meetings and assisted to bridge the gap between the university and school district in the team. The norm sharing process emerged within meeting discussions and built team cohesion and team trust. Team members felt more comfortable with each other over time and openly discussed issues and asked questions.

Recommendations to Increase Team Effectiveness

The curriculum development subgroup consisted of three high school science teachers (Sally, Lady Beetle, and G.W.) and three university members (Paul, Jon, and Meg). Paul led all of the meetings by facilitating discussions, monitoring the group’s progress toward goals, and managing any conflicts. The subgroup members worked through each meeting by using an image of the simulation projected on a wall and hard copy drafts of the manuals to make necessary revisions. At times, revisions were deferred to tasks between meetings due to excessive time required to revise code in the simulation or to rewrite large portions of the manuals.

While the group was not perfect and had issues and tensions emerge during curriculum writing, the group demonstrated high-level cohesion and trust. Team members brought issues and concerns to the group, and the group openly discussed and resolved issues. Group cohesion, efficacy, and trust were high as curriculum development subgroup members freely expressed comments during meetings and assisted each other with tasks during and between meetings as needed. Subgroup members referred to their own organizations and shared levels of organization norms by using pronouns such as my, we, our, but eventually the subgroup began to use the same pronouns to refer to the team as the group moved toward an initial implementation. The peripheral group members (Dr. Ridley, Steve, and Grant) did not attend meetings regularly, but each assumed roles and assisted the subgroup when needed. In order to strengthen group cohesion, efficacy, and trust further, the group leader could have facilitated purposeful norm level discussions within the first few meetings in order to provide Paul, the group leader, with more insight into the strengths of each group member and to facilitate task roles earlier in the writing process. As shown in this case, Sally, Lady Beetle, and G.W. assumed task roles based on group interactions and each teacher's strengths. I am not suggesting that all task roles will emerge just by having more norm level discussions, because as the group continued to work on new units, additional tasks may emerge. However, the team leader could have benefitted from listening for level comparisons more specifically during initial meetings and throughout group interactions.

Managing Roles and Tensions and Making Decisions

The chemistry team managed conflict by openly discussing which unit to select for the third and final unit development, allowing input from all group members, and suspending the group decision over two monthly meetings with varying group members present. Sally acted as group monitor and asked for clarification. The group cohesion at this point was high, and the group was already moving onto another aspect of the curriculum when Sally decided to make sure that all group members, particularity Lady Beetle, agreed with the decision. Attendance during the chemistry team meetings was not consistent, and the group only met once a month to discuss the curriculum. While the effectiveness of the group to manage the conflict resulted in a compromise and greater group cohesion moving forward within the development process, the time it took the group to conclude the conflict resulted in a loss of two months of productivity time to develop a unit and required the group to increase work intensity and to hire a Flash animation programmer in order to meet the summer institute deadline. Perhaps either increasing face-to-face meeting attendance or utilizing another form of communication between meetings (i.e. emails, message board, or meeting minutes for absent members) particularly with Steve may have resulted in a more timely decision making process and a swifter resolution to the conflict.

Case Conclusion Summary

Over six months, the team subgroup created three units with a total of nine lessons that were adapted to the needs of the local school district. The peripheral group members assisted when needed with Dr. Ridley acting as a final content editor of both documents and with Steve and Grant working within the school district to accommodate technology needs for the teachers who will implement the new units. Group cohesion was high as the group openly discussed conflict and resolved issues during face-to-face meetings. Group trust was also high as members assumed task roles and allowed each other time between meetings to complete tasks without a group member taking over or redoing another group member's work. The supportive nature of task roles within and between roles enabled the group to work diligently toward group goals.

The chemistry team met the goal of creating an artifact that focused on a specific innovation, the submicroscopic simulations for high school chemistry students. The time frame of six months was tight for this group as they only met monthly for three hours at a time. The team acknowledged the tight time span and responded to concerns about students' visualization of chemical reactions in one unit by hiring a third graduate student who was a Flash animation programmer. The third graduate student did not participate in the team or attend the meetings, but his work enabled the group to focus on the units and other simulations in order to meet the deadline.

While work (writing and editing) continued between meetings, each meeting provided team members with a time to reflect back on previous edits and move forward on new artifacts. Although the subgroup had only two meetings in which they all attended and the entire team never had a meeting with all members present, each group member assumed roles to assist the group in achieving the goal of creating technology-infused high school chemistry curriculum.

Chapter 6: Biology Team

The biology team contained a collaborative partnership between a local school district and a research institute and conducted high school biology curriculum development without a goal to select a specific technology innovation. The team contained three science supervisors, one education researcher, and eight teachers; however, members entered and left the group while the group created high school biology curriculum. Technology infusion was included by adding a description of how to integrate technology into lessons before each unit and by providing a menu of options which consisted of activities with and without technology embedded within lessons. Team teachers created the menu in response to the varied access to technology within schools as well as school district teachers' levels of technology expertise.

Tensions within the team resulted in discussions regarding changes to the artifact template format, the target audience, and concept connections within units. The team had a large teacher subgroup that formed with the intent to relieve teachers from the burden of excessive writing. The biology teacher subgroup formation resulted in a strong resistance to group leadership and the education research consultant. A change in leadership occurred during the writing process and altered the direction of the curriculum. The subgroup cohesion and subgroup efficacy were both high as the teachers responded to and worked well together. Overall team cohesion was low due to the lack of trust in the education research consultant and the initial group leader. The overall group efficacy was also low due to the departure of two group leaders and the strong teacher subgroup. First, I present the episodic cycles as a thick description in a case narrative, and then I analyze the team with the Team Effectiveness Framework and provide recommendations of how the team could have increased team effectiveness

Case Narrative

My first meeting with Steve, the science supervisor, occurred while I worked with him in the chemistry team. I asked Steve if the school district had any additional science curriculum development groups that I could observe. He told me that a biology curriculum development group had just formed and when the next meeting date was scheduled. He also described the biology team goals that were set by the school district level administrators. The team goals included: 1) adhering to the state assessment limits for the high-stakes biology High School Assessment (HSA), 2) incorporating Institute for Learning (IFL) principles, which was a school district initiative, 3) utilizing the BSCS (Biological Science Curriculum Study) 5E instructional model, and 4) infusing technology. Biology was the only high school science content high-stakes test for this Mid-Atlantic state: thus, all high school students had to pass the biology HSA in order to graduate from a public high school. The school district began the IFL initiative and expected the entire school district curriculum to follow the IFL principles as previously discussed in chapter five. The school district administrators also insisted that the biology curriculum adhered to the BSCS 5E instructional model. The BSCS 5E instructional model was promoted by the State Department of Education since the mid-1990s. The model mandated that 5E’s (Engagement, Exploration, Explanation, Elaboration, and Evaluation) be employed to structure lessons and units. To help ensure that the 5E’s were included in the development work the school district contracted Colorado, a research consultant with particular expertise in how to write curriculum utilizing the 5E instructional model. The team did not focus on integrating a specific technology innovation; rather, the group attempted to infuse different types of technology into the curriculum within lessons written by team biology teachers.

The biology team assembled a large group in order to create high school biology curriculum. The group leadership consisted of three science supervisors, Steve, Grant, and Melissa. The education research consultant, Colorado, represented the research institute partner. The team began with six high school biology teachers; Tisha, Emma, Dorothy, Lee, D. O'Neil, and Rita. Later, Dana, who was a high-school special education teacher and co-taught biology classes, and Will, who was a first year teacher and a member of Teach For America (TFA), joined the group. (See Table 8).[6]

Table 8: *Biology Team Members*

Organization Role	*Pseudonym*	*Leadership Roles*
Science Supervisor	Steve	Group Leader, School District Leader
Science Supervisor	Grant	Group Leader, School District Leader
Science Supervisor	Melissa	School District Leader
Education Researcher	Colorado	School District Leader
Teacher	Dorothy Massey	School Science Department Chair
Teacher	Tisha	Group, project manager, School Biology Teacher Leader
Teacher	Emma Miller	Group format editor
Teacher	Lee	
Teacher	D. O'Neil	
Teacher	Rita	
Teacher	Dana	
Teacher	Will	

[6] Most group members selected his or her pseudonym.

Meeting regularity, attendance, location, and time limitations were important group norms due to the face-to-face format and the time span of seven months to complete the work prior to piloting the biology curriculum in classrooms. (See Table 9.) The primary meeting location was the school district's science center; however, the group met at a local middle school to write the remaining lessons in the summer. Although the group met regularly, meetings began much later than scheduled and often ended earlier than previously scheduled. The relaxed and flexible time enabled teachers to attend meetings when they were not already obligated to other responsibilities for their school, such as teaching night school, advising a club, or coaching a sport. Only two teachers, Dorothy and Lee, attended every team meeting. When meetings ended earlier or if a teacher was not able to attend a meeting, teachers completed and posted lessons to a shared Google Document folder online. Colorado attended four meetings and kept in touch with team members, particularly Steve and Grant, via email.

Table 9: *Biology Team Meetings*

Date	*Meetings*	*Time-span*	*Attendance*
12/8/2009	Planning meeting at the School District Science Center	3 hours	Steve, Grant, Colorado, Rita, Dorothy, Lee, Emma, D. O'Neil, Tisha
1/9/2010	Planning meeting at the School District Science Center	5 hours	Steve, Grant, Melissa, Rita, Dorothy, Lee, Emma, D. O'Neil
1/27/2010	Editing & writing meeting at the School District Science Center	3 hours	Grant, Melissa, Dorothy, Lee, Emma, D. O'Neil, Tisha,
2/27/2010	Editing & writing meeting at the School District Science Center	5 hours	Grant, Dorothy, Lee, Tisha, Rita
4/19/2010	Editing & writing meeting at the School District Science Center	5 hours	Grant, Colorado, Rita, Dorothy, Lee, Emma, D. O'Neil, Tisha, Dana
5/26/2010	Editing & writing meeting at the School District Science Center	3 hours	Grant, Tisha, Rita, Dorothy, Lee, Emma, D. O'Neil, Dana, Will
6/3/2010	Editing & writing meeting at the School District Science Center	7 hours	Grant, Colorado, Tisha, Rita, Dorothy, Lee, Emma, D. O'Neil, Will
6/24/2010	Editing & writing meeting at a local Middle School	7 hours	Grant, Colorado, Tisha, Rita, Dorothy, Lee, Emma, D. O'Neil, Dana, Will
6/25/2010-7/13/2010	Editing & writing time at a local Middle School	7 hours daily	Grant, Tisha, Rita, Dorothy, Lee, Emma, D. O'Neil, Dana, Will

December Meeting: The Planet X Plague

The December meeting was held in the library of the school district's science center building. The library contained a large conference table in the middle of the room and smaller tables on the sides of the room. A large screen hung in the front of the room, and a projector hung from the ceiling. The left sidewall had a large chalkboard, the back wall was lined with windows, and the right side wall contained bookshelves filled with books. Science supervisors, Steve and Grant, education research consultant, Colorado, and the team biology teachers (Rita, Dorothy, Lee, Emma, D. O'Neil, and Tisha) attended the meeting. Steve introduced me to the group as a graduate student from a local university, and I described my research interests. I asked if I could videotape meetings with consent. I provided two copies of the study consent form (one copy for me and the second copy for each team member to keep), and all of the biology team members signed the form.

Steve began the meeting by summarizing the work to date and the Planet X scenario. Tensions within the group regarding the implementation of the Planet X scenario emerged in this meeting. Group leaders (Steve, Grant, and Melissa) coordinated the group at the school district level. However, the group leadership disagreed on how to proceed with the concept of having a scenario-based curriculum. The Planet X scenario, which was introduced by Steve, involved learning biology concepts via sample data from a fictitious planet; the scenario originated from research and work with a previous National Science Foundation (NSF) grant between a biology researcher at a local university and the school district in 2006 to improve high school biology instruction. Steve began the meeting with a lengthy description of the Planet X scenario.

Steve: So, the first mega piece is that we talked about the possibility of not doing Planet X all year, that we might reduce that to a semester, and that we would come up with other things, projects, whatever, during the last two quarters. That being said, what we had talked about doing was introduce the scenario, which again is the Planet X, so we would have probes going out to this newly discovered planet and that it's a mega-type of spaceship. So, rather than sending out individual missions to bring the stuff back, there's this one ship that allows us to take the samples at different times and send that information back as opposed to sending up 12 rockets or whatever we were gonna do. We narrowed it down from eight to four sites. Melissa and I were working on that piece and basically what we were looking at was a northern site on the planet where we would have like a northern bog, a southern site that I can't truly remember what it was, whether it was deciduous forest or not. The eastern would be more of a coastal type of sandy environment and the western would be more like, again using the United States, a prairie type, savannah type of structure. And so with that in mind, we talked about starting out with the students looking at abiotic and biotic factors. D. O'Neil?

D. O'Neil: Wasn't there a central?

Dorothy: North, south, east, and west.

Steve: Right, we did four. We didn't do a central. When we were talking about central, I think I was talking more about the prairie. It was just more like the central part of the United States, like the Midwest, that's central but that's gonna be minute.

Steve continued to explain the scenario to the team and shared his ideas and the origin of the Planet X idea from his past teaching experiences. He attempted to unite the team and used the pronoun "we" often during his lengthy description of Planet X until he began to shift to his own inserted ideas and used the pronoun "I." He dominated the discussion and spoke for approximately 10 minutes without interruption. Rather than convince or "sell" the Planet X scenario to the teachers, Steve simply described what the curriculum format would be and asked for minimal guidance about how to proceed from the teachers.

Steve: And we're looking at rock and soil and so the students would do work on those samples, but then the samples would be sent to what I've called GETIT, which is Geologic Experimental Testing Investigative Team somewhere, like an FBI thing, and further spectral analysis would be done on the materials. Looking at characteristics of life using the segue from energy to photosynthesis and we talked about the idea of a profile. Now, the profile here comes from when I was teaching it in 1977. I was doing BSCS Green and one of the things that we did is we had students go out and collect samples and they had to do what was called a niche profile. What we were looking here was to take that idea of the profile and as they collect data, create a profile of the information so they'd be developing a profile of that site and that the final, and I'm gonna jump ahead, the final project for this quarter would be a full report

> on that site. And so there would be information written out in terms of words; there would be graphic information as well so there could be comparisons of the four sites for when they're selecting where they may want to start this habitation of Planet X. So that is that portion. Now going from the biotic piece where we're looking at these different samples and DNA sampling, we're jumping to photosynthesis. Now my understanding of the photosynthesis piece, and ya'll don't have to talk this much if you don't want too…my idea of the photosynthesis piece was that this would be an initial piece of what we were doing. It wouldn't be full-boar photosynthesis, because we're gonna use that as a connection when we're going into respiration and the body systems later on. The results would be coming back from GETIT so we'd have an idea of types of organisms, kingdom, phyla related of what the DNA was that we had extracted and then why are they there, taking what organisms are there and looking at what surrounded them to branch off into the idea of ecosystems. Now, we had talked about using succession as a bridge. I'm vague as to why we're doing that. Now somebody has to say something.

The teachers seized the opportunity to steer the curriculum by contributing to the discussion and inserting their roles as biology HSA content experts. Steve advocated that the Planet X scenario span the entire school year, but the teachers' resisted the scenario and used their knowledge of the biology HSA content as a bargaining tool to control unit flow and content. For example, after Steve's long introduction comments about Planet X, he asked, "Okay, how important is succession on the HSA?" Steve opened the biology HSA discussion to which Emma replied, "I barely cover it usually." The teachers who prepared students for and administered the assessment to students annually were regarded as the biology HSA experts on the team. The NCLB Federal Law required states to test students at the high school level in at least one science subject. The Mid-Atlantic state selected biology as the only science HSA. The team biology teachers inserted their expertise to insist on edits and changes to the curriculum.

In addition to resistance to Steve, the teachers were frustrated with Colorado's contributions. Her comments focused the teachers on linking content together for students' understanding of the relationships between concepts. Colorado attempted to focus the discussion on the students, but she acknowledged teachers' concerns about how teachers perceived the new curriculum format.

Emma: To me, I feel like we can just focus so much time on reading the story. I think we need to be writing the stuff and then weave and maybe tweak placement afterwards, but make sure that we're hitting the big topics that we need to hit and then getting on, maybe we have a good outline or flow.

Dorothy: I guess my thing about the story was…for me, I don't connect to Planet X that's just me, so I kind of feel stifled writing because I was just kind of like…I don't know how to approach this because it's not…so I guess I was the one in talking to Lee I was kind of like do we have to stick with this the whole year?

Darius: Some of this is not even, I mean it might be cute to tie it in to Planet X, but you don't really have to. We've taught all of these things without Planet X before, so if there's a lesson that…for the labs to make sense if we're just talking about probes, okay we've got something from Planet X, but in the daily lesson you might not have to. You may just be –

Colorado: And I'm not thinking so much of the storyline in terms of the story that you're going to tell the kids completely as much as the conceptual story too, making sure the pieces connect well together and that they can make the connections we want them too. And I guess part of, and I haven't had a chance to tell them, I had a conversation with a young lady today from the ninth grade and she's got three or four new ninth grade teachers, I think that she's thinking- she's seeing that those teachers, they're new to the ninth grade curriculum and they're new to their building, but they're just kind of struggling still with trying to make sense of how all these pieces fit together for the ninth grade. So I'm just trying to make…I was trying to kind of push us so that we don't have as many issues maybe with the tenth grade.

Emma: But I see that…the way I see it is the bottom line is in biology, we have to cover certain things. That's it, period. So, and truthfully, Colorado, that, if we were to write down a prediction about how the ninth grade curriculum would go, the worst target group for that curriculum is exactly who you're explaining. A new teacher, a new building, ninth grade, all of it. I don't know, because a lot of this style of curriculum is hard for even a master veteran teacher to teach, so it's so outside of comfort zones anyways that I think…I hear what you're saying, but I think the people that you're talking to aren't necessarily…cause I know teachers in our building who've been teaching for five, the class or they've been teaching ninth grade science. And it's frustrating going through it, but they can do it because they know how to make it work.

The disagreement between Colorado and the high school biology teachers began in this meeting. Noticeably, Colorado referred to all members of the team collectively as she made her suggestions, but Emma was clear that the teachers and Colorado were members of distinct groups with different priorities and responsibilities. Emma shared that biology teachers in this Mid-Atlantic state worked under more pressure to prepare students for the biology HSA assessment imposed by the State Department of Education in response to the Federal Law NCLB than the previously developed ninth grade science curriculum. At this meeting and elsewhere, Emma and the other biology teachers referenced content in the biology HSA state documents to overrule content suggestions from Steve or Colorado. From the very beginning of the team, the teachers sought to limit the use of the Planet X scenario as much as possible.

Colorado attempted to bridge the gap between her and the biology teachers. When Dorothy felt like leaving the group with her high level of frustration regarding the Planet X scenario, Colorado convinced her to stay with the group and to keep asking questions.

Dorothy: The pieces, the chunks, the pieces…cause if it doesn't flow, for me right now, it's coming, it's meshing and every time he puts it up, I see it a little bit more. But I'll be honest, I was quiet at first because I'm about to ask him [Steve] to be removed because I don't think I'm going to be able to give them what they [school district administrators] want. But then when you said we could go with something else for the next quarter, I was okay, maybe my star will shine then. Right now, I'm feeling a little dull.

Colorado: You're asking the right questions.

Steve: Exactly.

Colorado: And there will be others, so you might as well start, you know, hash through some of this now because there will be others that have the same issues.

Emma: Yeah, and part of it for me, is that I'm very visual, so I think that's why I need the curriculum to be written, so I can see it, because I feel like it doesn't all –

Dorothy: We're saying it, but until we start putting it together, it's not going to get it for me.

D. O'Neil: So what's next?

Colorado and Steve also attempted to provide direction to Emma when the team discussed a lesson that Emma wrote on predator-prey relationships. In fact, Steve used humor and suggested to Emma that her lesson would be used as "a sacrificial lamb," and she agreed to allow the group to critique her lesson. Colorado had given the research institute documents to the group members and attempted to answer the teachers' questions and ease confusion of the 5E instructional model. The discussion was strained; unlike in the chemistry team where group members were in sync and finished each other's thoughts, here, the group members are interrupted as they made contributions, and Colorado's explanations were not well received.

Emma: And I get that. I really didn't know how to fit it in to the template that we're using.

Colorado: The other thing that you can think about engage is that you're trying to find out what they know.

Dorothy: I was gonna say that I-

Colorado: So I was thinking about, and I think you can do that with this –

Emma: So I can put notes on here if there are things that I need to change or do backwards?

Colorado: One of the things I was thinking about is, so let's see if…and I'm trying to think, it's been a long time since I've taught this, so I'm trying to think through if you have the kids put the predator structures, function and then the prey structures, function and the somehow compared the lists and get them to somehow put into a sentence or summary of how do they see the relationship between structure and function then you're really getting at how they envision those two ideas linking together as an engage. So you're getting at their prior knowledge of the relationship, because that's what you say you want to do.

Emma: That's what I'm trying to pull out here is can they -

Colorado: You want to get that out, but what you've got written there is almost there to me, but not quite. Because you don't go to the point where you're ever getting the kids to commit how these related to one another. You get them to write structures and functions, but you don't get them to verbalize, somehow, what the relationship is. And it is hard because…and see this is where I think having the conceptual piece to flow through, you can decide, okay, so how are we gonna use that, that becomes the engage and explore…getting to kids to play with the ideas first, make meaning of them, and then the explain is they're sharing their ideas and putting together pieces and then you fill in the supporting information, because there's always gonna be some of that.

D. O'Neil: Right, so then that is, both of those are explain or is it –

Steve set the team workflow. The teachers wrote the lessons, placed them in a Google Documents folder for Steve, and Steve eventually sent the lessons to Colorado. Colorado attempted to assist the teachers by further explaining the 5E instructional model in the meeting. She also reminded the teachers that she was available to review their work, but Steve interrupted her and reminded Colorado that she did not receive lessons until he sent them to her.

Colorado: Yeah, it's just the explain section. And then the elaborate, you really want to think about, is where you're really trying to deepen their idea with a different twist of an example, somehow pulling them deeper. A couple of things that I noticed in looking at the pieces, you don't have to…you can kind of combine…sometimes an activity really is an explore/explain. Like I think for the DNA piece, part of that worked really well for, okay the kids are exploring, they're gonna do the extractions, right? And then they're gonna put that together and then the explain was them putting their explanations together and justifying them. So in the BSCS products, we would call that lesson actually an explore/explain and sometimes you have a couple of explore/explains before you go to an elaborate because it takes a couple of pieces to be ready to go to an elaborate. Cause if you look at some of our books, the chapter will start with an engage and then it's an explore; sometimes it's explore/explain, sometimes it's kind of melded together, so it doesn't have to be hard and fast. And the evaluate, to me that's the hardest because you're constantly evaluating kids, but think of that as sort of the end. Sometimes those evaluates really kind of finish off at the end, those big evaluates, because that's where we put an evaluate is at the end of a chapter. So it might be at the end of a big section. So some of the lessons you all are putting together, you don't have to feel like you have to have a formal evaluate there. It could be a little bit later when you've got more content. Does that make sense? And I'll always be there to review and –

Steve: When I pass them to you at the end.

In addition to using the biology HSA as a means to control content, the teachers also felt pressured to review the biology HSA test format and content daily with students. Some team teachers felt that class warm-ups should be written into each lesson and contain the HSA multiple choice questions. D. O'Neil opposed writing warm-ups or objectives into each lesson as he felt that the teachers could write their own, but he was swayed by Tisha's comment about the school district's biology HSA concerns and the audience of the document being written for novice teachers.

Tisha: I think that that's great, because some people work very well that way and so having it all up front, they see, okay this is where we're going, I think that's great. But I think that there are also other people who are going to need to have it right there in the lesson in order to make the connection. Because people just work differently, and they think differently, and I think that unlike the ninth grade, tenth grade is, the stakes are higher and that I agree with Emma and Rita that we need to give them objectives. I really do, and I think that we should also give them warm-ups and how…the veteran teacher won't use them, but the teacher who's just starting out will really appreciate it. And I think that we want to help those teachers that are just starting out.

D.O'Neil: On that note, I see your point, about the objective part. I like to have the assessment limits in one place and then again this is just me working how I work, but it works well for me because not only do I see that lesson, but I see where we're going, so I think if I finish early, I can already have a lead in about where I need to go the next day as opposed to flipping through this long document. I'm not sold on the idea of giving them objectives and warm-ups, but I'll open my mind to say okay because it will help some new teacher who's in a new building, who's at a new school, who's stressed about teaching, who obviously has new ideas, but when it comes to oh crap, I'm going to get assessed on this stupid objective thing, let me just write it down. Although, I already know what I'm doing, let me just write it down, it will help me out with my [school] administration –

Emma had stronger feelings about "teaching to the test" and felt that teachers should not reduce lessons to test preparation. She wanted the lessons and even the warm ups to be more than biology HSA test preparation.

Emma: I taught to the test one year and I felt like it felt like I was teaching to the test and for the kids too sort of. I -- at the end of the year I didn't feel like we have a whole picture of biology and my kids didn't do any better on the test. And so for me I would much rather get them to think critically about how to come up with an answer rather than answering multiple choice questions.

Along with resisting direction from Steve and Colorado, the teachers voiced their concerns about the other school district level administrators such as the Director of Curriculum and Instruction and the Superintendent's office representatives. The team discussed perceived norms set by the school district. During the warm-up and objective discussions, Emma shared that she could not use PowerPoint slides for her warm up and objective because she was required to have both available at all times during a lesson. She thought that this was a school district level norm, because she taught regular high school and night school for alternative students. She discovered in this meeting that it was not enforced in each school.

Emma: Anytime an administrator walks into your room, you have to have a warm up and objective on that board. And that's -- I have to have that in night school and day school, I thought that was just standard.

Rita and Steve (when he used to teach) shared that they used a transparency with an overhead projector for both the objective and warm up to satisfy the requirement, but the rest of the teachers said that they were not required to keep them posted for the entire lesson. While the discrepancy appears to be minor, the debate of whether to include warm ups and objectives for teachers in the curriculum template for each lesson began in this meeting and persisted in meetings over two months. The inclusion or exclusion of objectives and warm ups confused group members when they attempted to write lessons with the 5E instructional model. Sometimes a lesson spanned just one class period while other lessons spanned several days. The group decided to include objectives and suggested warm-ups in the curriculum. The word “suggested” was important to the teachers. The teachers wanted flexibility for classroom teachers built into which warm-up was given to students each day. Also noted during a break, some teachers accused school level administrators such as principals of writing teacher lesson reviews as inadequate based on what was written in school district curriculum documents.

The school district administrators, which Steve initially acted as the boundary spanning team member, also imposed the intense timeline, the IFL principles and the

5E instructional model template. The team teachers referred to school level administrators as “they” without ever naming any particular administrator. The teachers wanted to make sure that their own concerns about the issues were conveyed to Steve who could hopefully work with the school district administrators and ease the pressure on the team teachers’ productivity.

Tisha: They [School District Administrators] want a quality document? They want a quality document. Right?

Steve: Yes, that is correct.

Colorado: And so does Steve.

Tisha: I know Steve does, that’s why I’m saying they because I know…yeah.

Steve: I mean because our names are on it and even if our names weren’t on it, the type of people you are, you’re going to want to produce something –

Dorothy: Yeah, I was going to say, we’re the most anal retentive people in the world–

Tisha: That you could ever put together.

Steve: So my hope is, at this point, that –

Tisha: So that just makes me nervous, the timeline –

Technology infusion with this group stemmed from team members who championed technology use. Grant and Emma emerged in this first meeting as the two primary group members who championed technology use. During the meeting, Emma shared how she assumed the format editor role for the ninth grade curriculum and described to the biology group that the ninth grade document had gaps and flaws particularly with how technology and websites were embedded in the units. Her concern was that the information was not presented well to teachers and that teachers would not understand or use the materials that the ninth grade team assembled for the curriculum. Emma advocated for writing the biology curriculum for teachers and by teachers to assist colleagues with implementing the new lesson format. She also wanted to make sure that "web jargon" was not just copied and pasted into teacher materials and that the team established a better way to present the information to the school district biology teachers.

Emma: I would say this still to Dorothy's question, because I think before you also said are we making PowerPoint's and all of that…from the other end of it, which is that I did the ninth grade curriculum, but I did not write any of it. I put it together in the end, like purely from an editing standpoint and everything, some of those pieces were missing here and there, not to pick on ninth grade, but if you want to have a straight idea –

Steve: Well it's the only real solid example that we have.

Emma: So you might say, go to this website and find information, but you haven't actually researched the website or you haven't read what's on there and you now have included like a ten-page document of just web jargon for people….they have to filter through for what they're supposed to get. So from that perspective, I would say if we’re going to make these lessons so that we want teachers to use them and understand them, then all of those ancillary materials, we really need to be good about making sure that we put them together, and we put them together well.

While the group discussed a lesson that Emma and Dorothy co-wrote, Emma advocated for students’ use of Microsoft Paint software program to create fictitious animals for Planet X. Grant championed the use of Google Images, but Emma reminded the group to only use images with permissions to reprint them in the curriculum. The lesson provided a lens into how technology was infused within this team. Individual or sometimes pairs of teachers wrote lessons and suggested different types of technology to use within the lesson.

Dorothy: And what I had described to her was like maybe an elephant with spider legs or something like that, but she said she has -- she’s not getting how to do it. So I was like maybe you can give me a lesson 'cause I don’t know.

Emma: I'm trying -- I have -- let me think about that.

Dorothy: Okay, 'cause I can cut and paste, but I can’t --

Emma: Well, but there’s also ways that -- there’s drawing programs when you can actually draw -- just draw the organism in paint -- I think in Microsoft Paint you can just use your mouse and literally draw the organism. So that might be -- it would be a very sort of rough thing, so that's why I gotta think about how you could --

Dorothy: 'Cause otherwise, I could cut and paste and then we can just scan it in.

Emma: Yeah, but if we -- as long as we can get it into this document electronically, it doesn't matter to me how you do.

Dorothy: Okay.

Grant: Have you guys Googled any of these? Like stick figures of animal and then you could modify those.

Dorothy: Stick figures of animal?

Emma: Or imaginary figures or something like that.

Grant: Yeah.

Emma: The only thing, when you do Google images is you need to make sure you're doing the ones that are allowable for reprint.

The technology infusion was a function of the teacher's comfort and use of technology in his or her own classroom and the teacher's access to software and hardware. For example, Emma's lessons included a variety of technologies, such as different types of software; Rita's technology use was centered on using PowerPoint presentations of biology content. Emma even described how she began to use her newly purchased personal iPhone in her classroom. She created videos and linked them to her classroom webpage for her students to download and review biology content. The meeting ended early, and the group set the next meeting for January 9th at the science center. The teachers were paired and co-wrote lessons together for the first quarter concepts. The workflow for writing was established during this meeting.

January 9th Meeting: Planet X Minimized and Biology Teacher Subgroup Strengthens

The team met in the library at the school district science center again. The meeting was scheduled to begin at 8:00 a.m., but teachers did not begin to arrive until between 8:30 and 9:00 a.m. The team was provided a hot breakfast, and team members ate while they began to hold the meeting. Since Steve had other obligations and planned to not join the group on time, he remained downstairs in his office. D. O'Neil attended for the first hour and assisted in gathering documents and lessons for the group before he left to coach his swimming team. Dorothy, Lee, Emma and Rita attended the meeting, but Tisha was not able to attend the meeting. When Steve was in his office, Melissa, another science supervisor, joined the group and shared her concerns about the curriculum, particularly the time frame of the development and the Planet X scenario.

Melissa: I'm concerned and I'm really got to shut up, because I don't want to add to the already heavy burden. But my concern is that we're taking a document that's going to end up looking like the document already looked because we're going to be crunched for time and by "we," I mean you all [referring to the biology teachers]. And I say that because we all know that what we're starting to do right now is divide and conquer. And to write it inquiry-based or an inquiry-infused curriculum divide and conquer is not the best way to get that done. And we're already going into that mode and not saying that the old curriculum was great, but it wasn't bad. So sounds to me like we're just moving stuff around from the old curriculum. Or that's what's going to end up happening in a new template.

Grant: Not necessarily-

Melissa: Where- what service does that serve for the teacher?

Grant: Right, right I hear you strongly, but I don't think it's going to end up looking like the other document. Look at support for example. It's scenario-based and that's the goal that we have the second quarter or third. Planet X will not play out, but it's going to be more scenario-based or inquiry type of-

During this meeting, the group was disorganized. Teachers had uploaded lessons to a shared Google Document folder, but then they realized that not all of the lessons were in the right folder. The group discussed the same topics (format, warm-ups, and objectives) as they had in the previous meeting. Steve did not join the group until approximately an hour and a half later when the group asked him to help locate other missing files. The conversation quickly turned to the order of biology content across all four quarters. Again, Lee pointed out that the current sequence might not be the best flow since genetics was a large section of the biology HSA and might need to be a topic covered earlier rather than later in the school year.

Emma: Steve, where is this from? Did you update this last time in there?

Steve: This was just before we met last time.

Grant: Where is that?

Steve: That's downstairs I think in notes-

Emma: Yeah, because I feel like maybe going backwards on things. Like if we're not looking for what we recently talked about in terms of flow then we could be rehashing. Do you know what I'm saying? I feel like we're having the same discussions.

Steve: Right. We can't afford to do that. All right then let me go downstairs see if I can find that and I think I saw it when I was looking for the other document. And then we can –

Grant: Meanwhile we have to find a topic for second quarter. Do you want to do that?

Emma: And I thought even last time we went through -- she [Colorado] had some questions about how you -- it's like. I thought it was as simple as just assigning people.

Dorothy: I don't think that should be third quarter.

Grant: That's third quarter. Remember third quarter is the body systems substructure and function. That's what I got.

Dorothy: You said third quarter substructure and function and then, fourth quarter is genetics.

Grant: Right.

Lee: That scares me.

Grant: Fourth quarter is genetics and bioengineering.

Lee: That's scary to me because when people are behind in a curriculum that means it's going to get shortened and that's a big part of the test [HSA] is a major part of the test-photosynthesis and genetics-and I just I don't think I should put it in like that.

Grant: So some of that should come up with third? Okay.

Rita: What are we doing in biology processes?

Lee: Isn't photosynthesis? We're not going deep into they just need a full class.

Steve added another layer of frustration to the teachers' confusion and stress by reminding the teachers that IFL principles needed to be added to lessons. The team had focused on the content and flow but neglected the IFL goal.

Steve: 'Cause the part that we're missing right now - that we haven't really focused on 'cause we've been doing all this content stuff - is the IFL piece. So if we had a unified first quarter we'd say, "Okay, let's take a look at this lesson and let's see where we can start putting in some of the IFL strategies." And I'll give you cheat sheets that you can use for that-those IFL strategies. And then we'll start that process. So hopefully at the end of those three hours, we will have one or two of the chunks for first quarter with IFL infusion pieces so that you can start using that and reconfigure, if you need, parts of your other lessons.

Steve sensed the growing tension within the team, and he acknowledged that too much time had been wasted on organizing the topics and convincing the teachers to write the Planet X scenario into lesson plans. Steve took the blame for the delays and encouraged the teachers to keep writing.

Steve: So we can see where the blame lies - with me. But I appreciate you doing this and continue doing this, because I know it’s been kind of running through a marsh. And for now, it seems like we’ve hit some quick sand within the marsh. So please, please just keep on going and I promise it’ll get better, or I’ll be hanging outside in one of these trees. I won’t say at whose hands. I'll go and share that with you now downstairs. All right?

Emma: Thank you.

Steve: Okay, you’re welcome. All right?

Emma: Thank you, sir.

Steve: No, that’s all right. I'm going to run downstairs. And if you run into roadblocks that are not making sense please e-mail me so that we can start a conversation here and try to give you some help with that in the rough spots, because it’s kind of constructing those rough spots at this point. All right, guys, have a good rest of the day. Thank you.

Technology infusion in this meeting was minimal. The team teachers struggled to organize and lost time by rehashing old topics so they did not proceed further with other lessons. One particular contribution was from Rita. She described in more detail how she set her classroom norms of integrating PowerPoint presentations into her lectures and explained how she made them more interactive with students.

Rita: And what I do for my PowerPoints is I already have my PowerPoints in the form of notes, so I'm doing the PowerPoints and my students are writing and then I might have the question and they are writing down the answer. So it's not like they're just sitting there and watching and not doing anything.

After they ate the provided lunch, the teachers decided to end the meeting several hours earlier than scheduled end of the meeting. Grant agreed that the teachers could write lessons on their own time at home to make up for the missed afternoon hours of paid curriculum development. The next meeting date and time were set before they left the meeting.

The team appeared to be repeating topics and debating issues that had been covered in the previous meeting. The repeating episodes slowed the work productivity of the team and interrupted the workflow. Although Steve voiced concerns and took the responsibility for the lack of progress, the team did not alter the workflow before leaving the meeting. Therefore, more writing time between the meetings would be lost.

January 27th Meeting: Goodbye Planet X and Steve

The biology teacher subgroup successfully eliminated the Planet X scenario, which was completely omitted from the biology curriculum between the January 9th meeting and the January27th meeting. During the same time period, Steve stepped aside as the primary science supervisor and group leader. He stepped aside in part to focus on numerous other school district level projects and also due to his realization that the time frame for curriculum development would be extended beyond his own timeframe as he pursued a new position in a neighboring school district. Melissa attended the January 27th meeting, but she became less involved with the group as she became more involved in another grant-funded school district level project and while she also wrote her dissertation. Grant became the primary team leader at this meeting, and he agreed with the teachers to drop the Planet X scenario. Instead of using a fictitious Planet X for the scenario, the team decided to use a local bay watershed as the scenario to teach biology concepts during the first quarter. The group rejoiced with laughter at the decision to drop Planet X.

Dorothy: Let's do that, and we can get that- great out of what abiotic and biotic factors historically have impacted the [Local] Bay. Yeah! No more Planet X. *[in a singing tone]*

Grant: No more what?

Dorothy: I'm sorry. Excuse me.

[Group Laughter]

The team met in the library at the science center once again. Dorothy, Lee, Emma[7], D. O'Neil, and Tisha attended the meeting. Rita was home sick. The group began to brainstorm how to overhaul the entire first quarter with the new Bay scenario and essentially start over, but now the discussion flowed smoothly with an air of excitement among the teachers. Grant assumed a technology champion role and

[7] Emma brought her infant daughter and preschool-aged daughter to the meeting.

began the meeting by asking the teachers to think about different types of technology that can be used in the lessons.

Grant: So, technology. What I'm trying to introduce by technology could you use, equipment.

Emma: I would say it might be important to have sort of this whole perspective of what it was like X amount of years ago.

Tisha: How has the Bay changed over time?

Emma: And the thing about the Bay…there are so many resources online.

Grant: The succession of bay.

D. O'Neil: Now, this is going to be given to them?

Tisha: We can maybe find an article or something, a variety of articles.

D. O'Neil: 'Cause I think this would be amazing to do on the first day, even assuming-

Tisha: I am so glad.

Lee: I always teach about that!

[Group Laughter]

D. O'Neil: Me too.

The biology teacher subgroup gained a new level of team autonomy under Grant's leadership. They were able to make content flow decisions and to move quickly through different topics. For example, they discussed D. O'Neil's adapted first lesson of the first quarter.

Emma: Your lesson.

Dorothy: But it's still fine. I agree with him. Talk it out so everybody knows it's…

Darius: So the first one is – the construction would've been great, and so now it's sometimes moving to abiotic biotic, so we're still using the bay, have this picture of the bay, have the kids divide it up. These things are what you see in the bay and this is how you divide it up: living and nonliving. And from there we move on like Yes? No? Yes? No? cheese *[Laughter]*

Emma: So, abiotic, biotic factors and use the biotic factors for the characteristics of living things?

D. O'Neil: Done. You see how we –

Dorothy: And it's a HSA, so we could link it back to an HSA question. Remember the fish?

Emma: So then use the biotic factors in the introduction to the characteristics.

Lee: Did you see how the vibe has changed?

D. O'Neil: Yes.

Melissa: It feels so much better in here from my perspective.

Tisha assumed responsibility of typing content into the word template during this meeting. She also began to motivate and monitor group members during discussions. For example, Tisha noticed that Dorothy was quiet and not contributing, so she prompted Dorothy to share her opinions. “Don’t get quiet on me, Dorothy. Come on. Come back.”

As the team continued to organize their thoughts on the flow of biology content across the school year, they shared how they each covered different topics and where to fit different topics into the content flow. With only approximately 30 minutes into the meeting D. O’Neil commented about the amount of work productivity for the meeting already, and Grant tried to smooth over the previous tension.

D. O’Neil: You said diversity of the population of nutrients?

Emma: Diversity within a population and then diversity among populations.

Grant: What, pollution?

[Crosstalk]

Melissa: You’re talking about within a population. I need you to remember.

Emma: And how does that –

Lee: You can do it big time. I do it when I talk about – but I do it when I talk about impact–

[Watching the screen as Tisha adds content]

Lee: Yeah just diversity, and then talk about why biodiversity is important. The intersects of those roads that organisms have.

D. O’Neil: So, here we’re talking about symbiosis and trophic levels also can go.

Grant: Population dynamics, everything about population.

D. O'Neil: I just feel like we've done so much work today.

Melissa: That is so good.

D. O'Neil: Not before.

Grant: Before it was okay, too, after the storm, before the calm.

Toward the end of the meeting, Tisha raised a question about how the teachers should divide the work of writing lessons and began to assume a leadership role in this meeting. The exchange revealed the teachers' interests in selecting what they wrote and how much work was assigned to each teacher. The teachers banter with laughter about the equity of workloads for each teacher, but the subtle tension demonstrated that no single teacher wanted to do more than a minimum amount of work outside of the meeting time. Grant told the group to divide the work, but did not facilitate the conversation. Instead, Tisha assumed a leadership role and facilitated the division of work.

Tisha: So we wanna break it up?

Darius: Yes.

Grant: Break it up. Let's get out of here. You guys did a fantastic job.

D. O'Neil: Thanks, guys.

Emma: I would be interested in doing food webs only because I would do now mind you I would do horseshoe crabs and monarchs for terrestrial and of course, but I'm open to anything; it really doesn't matter, but if you give me that one, that's what you get.

Tisha: So, Emma is doing food chains and food webs?

Dorothy: We already did it.

Emma: Plus, I already did it. Yeah.

Dorothy: That's already done! That's not fair.

Emma: I didn't even think about that.

Dorothy: No. I'm not writing another thing.

[Laughter]

Emma: It has to be adapted, Dorothy.

Grant: They need to be remade. Come on

Dorothy: It's written.

Emma: I tried, 'cause I wanted to do monarchs and my horseshoe crabs.

Dorothy: You tried.

Tisha: Emma, you can adapt this and then take something else.

D. O'Neil: Can we start out –

Emma: I'm not doing work and a half.

D. O'Neil: Can I have –

Tisha: So, Emma, why don't you take food webs and – I'm sorry, were going to say something? Why don't you take –

Emma: Would you like to adapt the lesson, Dorothy?

Dorothy: Nope.

D. O'Neil: Dorothy, you need to be a team player.

Dorothy: Nope.

Tisha: Emma, what if you took food webs? I mean, we're all gonna have a lot to do, but what if you took food webs and you adapted what you had and then you did a piece of the introduction, not the whole introduction but maybe?

Emma: That's fine.

Tisha: Is that okay?

Emma: That's fine.

Tisha: Okay.

D. O'Neil: Can I do – I think it was life on the bay?

Several times in the exchange D. O'Neil attempted to volunteer for a section, but until the issue between Emma and Dorothy was resolved, Tisha did not turn her attention to him. Tisha recorded the teachers' names in the document next to each assigned topic. The exchange continued as Emma checked in with Dorothy. The two had worked on a Planet X lesson together and did respect each other's opinions and work, but neither teacher wanted to complete any more writing than the other teachers. Grant advised Tisha to color code each teacher's name and indicated where in the document to put the names, but he did not suggest any particular tasks for teachers. He struggled to lead the group directly and instead delegated leadership to Tisha, who facilitated the division of work conflict among the teachers.

Grant: Person's name and their color on it.

Tisha: Yeah I was not sure where to put that.

Emma: Is that better with you, Dorothy?

Dorothy: Yeah.

[Laughter]

Dorothy: You tried to get out of it.

Emma: I did not. I was totally thinking about-

Dorothy: I'll take it and put it together.

Emma: No, it's okay. I will adapt it to all my stuff. Don't worry.

Tisha: Who wants to do the introduction with Emma?

Dorothy: I'll do it with her.

Emma: Great.

[Laughter]

D. O'Neil: Can I have life on the bay?

Emma: I was gonna say something. When you're done Tisha, I just have a couple notes to run by people in terms of how they do the template, things to keep in mind when they do it.

Tisha: So, Emma and Dorothy, introduction, and Emma is also-

Emma: You're gonna e-mail this or put this on Google or something?

Grant: She will email it.

Tisha: You're [D. O'Neil] taking the whole life in the bay?

Darius: Yeah.

Dorothy: I'll do the relationships.

At the end of the meeting, teachers were assigned lessons including Rita who was home sick. Once again, the group adjourned well before the scheduled end of the meeting. The teachers were pleased with their progress and ready to write the lessons on their own at home. They determined the next meeting date would be an eight hour

Saturday session on February 27th. Grant's last statement to the team described the end of Planet X and the new direction for the group.

Grant: I think we got a far way today. Planet X is over. The more context we give these concepts with, I think it's better. The kids will get it, especially closer to their understanding.

Steve's departure altered the group dynamics and the team began a new episodic cycle under Grant's leadership. The team decided to omit the Planet X scenario and that decision cost the team more time and an increase in work productivity in order to rewrite the entire first quarter. Even though the teachers were faced with additional work, they rejoiced in obtaining the desired result of eliminating the Planet X scenario and gaining team autonomy to make content decisions.

February Meeting: Format Confusion

In February, the team was scheduled to spend a full eight-hour day at the science center. Grant, Dorothy, Lee, Tisha, and Rita attended the meeting. They met in the lobby of the building, which contained a lab with computers on tables in a large square around the middle of the room and several additional tables of computers inside the large square. The teachers used the State Department of Education Core Learning Goals (CLG), the quarter one lesson outline with teacher lesson assignments, and the newly generated quarter two lesson outline documents during the meeting to construct the lessons.

Grant began the meeting again by introducing technology resources to the group and reviewing components of the lessons that needed work. He encouraged the teachers to assume the role of "curriculum writers" and to use different types of technology. Rita complained that her science department chair (the school district refers to this position as TC or teacher coordinator) had not provided her access to the classroom performance system (CPS) or the clicker system in which each student had a clicker device and individually responded to the teacher's questions during a lecture. At first Grant asserted that each school has a CPS, but then he conceded that lessons that required CPS use should be listed as suggestions in the curriculum. The confusion about what equipment was listed on paper in individual schools and what access to technology that teachers reported impeded the infusion of certain types of technology. Grant began his technology discussion and mentioned that Tisha would lead the group when he stepped away to attend to another group who was meeting in the building.

Grant: More or less the rest of the day is going to be-wanting you guys to do quarter 1 and quarter 2. The reason why I stapled this is so that you can keep it separate**.** Tisha is taking the lead on this. And then quarter two, you were supposed to give us input in terms of the unit flow as it is- anything you want to change, so that's the second part of the goal for today. All right? And I sent you guys some sites. I know that you have a website Lee in terms of case studies. We can revisit them. I sent you guys a 5E site. It can help as you write it's a one-stop shop for 5E okay? But let me share a site with you. There's a NSTA.org. This is free, so you may want to browse in your – just http://www.learningcenter.nsta.org. You can register.

Some of the stuff is free – most of it is free. If you want to personalize PD [professional development] for a group, you would have to pay a minimum of $4.00 to $30.00 depending on the site. But this is what I'm excited about. Where's my account? My library last night – I think I sent you this link last night.

Tisha: Yeah.

Grant: What I did last night was I went in and bought some – Where is my stuff? I book marked some stuff. Where's my account? Okay, here we go. So I book marked, and you can see this, several of these. Okay. And I just stopped on Page 2 with 11 pages filled with these, the coral reef one, abiotic factors... You know what, let's do this. *[He is having trouble with the page loading.]*

Dorothy: Don't you hate that when you're teaching the class and this happens? *[Laughter]*.

Tisha: *[Laughter]*. That is the worse.

Lee: That is the worse. You're just sitting there going, okay, so what happened? And they're just like…*[laughter]*.

Grant: There we go. It gives you a description, and most of these are two-hour sessions that you can recommend to your teachers. And what they're saying, too, sometimes it's good to recommend kits. So as a curriculum writer, you want to browse it to see exactly what are some correlations. So you see, the price is zero here, zero for non-member or member, and that's your description. "If you wish to review this resource, click here." So you gotta grade it so forth down.

Dorothy: Grant, so how do you? – and I had to think about this because I was using some of the, uh, what do you call it, cases – the case studies, one of them was a clicker case study where you could use the Classroom Performance System along with the case study, and I was fearful of choosing that one, because I didn't know how many schools had CPS.

Grant: All of the schools were given at least one set. Remember when we did the biology adoption? You were involved. *[Looking at Dorothy who is the science TC for her school]*

Dorothy: But we shouldn't expect – we wouldn't want to – see, she's saying they don't have them–

Grant: We would suggest – you guys have CPS systems. Check with your TC.

Rita: We've done that several times.

Grant: Everybody. We have a document saying that every TC signed one, so you may want to double-check with her. Please check. I was told that biology adoption that each one of the TC signed for one.

Dorothy: Okay, but so that shouldn't be – I guess what I'm asking, that shouldn't be the main lesson…

Grant: Right.

Dorothy: We should – as a supplement, we could say…

Grant: Yeah.

Dorothy: Okay.

Grant: Okay, this is abiotic setting, and it talks – you can click on each one, there are 8 pages of them. You go next. I will go to the one where – and it shows you which of the world, the role of the sun; it talks about photosynthesis.

Grant continued to share technology resources and information to the team teachers. He walked through the NSTA website highlighting biology content areas. Then, he explained how the school level administrators "want to push technology in the entire curriculum." Prior to the meeting, Grant met with a supervisor from library media services to obtain copyright privileges for the ninth grade science curriculum in order to upload videos and have them available for all of the science teachers. School district administrators considered video clips with correlated content a use of modern technology. However, Dorothy pointed out again that the teachers should only list web and video resources as suggestions. The teachers were content to list tools and resources as suggestions for particular topics for school district biology teachers' use.

As Grant stepped away from the group in order to meet with the ninth grade science curriculum teacher, he gave each team teacher a DVD with virtual biology labs. He told them that each TC would get a DVD for the school science department, but that he wanted all of the curriculum writers to also have a copy. Tisha assumed the group lead as he left. She struggled to clarify the 5E instructional model with Dorothy, Lee and Rita. They worked together through each lesson and shared how they interpreted the format differently. Emma and D. O'Neil were not present at the meeting and did not weigh in on any of the decisions that the teachers concluded. Lee shared her frustration with a lack of a writing process, and she did not want to keep redrafting the same lessons over and over for each topic when the group made decisions to merge different topics. While Tisha began to take a group lead, she backed away from assuming a lesson format expertise role, or the 5E instructional model and IFL expert roles.

Tisha: Under community, there would be – which I'll do a whole lesson in 5E's. I mean if you look at the way that the 5E's are set up, this isn't the normal 5E's – you do 5E's in one class, this is really – it's really a problem.

Lee: I'm about to cry because this is why, I mean – this is the lesson I spent so long doing –

Dorothy: Oh, on biodiversity?

Lee: – was biodiversity. And now to hear that, it's like –

Tisha: But I was just asking. That doesn't mean that I'm right. I'm not I'm just asking

Lee: I don't know if this is writing. It just seems harder this time around.

Tisha: I think it's because the last time, we did each individual lesson. So like for a topic, for each topic, there was an individual lesson instead of trying to do more a-

Lee: merge

Tisha: or an approach. I think that we're used to doing it a different way, and because our approach is changing and we're having a hard time, you know, figuring out what is really is expected here and what really goes where.

Lee: Right. I mean I know I took time to do it and don't wanna – but I guess what I was thinking was, okay, since it's like this, it means that we need a lesson, a 5E model on biodiversity, and that will incorporate biodiversity into some other-

Tisha: Well, what if you use biodiversity to teach community interactions? Like what you did…

Dorothy: Yeah, I don't see a problem.

Tisha: Exactly

Dorothy: We could just modify it so that it includes all that. Why are they important now? Now, you know why need all these organisms because we need a predator, we need a parasite, we need some mutualistic symbiotic relationships.

Lee: I mean I understand that, but it just wasn't clear to me the first time. So it's-

Dorothy: Just like I said, let's look at lesson 1, because I just – I felt with my – I wasn't really sure if I was hitting on the right – that's why I said, as a group, and we talked about, not writing up the worksheets just yet, put the broader thing there and then do the worksheets. Because I want feedback and she wants feedback in the lessons. Do it right, and then branch from there.

Lee: I think we have to come up with some kind of system because I cannot do this again for quarter 2, and then you come back and say, hmmm, maybe we should have merged that. If we can, together, look at the topics and say, "Okay, let's get the lessons done, these concepts," and then go from there, but just list topics we need to cover and make it look like they are separate lessons. I just want to clear that up before we continue to write–

The teachers struggled as they read through each written lesson. Dorothy claimed that she wanted "feedback" to "do it right," but she did not specify who she wanted feedback from or when the feedback would be most helpful. She readily accepted feedback from other team teachers even though all of the teachers struggled with the same issues that she had. Dorothy did not want her engagement and warm-up to be the same in her lesson. She also remembered that Emma did not want to use biology HSA questions as warm-ups, but Tisha reminded her that they needed to list biology HSA questions as options. As a group they dissected each lesson written by the teachers who attended the meeting and determined where the template format should change. For example, the teachers were not certain if materials should be listed for each lesson or each module (unit). Tisha raised the issue, and Dorothy moderated group consensus.

Tisha: The only other question that I have is you see how here you have the summary of the activity and the materials that you need, and then I guess like this would be like the instruction, is that the kind of format that we all want to do, and should we always have – should it always be in that format summary or activity materials and instructions?

Lee: Where are you?

Dorothy: She's on the front page where it says, "explore of the case study." And I know that I took that from Emma's template.

Lee: Right. And I saw that too, and I think I did that for one thing, and then I didn't see it on the other chart and so I didn't do it.

All four teachers in unison: We need to be consistent!

Dorothy: So it's up to you guys. What did we wanna do?

Tisha: And I personally like it. And I think that we should always follow that format, and if there are no materials, that we just say that there are no materials required – no additional materials required. And not materials like a textbook or anything like that, but if there's activity in the appendix, or if there is – you know if it's like a lab activity, where you use materials. Or you can take that out and put that back in the chart up front – the materials.

Dorothy: Do you all as teachers do you- do you like all the materials listed up front or do you like it in front of each lesson?

Lee: Each lesson because I know for that lesson is what I need-

Dorothy: yeah that's what I- yeah when do I use that? I see five cotton balls but I don't see where the 5 cotton balls fit in…

Tisha: Yeah I think we should.

Dorothy: So are we all in agreement to be consistent and do that? Okay, so for every – even if there's nothing there, make sure okay.

The teachers were determined to create a better content topic flow for the second quarter. Tisha had prepared a content flow document for them to discuss at this meeting. She presented her document to the teachers and began by seeking their feedback on the flow of quarter two content.

Tisha: Okay, so I think the first thing that we should do for quarter two is make it clear which topics are actual 5E lessons, and what are the subtopics underneath, so we don't make that mistake again. So when I wrote this – oh, and I guess also looking at this, I'm the only person that's done this so far, so I need everyone's feedback, like do you think it's good? Do you want to reorder some things? What are some things that you want – you know what I mean? Let's do that first. This is our biochemistry unit and cells. It's kind of merged all into one. So the whole thing that I did for this one is like brain cells linking back to the characterizes of life, and then the ingredients for life, and then looking at how these ingredients come together to formulate a cell, the function given for life, and then how the cell meets its energy needs. And then applying it to what processes does the cell have to carry out in order to maintain homeostasis. So that's the flow I came up with.

The teachers exchanged ideas for how to reorder concepts based on how they would teach the concepts to their students. The team cohesion was high as they openly discussed topics, and each teacher introduced concerns or possible modifications. For example, Rita asked about covering cell organelles.

Rita: I'm just thinking, I mean are we going to do enzymes like another like ribosomes? And are we still skipping the information about what an organism needs for energy demands? Or other cell parts?

Tisha: I mean I think if I were teaching this, probably after I did carbon compounds, I would show a picture of the cell, and maybe that's what's missing. Maybe what's missing is cell structuring and classification. Like I would show a picture of a cell and different types of cells, and I would – and you would talk about the fact that the cell – eukaryotic cells have these organelles, where these processes happen and certain processes happen in order to help a cell meet its energy demand. So maybe that could come into the homeostasis classification.

Tisha attempted to keep the team all “on the same track” by correcting the changes to the format and sending the new template with the lesson assignments in an email. The teachers did not read through either Emma’s or D. O’Neil’s lessons, and neither teacher received any written feedback. Instead, the teachers divided the next set of lessons for quarter two and assigned the tasks for all of the teachers, which included Emma and D. O’Neil. The teachers ate the provided lunch and left early at 1:00 p.m.

Under Grant’s leadership, the team entered the next episodic cycle with Tisha in a leadership role. Without Grant actually acknowledging her leadership role to the group, Tisha began to organize the new workflow for the group. She intended to write more and also edit the other teachers’ lessons. Her dual role as writer and editor would increase her own time devoted to the team and her work productivity for the team.

April Meeting: Colorado’s Feedback Not “Heard”

The team returned to the library at the science center for the April meeting. The meeting was scheduled to begin at 8:00 a.m. with a provided breakfast; however, the meeting did not begin until 8:55 a.m. Grant, Rita, Lee, D. O’Neil, and Tisha were present when Grant began the meeting. A new teacher was also added to the team, and she arrived at 9:00 a.m.: Dana, who co-taught biology as a special education teacher and co-taught night school with Emma, introduced herself to the group and shared her concerns regarding information retention for special education students.

She asked that the group embed more learning strategies within the document in order to assist all students, but particularly special education students. The biology teacher subgroup willingly changed the format based on Dana's concerns.

Dana: Last year, I taught biology and co-teach seven. This year, I'm teaching intensive and co-teaching biology. I'm really still learning a lot of the content- what's required. I'm trying to figure out what I need to focus on. With intensive, I'm not sure how many of you work with special education students, but it's really hard to move from one topic to another the way that you can in a general education setting and hope that they retain that information so I spend a lot of time going back because I can ask a question about something that we spent many many lessons on maybe a month down the line and they will have no idea what I am talking about. A part of my curriculum and the way that I have them learning is maintaining a journal that is successive so that they are able to go back and use it as a resource.

After Dana introduced herself, Grant told the group that Dorothy and Emma[8] were on their way and that Colorado would arrive at 10:30 a.m. Grant also told the teachers which future meetings Colorado would attend, the teachers responded with a collective response "Oh, she's [Colorado's] going to be here?" Followed by a bolder statement from Tisha:

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[8] Emma arrived at 9:15 a.m. and Dorothy did not arrive until 10:50 a.m.

Tisha: We don't want her [Colorado] here. *[Laughter]* I didn't mean it like that. I'm sorry. Maybe she can come the first day of [summer] curriculum writing.

Grant handed out documents (agenda and quarters one and two lesson outlines and the State Department of Education biology CLG) to each team member. For the first time, he handed out an agenda that listed three goals for the day: the group needed to finalize lesson plans for quarters one and two, infuse IFL principles into quarters one and two lessons and identify quarters three and four topics. He also shared with the group that only forty-eight percent of the school district's students passed the biology HSA and the "status quo and current curriculum is not working." The team began to organize themselves for the day as Tisha and Emma discussed and then divided editorial roles for the team. Tisha primarily focused on the content and flow of the lessons, and Emma compiled the lessons into one document and primarily focused on the format issues such as font size and bullets. They were not formally presented to the group in these roles until the May meeting, but they worked out the editor roles between themselves in this meeting. Both Emma and Tisha also continued to write lessons.

Emma: And Tisha, I'm fine with doing that piece of it. You're very good at doing this kind of stuff [flow of concepts] too which I'm not so good at so maybe if I try to do the technical aspects of putting the lessons together-

Tisha: Right because I don't know how to do that.

Emma: That might work better for us to separate a little bit because I'm not- I haven't been here enough to follow the flow as much either so-

Next, the teachers turned their attention to the content flow for quarters three and four. D. O'Neil began to write the flow on the chalkboard as the teachers discussed how to connect biology concepts. Again, teachers discussed topics and relevancy to the biology HSA. The team teachers celebrated when linkages began to flow smoothly. For example, the teachers erupted in laughter and D. O'Neil and Tisha exchanged high fives when writing the transition flow from the end of quarter two to quarter three. Tisha became excited when the concept flow made sense to her and the other teachers and also aligned with the biology HSA.

Tisha: Hold on wait. Before we switch it. I really like the way that you (D.) related body systems to cells. Right. So we're talking about because that's the way the state writes it so we're talking about single-celled organisms and how single-celled organisms maintain homeostasis, and then, you go from single-celled organisms to multi-cellular organisms and how they manage transport and maintain energy all of that I really like that-

Dana's modifications were welcomed by the teacher subgroup; however, modifications in teaching strategies and flow from Colorado were not as well received and met with resistance from the teachers. Colorado, who entered the meeting late, shared norms from across the United States with the team. Teachers did not respond well to the explanation of what other states were doing regarding content issues as the burden to adhere to the biology HSA provided the set norms for content coverage in this Mid-Atlantic State. For example, during the meeting the group discussed dichotomous keys.

Emma: I know dichotomous key has been on here [referring to the state core learning goals and the biology HSA].

Colorado: Well that's one of those things that if you look at many states it's disappearing.

Emma: Yeah but I'm saying that in the last couple of years. This is-

Colorado: much of the classification is just kind of like going bye-bye

Since Colorado's national level expertise was not valued by the teachers, the teachers adhered to the state core learning goals document and the biology HSA test preparation documents from the State Department of Education rather than ask for or listen to Colorado's content comments.

The teachers became increasingly frustrated with the writing process that Colorado attempted to engage with the teachers. Dorothy felt that the teacher subgroup had rewritten the same lessons so many times already due to changes in the scenario focus and formatting issues, and she did not want to rewrite any of the lessons again. Lee and D. O'Neil shared Dorothy's concerns even though the teachers struggled with revisions, lesson flow and concept linkages. Emma began a discussion about the types of details that Colorado sought in the lesson plans. Both Emma and D. O'Neil rejected the types of specific details that Colorado recommended; they saw the modifications, such as accountable talk, as dictating to teachers on how to establish classroom management.

Emma: Because accountable and maybe this is just definition stuff but accountable talk to me doesn't seem like something you necessarily put into a lesson but that's really how you carry out your classroom. I mean how you dialogue in your classroom

Colorado: And so one of the things that I was curious about what you all had written for the first quarter is how are you going to help the teachers introduce cooperative grouping, working on norms of discussions in your class sort of that whole classroom culture piece. Are you all going to write lessons for that or are you going to just start with the core content?

Dorothy: I know for me I was writing opportunities into the lessons so it could be just already there.

Emma: Are you saying for like the brand new teacher?

Colorado: Well

Emma: because obviously for all of us it's a different-we don't think about it

D. O'Neil: Yeah, right.

Colorado: Well but there is you know. Well and so you all are probably the exceptions to the rule, but if you think about your colleagues opening the school year- what I can't tell from what I have is what are you all planning for them to do the first couple of weeks of school?

Emma: Right but what you are saying is more like how the class functions

Colorado: Yeah so you want to get those routines established in the beginning

D. O'Neil: Isn't that based like how you deal- isn't it like more classroom management?

Emma: Yeah.

D. O'Neil: Because I have a class, even me having student provisos, I have one class that I would not put together in groups because they talk too much. Another class, the same biology class, I would put them together in groups all of the time. And so-

Colorado: But part I mean part of accountable talk is that and what the talk research the discourse research is showing is that kids have to be given the opportunity to talk about something that's of importance

Colorado wanted lessons to focus on what students are doing and how teachers engaged students in the class. The teachers instead wanted to provide options for teachers on how to teach different topics without dictating to teachers how they should teach and manage students. Colorado made copies of two documents, 5E instructional model and National Standards classroom inquiry, for the teachers to help them as they wrote lessons. She also asked that quarter one lesson plans be compiled in the sequential order and in one document: she planned to review the lessons and to provide feedback.

The team set the next meeting date and time. Teachers divided the lessons amongst themselves. The agenda listed the meeting ending time as 4:00 p.m., but the meeting ended after the provided lunch and final discussion with Colorado at approximately 1:15 p.m. At that time, the teachers had planned to write lessons at home during the afternoon writing hours.

The team had two particular occurrences within this meeting that altered the team and caused two more episodic cycles. Frist, Dana, the special educator, was added to the team. She suggested and the team agreed to alter the format again causing more work on each teacher to alter each lesson. Next, Emma suggested and Tisha agreed that the editor role for the team be split between the two of them. Emma focused on the format details while Tisha focused on lesson content. Even though Colorado was supposed to review and edit lessons, Grant and the teachers only sent a few lessons to her, and instead, the team relied mostly on Tisha and Emma for edits.

May Meeting: “We Own Our Curriculum.”

As promised, Colorado sent modification feedback for the quarter one lessons to Grant before the May 26th meeting. She wanted more precise details of how concepts explicitly linked together in the 5E instructional model and how teachers would infuse the IFL principles into the lessons. Grant introduced Tisha and Emma as biology team co-program managers. This was the first official recognition of their leadership roles within the team. Grant had left Tisha in a leadership role in February, but only three other teachers attended that meeting. She and Emma had also divided the editor role in the previous meeting and began to work as both writers and editors, but this is the first meeting where Grant introduced them both as “program managers." Grant told the whole group that both Tisha and Emma made an extra fifty dollars beyond the two hundred dollars per eight hour day of curriculum writing that all of the teachers earned. Grant distributed Colorado's recommendations to some of the team teachers. In response to the teachers' tension and resistance towards Colorado's comments, he proceeded to devalue Colorado's comments:

Grant: It is a suggested format. We do not have to take hers [Colorado's] and what she did and I'll talk to you guys when you break up [into ninth grade and biology teams]. She took one of your biology lessons and broke it out. As a matter of fact it's your sample. Yeah. It's the sample. I didn't make copies for everybody. So you are going to want to look at that. We can talk about it as we- we don't have to stick to any of it. Okay. We own our curriculum. Keep that in mind. They are advisors and work but we own it so that we can better serve our students. Bottom line- students must be successful. Okay?

Along with Grant, Emma, and Tisha, Rita[9], Dorothy, Lee, D. O'Neil[10], and Dana, another new teacher, Will, attended the meeting. The meeting was held in a portable laboratory classroom outside of the science center building because the building was being used by another teacher professional development activity. The classroom had two long rows of tables and student chairs. Teachers were provided dinner and began the meeting 30 minutes later than scheduled.

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[9] Rita left the meeting early due to other commitments.
[10] D. O'Neil was also involved in the other project inside the building, and he went back and forth between the meetings.

Just as the team teachers welcomed Dana and her comments in the previous meeting, the teachers also welcomed Will, who was a first year teacher and a member of the Teach for America organization. He first asked Grant about the focus of the curriculum whether it was to be scripted or allow for teacher flexibility.

Grant: Biology curriculum we have this in place [*holding artifact copy in hand*], but I think that it's too scripted and precise so we are not giving teachers flexibility so the challenge now is to convert what we have. I think that we are going in the right direction for biology. Yeah-

Will: Can I just ask a question? So in terms of it the goal here because it looks like there's a lot of detail that she [Colorado] is asking for in the template which I think is a good thing, but is the goal for the curriculum as a whole to be very scripted or is the goal to give the option to the teach- the educators to do the things that the curriculum is kind of framing?

Grant: ah define scripted- detailed is not scripted

Emma: the goal-

Grant: Go ahead.

Emma: Is to infuse the IFL principles and the nature of that is that it's not scripted. It goes sort of where the kids go in terms of learning.

Will: So more as educator as facilitator facilitating information as they interact

Grant & Emma: Right.

The teacher subgroup voiced their issues with Colorado's comments and D. O'Neil reminded the subgroup of their internal biology teacher subgroup promise to not change the format again.

Emma: I kind of feel like this is great, but why are we getting this now if this was her [Colorado's] thinking why couldn't we just have this two months ago?

Grant: She [Colorado] reflected upon ninth grade curriculum.

D. O'Neil: Didn't we agree that we were not changing the format anymore?

Grant: That's before IFL, but this format makes a lot of sense. If you look at it, it's similar to what we have its just addressing some stuff upfront.

Emma had resisted Colorado's suggestions before, but this was the first time that the suggestions were written into a document rather than just discussed at a meeting like during the April meeting. Even though earlier Grant told the teachers, "We own our curriculum," he then attempted to make the teachers consider Colorado's comments. Grant also responded to D. O'Neil's comment about the teacher subgroup's promise to not change the format that the promise was made before IFL infusion; however, the promise was made just after Planet X was no longer in the curriculum. The IFL principles and the 5E instructional model were incorporated into the format from the very beginning as the group goals were set by the school district level administrators, but the teachers did not write the lessons with the information embedded in them. Dorothy was disgusted by the latest curriculum overhaul imposed by Colorado and supported by Grant. She took a break from the group and walked out of the room. Tisha attempted to coordinate the group and to resolve the conflict. She felt the tension among the teacher subgroup and in response to Colorado's comments. Grant again appealed to the teachers to read through and consider Colorado's suggested changes.

Tisha: It [curriculum] needs to be great because the stakes are so high but- I think that I just feel the- in the group it's just the-I feel the- I don't know what the word is-

D.O'Neil: Tension.

Tisha: Tension! That's the word [claps hand] I feel tension in the group because-

Grant: the only addition that she [Colorado] is asking here is for us to put the activities in the chart.

The subgroup decided to make one more change, based on a recommendation from Will. Will offered an alternate format change to the curriculum that differed from Colorado's suggestions, and the teacher subgroup welcomed his input. He described the template that he used while writing his own classroom lesson plans and felt that the format might resolve the level of details that Colorado sought from the teachers.

Will: So one of the ways one of the lesson planning templates that I use divides it into student actions and teachers actions which is sort of allocating the same space but instead of 4 columns it's 2 columns because I don't – I sympathize with everything that's being said here because it's a long lesson-but then the teacher action column kind of becomes the column where you're addressing those kind of- how's the teacher facilitator going to do it? How are you going to differentiate each point? What are the materials? The student actions are what they should be doing.

Emma: I like that idea.

Will: I can pull out the template and share it with everybody.

Emma: That would be nice, and I appreciate you giving it to us on the first day that you meet with us.

[Laughter]

The teacher biology subgroup again welcomed input from a subgroup colleague over the education research consultant and modified the format to include teacher action and student action columns.

Technology infusion occurred briefly during the meeting when Grant championed a new online website and technology hardware. He explained to the team that he met with representatives from Explore Learning about the Gizmos online science learning through online interactive simulations and virtual labs. He said that all of the special education classes would have access to Gizmos and Mimio, which is a company that provided hardware to transform any hard surface into a Smartboard. He again described the technology capabilities to the team, but did not encourage either technology as a specific targeted technology to be used within the curriculum.

At this point, the team ended the meeting after they discussed the next meeting date and time, and they finalized the latest version of the template format. The team gained more team autonomy from Grant to create and edit lessons without adhering to the Colorado's advice. The change in template this time came from the newest member, Will, and not from Colorado. The team entered yet another episodic cycle as it changed the template, and members had to modify all lessons again. Team members made alterations between meetings.

June 3rd Meeting: Colorado's Formal Presentation

Grant began a joint team session with both the ninth grade curriculum and biology curriculum teams in the library of the school district science center. He had a representative from the Fergusson Foundation present technology-rich filed trips. Students could use GPS, digital pens to record data and digital cameras while conducting field studies of national parks in the area. Teachers asked for specific administrative information such as, "Where do I register for a trip online?" and "How many adult chaperones are needed for the trip?"

Next, Grant handed each team teacher a large binder for them to use to organize their curriculum documents, and he turned the meeting over to Colorado. Colorado began a more formal presentation for the teachers. She handed each teacher a folder filled with the same documents (5E instructional model and National Standards classroom inquiry) that the teachers had been given in prior meetings and additional documents that "reinforce what your colleagues need." As she went through the materials and fielded questions from the teachers, she stood with her presentation clicker in hand and moved near the front and side of the room. Colorado described how she felt the curriculum writers needed to write the lessons.

Colorado I also want you to keep in mind that you all are here because you bring a set of strengths that may or may not be among your colleagues, and so, one of the things in my mind as a curriculum writer that's really important is to be as explicit for them as possible. So that, if you get new teachers next year in your building or in your schools- I mean in the schools in the [school] district, they can pick this up, and they can read your mind almost and see where you wanted them to head. And for those who are more experienced who have been here awhile and maybe they didn't get as involved as they should have the first year time frame, they will have a better sense of what is happening.

She described the research about how students learn science concepts. She stressed that lessons needed to elicit student preconceptions, ways for student to express their thinking during the lesson, and ways for students to keep refining their thinking about concepts in later lessons. She acknowledged that with "HSA biology there is not much time and that is a concern."

Will, who entered the group in May and met Colorado for the first time in this meeting, raised the concern that the first quarter biology material had lessons which relied heavily on the Internet, and teachers responded to a question posed by

Colorado. Finally with the entire team present, the team discussed technology resources in the school district biology classrooms and access to the Internet.

Colorado: How many of the teachers in the [school] district have access to multiple computers in the classroom?

Grant: It varies-

Emma: In my school none of the science labs have them or only the new ones so

Grant: Plus they have all of the carts but they are taken away for testing-

Emma: But let's yeah- the mobile labs are 4 or 5 years old now. They have not been maintained so- it depends on the school obviously-

Colorado: How many classrooms have at least one computer and an LCD?

Grant: I would say over 90% or even greater.

Colorado: That's something that I want you guys to think about as you write this stuff a lot of times you'll say go to this website and show the kids these pictures. You're now telling me that all of your teachers do not have easy access and that's something that you want to watch for. One of the things that I was thinking is kids instead of creating a chart paper could put it on a PowerPoint slide and show their PowerPoint slides.

Will: I think that (Internet access) is a really big concern because for the first half of the year our building did not have Internet access most of the time. So that's one concern for first quarter which is web-heavy-which I like on the one hand if I had access.

Emma: So maybe we should be putting in alternatives. We should be integrating the technology too.

Grant: Right exactly.

Emma: Right so but if we have alternatives so that if you can't do the virtual because I don't do most of them truthfully but I do think that it needs to be in there but a teacher who doesn't have it can still do something meaningful.

The team lessons to this point were written by the teachers and incorporated technology wherever the individual teacher wrote technology use into different lessons. Based on the technology access discussion, the team moved to integrating both technology and non-technology options into lessons. The team division was evident in the way group members addressed each other during the meeting. Colorado referred to the biology teacher subgroup as "you guys," and Emma referred to the teacher subgroup as "we" again. Both Emma and Will shared norms within their schools regarding technology availability, and Grant's use of "they" referenced availability for high school biology teachers across the school district. As the co-program manager, Tisha was quiet for most of the meeting until she commented about biology HSA and inserted the decision making authority.

Tisha: We just cannot afford for that [pacing and assessment issues of lessons] to happen in HSA biology. It just cannot happen. So you know, we really have to, you know, strike a balance. We really have to as a group you know be very clear and deliberate about you know what are the assessment limits? What are the expectations? What are the certain things that are non-negotiable, and how to you know work through these experiences and help the teachers help the kids through these experiences so there will still be the inquiry experience, but we are not losing sight of you know what they need to know in order to pass an assessment- that truly isn't an assessment for an inquiry course so you know it is difficult to you know if we are talking about an assessment piece that's not aligned to our curriculum you know that's really difficult so we need to be explicit and deliberate in my opinion about that.

Tisha referred to the team as "we" and then used the same term, "explicit," that Colorado used in her opening comments. Instead of wanting teachers to be "explicit" in the details of the lessons, Tisha's comments contrasted Colorado's: Tisha encouraged the team teachers to be "explicit" in how the teachers wrote the lessons to help students pass the biology HSA. The contrasting comments from Colorado and Tisha demonstrated the divide between the focus of the education researcher and the teachers regarding the goal for students to learn the concepts well (theoretical) or pass the state assessment (practical).

As she criticized the feedback from Colorado, Emma shared her frustration about template format edits. The divide between the teachers and Colorado deepened. Tisha intervened in a moderator role again, but the tension mounted.

Emma: We are trying to create template that we are not going to have a template that has everything.

Grant: Right.

Emma: Because at some point we are writing things into the lesson and so when you are talking about evidence Grant that's not necessarily something that you're going to have in your engagement you know that's something that the writer is going to have to put in that these are things that –

Grant: Student actions. What are the students doing?

Emma: But we have a whole column for student actions. Well no because it's in the template so when the lesson is written –I mean the evidence of the students are going to be presenting. So I guess it's frustrating a little bit I'm just speaking for myself, but it's frustrating to be told okay put this in there put IFL DL IFL DL with taking away the thought that we're going to write lessons the way that you know we I mean like Dorothy is saying "I want to write. I want to write." Because we're going in circles about a template that we're trying to incorporate every single little piece that we can think of into this template when I think that this really it says teacher actions student actions so in there the curriculum writer okay should be able to say, “This what your students should be doing right now. This is what the teacher should be doing right now.” And some of the infusion pieces we’re going to infuse but I think teachers are not going to see it any more if you put this in everything they’re never-they’re not going to see it any more. Right. Because you get so it’s always there so like we’re already going to lose the focus on some of these things, because we’re putting it –we’re assuming that if we put it enough that it’s going to be like advertising if you see Tide enough you’re going to go to the store and buy Tide. If you see accountable talk enough, you are just going to ignore it in the lesson. That’s the reality of it, and we can talk about it all we want but the reality is the teacher is going to be like okay yeah this has got all of those accountable talk in it now what do I need to do?

Grant: Well you know the reality of it at the end of the day as the trainers come in to train they will go over it. I mean-

Emma: Right and that’s why we have student actions and teacher actions.

Colorado: When we looked at the student and teacher actions, nothing looked like it was science.

Emma: Well, we haven't rewritten our lessons yet. We haven't even had a chance to do that.

Tisha: So are you [Colorado] saying that the terminology that we came up with doesn't look- it's not science?

Colorado: This doesn't even look like science. This could be social studies.

Emma: The descriptions of student actions. Is that what you are saying? What's in student actions? But Colorado that's-we took that-we sat with your template and it said think-pair-share like it had strategies for how you get students to do things so we took that really from-that was the feedback that you gave us so that's what we were trying to do with it.

Tisha: We were trying to be specific about how we would because it seemed like from your feedback it was like well what would this look like? You know be more specific you so that's why we went that way.

Later, Colorado added that the template that they created was to be used by the writers and would not need to be seen by everyone else. Emma said that maybe other teachers would not see it, but she thought that the template is also to "appease the school district administrators" and to show them that IFL is in the curriculum. The teachers were even more confused since they designed and adapted the template with other school district teachers' use of the document in mind.

At the end of the meeting, Colorado asked where the teachers thought they would be before she attended a writing meeting on June 24th. The teachers planned to begin writing in the summer writing sessions on June 21st. Teachers continued to write lessons at home and received additional pay between June 3rd and until June 21st. Emma suggested that instead of meeting during that time period, everyone selected a night and used Google Chat to communicate any questions that writers had while writing. Colorado would wait to review more lessons until Grant sent lessons to her.

June 21st through July Writing Meetings: Writing in Isolation

During the summer writing time, teachers attended when they were available and sat in the same middle school classroom. The teachers wanted time as Tisha said to “sit silently in the same room and write lessons with only interruptions if someone had a question.” The teachers listed when they would be late or absent on certain dates on the left side of the whiteboard in the front of the room. Daily, teachers entered the room at various times and set up a workspace area. Each teacher sat in a student desk or at a long table in the middle school classroom, listened to music through headphones and typed lessons on a laptop. When teachers had a question, they interrupted another teacher for clarification, but most of the time the room was quiet with the sounds of keyboard typing and various muffled music. Content flow questions were directed to Tisha and format questions were directed to Emma.

Colorado attended a meeting on June 24th, and she shared with me that the biology team had not sent any lessons to her for review. She spent most of her time in another room with the ninth grade curriculum group. During the meeting on June 24th, Grant was also nervous since he had to present a completed first quarter of biology curriculum to the school district administrators at eleven o'clock that morning. The teachers quietly typed away on their laptops before, during, and after his meeting. The school district administrators were pleased with the document, but wanted more work completed quickly.

During the remainder of the writing time period, the team added a technology summary paragraph before each unit which included an overview of where different types of technology could be inserted, and teachers wrote the lessons embedded with technology (i.e. PowerPoint presentation, videos, or virtual labs) as well as alternatives to technology (i.e. printing out web content for teachers or referring teachers to the laboratory manuals) within the lesson template. The first draft of the document was completed and the team concluded activities for the summer.

Team Effectiveness Framework Findings

The biology team's contextual and antecedent inputs shaped the team mediators and resulted in the team performance and goal attainment outcomes. As shown in Figure 6, I utilized the Team Effectiveness Framework constructs apparent within this case to examine how the team worked to create technology-infused high school biology curriculum. First, I present the findings. Then, I offer suggestions of how this team could have increased team effectiveness.

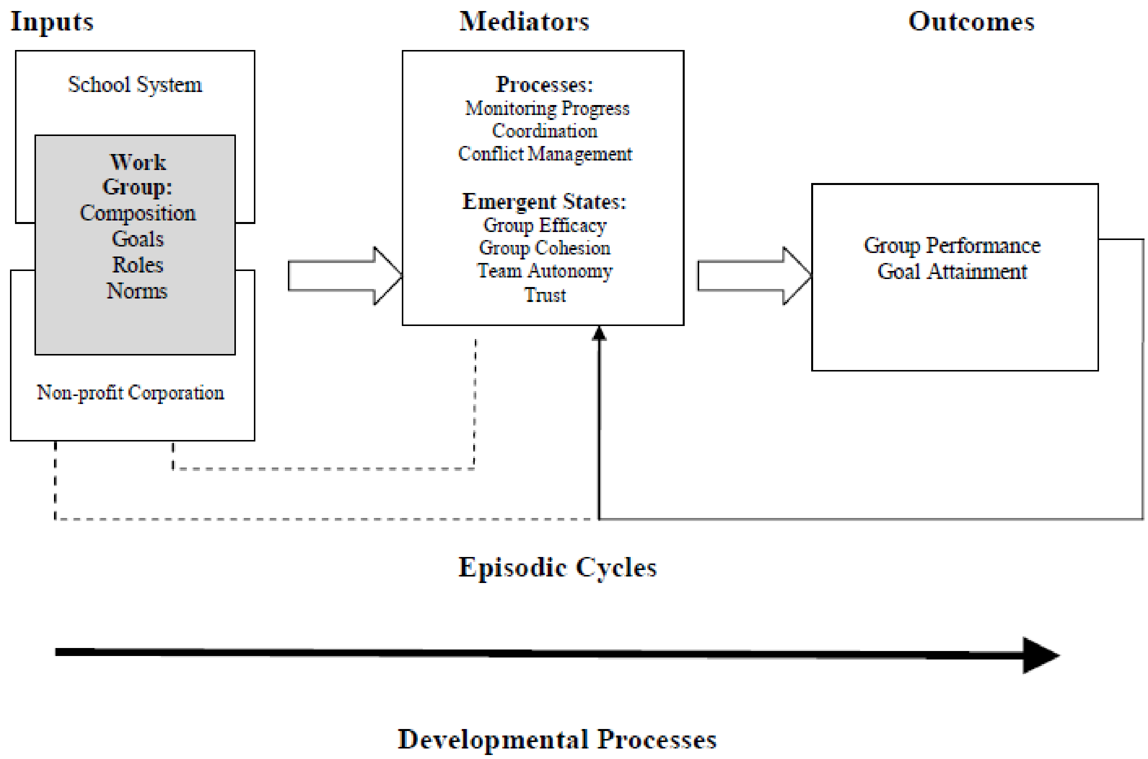

Figure 6: Adapted Biology Team's Team Effectiveness Framework with inputs examined and mediator constructs apparent during team interactions (J. Mathieu, et al., 2008)

Quilted Technology Infusion

The goal to infuse technology into the biology curriculum was set by the school district level administrators. The biology team had an eclectic way to infuse technology. At first, each teacher wrote lessons for biology to infuse different types of technology (PowerPoint slides, videos, virtual labs, Internet activities, etc.) into lessons. The selection and use of technology was a function of the types of technology and access to resources that each teacher had within his or her own classroom setting. Later, after the team discussed access differences among schools across the school district, the team added both technology and non-technology options for biology teachers to select.

The biology team was able to meet the goal of technology infusion in part due to the two technology champions, Grant and Emma. They advocated for more technology infusion during team meetings. Grant consistently shared technology resources (equipment, website content, simulations, virtual labs, etc.) with the team teachers, but he did not encourage the use of any particular technology. He left technology infusion decisions to the biology team teachers. In early meetings and in side conversations, Emma shared how she used her iPhone and other technologies in her classroom. Unfortunately, she did not share technology uses in later meetings, because her focus shifted to the template format and her editor role to integrate all of the lessons into the template. The team benefitted from having technology champions and eclectically infused technology across all of the biology units.

Team Roles: Who is in charge?

The team struggled with leadership and role clarification issues throughout curriculum development. First the lead science supervisor, Steve, left the group and with his exit, the team removed the curriculum scenario concept Planet X that he had advocated. Consequently, the curriculum had to be completely modified. Next, Melissa, another science supervisor, also left the group. The only science supervisor who began and remained with the team was Grant.

Grant’s approach to leadership differed from Steve. He allowed the biology teachers to gain a level of team autonomy in terms of making content and technology decisions. He listened to content discussions and occasionally offered suggestions, but he mostly deferred the content flow decisions to the teachers. He also championed the use of technology and provided resources for the teachers to increase their exposure to different types of technology. In addition, he elevated two teachers to co-program manager status when they had already assumed editor roles with the group. Tisha edited and organized the flow of content and task assignment and Emma, who had edited the template format for the ninth grade curriculum, assumed the format editor role and assembled the lessons into the ever-changing template. Their increase in status also meant an increase in pay since they would assume more work than the other teachers. The division of workload was an issue for the teachers. The teachers wanted to make sure that each had a fair share of work and that no one was doing more work than anyone else. Tisha ultimately directed the division of labor. First, she solicited volunteers who attended the meetings for topic selection and then she sent emails to the absent team members. Although teachers left meetings early and were tasked to write more lessons at home, they struggled with how to write the lessons and how to adhere to the changing template format. Their work productivity was low.

Colorado's team roles were as an expert role for the 5E instructional model and the IFL principles and as an editor to provide feedback to the teachers. She repeatedly provided information to the teachers and attempted to give the teachers feedback, but her recommendations were not well received by the teachers. The biology teacher subgroup resisted her guidance, and Grant ultimately devalued her contributions during the May meeting and provided the teachers with what they wanted to hear, which was, "We own our curriculum." The teachers did not have to follow her guidance. After a member check, Colorado shared with me that my account was accurate and that she felt that the school district administrators had competing demands. She attempted, but was not able to fully assume an editor role in the group.

Isolating Members with Multi-level Norm Discussions

The team acted as a bridge spanning between two distinct organizations, the local school district and research institute. At each level, norms were imposed which shaped the behavior patterns within each level. Norms at each school varied depending on the school administrators and resources within each school. Norms within each classroom were shaped by the individual teachers but were also influenced by other levels above the classroom level such as the school district and biology HSA (see Figure 7).

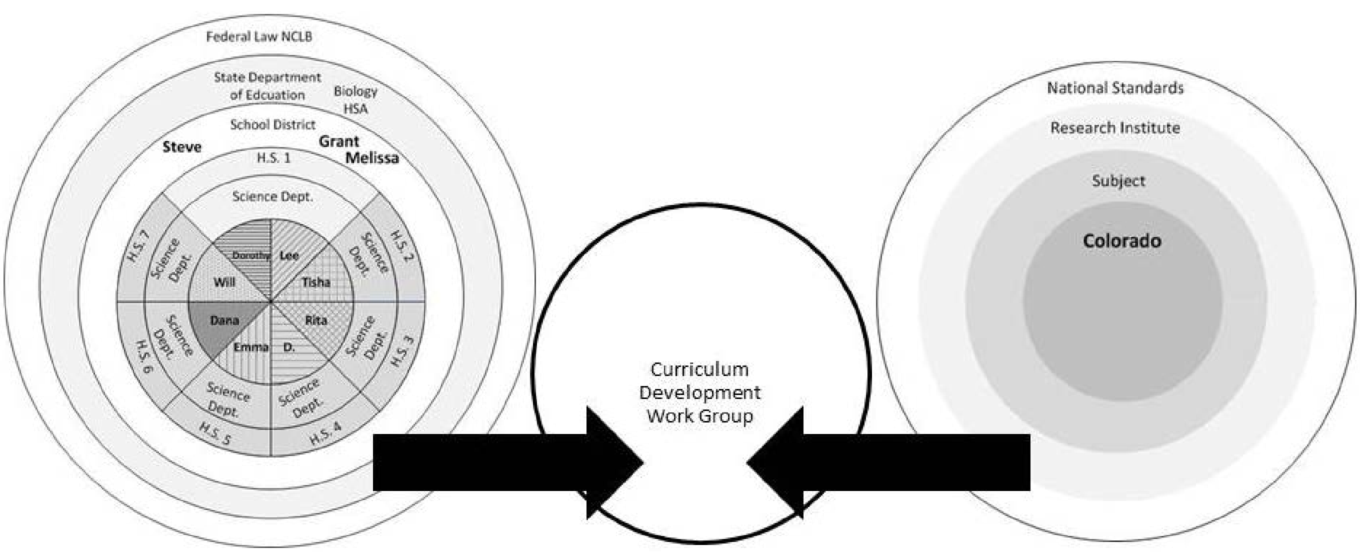

Figure 7: Biology Team Members' Multi-level Norms. This figure illustrates norm levels that each team member brought to the curriculum development team. Each teacher set his/her own classroom level norms while working under the norms set by

the other levels (science department, school, school district, State Department of Education, and Federal Law). Lee and Dorothy were the only teachers who taught in the same school. As school district science supervisors, Steve, Grant, and Melissa reported to the Director of Curriculum and Instruction under the Superintendent at the school district level. Colorado, who was an external education researcher consultant, shared norms from her institute and from other states and school districts where she consulted with other curriculum development groups.

Team members shared and compared norm differences during meetings. Teachers shared how they taught concepts within their own classrooms. At times, the discussion revealed variations in school administrators' expectations such as the lengthy discussion regarding whether objectives and warm-ups needed to be visibly posted in the classroom at all times. The overriding norm that exceeded all other changes was the biology HSA. The teachers used their biology HSA expertise to control curriculum changes. The teachers did not acknowledge Colorado's expertise of how other school districts resolved issues or her guidance with what content to include; instead, they inserted conversations of why changes were needed due to the biology HSA content. Colorado was not the only group member that they isolated with the biology HSA norm level discussions; they also invoked their biology HSA expertise to manage and to devalue input from Steve, Grant, and Melissa. Since all three science supervisors left the classroom and no longer prepared students for or proctored the assessment, they lacked the current knowledge of how the assessment content changed from year to year, and the teachers quickly inserted their current lack of biology HSA knowledge.

School level norm discussions involved issues of access to resources and school level administrators' norms. Teachers in the team taught in seven of the twenty-two school district high schools. They shared how resources, such as the computer performance systems also known as the clicker systems, were supposed to be available to all biology teachers, but were in fact rarely accessible. School level norm comparison included which schools had adequate computer resources in each class, laptop carts that were outdated, and even adequate and consistent access to the Internet.

Team Trust Barriers

The teachers lacked trust in Steve and Colorado. Steve left the group and his Planet X scenario ideas were omitted by the teacher subgroup. Next, they focused on Colorado and refused to attend to her comments and guidance. The teachers preferred to hold meetings without her, because they wanted meetings coordinated and conducted in their own way with the teachers making decisions. According to Dorothy, the teachers perceived Colorado as "slowing down" the process with more group discussions that confused and frustrated the teachers. Time spent discussing rather than writing and moving on to the next set of topics concerned the teachers who worked under a tight timeline imposed on them by the school district administrators. Teachers preferred to talk through how to link concepts in team meetings without Colorado present and shared their classroom norms openly with each other without someone questioning them. Their discussions increased the teacher subgroup cohesion and subgroup efficacy and empowered the teachers to complete the concept flow the way that they wanted to write the artifacts.

Recommendations to Increase Team Effectiveness

The biology team had tensions that emerged during curriculum development. The tensions included a struggle over who was in charge of the team. Once the teachers retained subgroup autonomy to make content flow, template edits and technology infusion, the teacher subgroup cohesion and efficacy were high. In fact, two more teachers joined the group and no teachers left the group. However, overall team efficacy and cohesion were low. Two science supervisors left the group, and the teacher subgroup did not utilize the education researcher's expertise. Team trust was also low: the biology teacher subgroup refused to acknowledge Colorado's comments and instead resisted her guidance. Below I provide recommendations for how the team could increase team effectiveness by more consistently infusing technology, clarifying group roles, sharing multi-level norms, and building team trust.

Consistently Infusing Technology

The team had two technology champions who shared a variety of technology with the team, but the team lacked organization. Teachers shared technology issues during meetings, but the team did not have a more specific access discussion with the entire team present until the June third meeting or seven months after the group began to write curriculum. The group also had limited information regarding technology access for all of the twenty-two high schools where the biology curriculum would be implemented. The teachers who represented seven of the high schools shared their own experiences from access to equipment to the lack of consistent access to the Internet. At the very least, the group needed more direction on specific technology that should have been infused more consistently into the curriculum. A technology editor could have provided more consist editing across all of the lessons in the curriculum instead of the quilted variety that the biology team created. In addition, the group could have benefited from an education technology expert who could develop or alter existing technologies for infusion into the high school biology curriculum.

Including Members in Multi-level Norm Discussions

Unlike the elementary group, which inadvertently isolated the middle school teachers through multi-level norm discussions, the biology teachers more pointedly inserted norm level discussions in order to control decision making in the team. The teachers' biology HSA expertise was used to control group discussions and decisions. The biology teachers gained subgroup autonomy to make changes based on their biology HSA expertise, and they inserted biology HSA content to override Steve, Melissa, Grant, and Colorado during meetings. With only forty-eight percent of the high school students passing the assessment, the school district was eager to make changes in how the students learned biology, but the teachers resisted changes to the content that they felt would take the students too far from what was needed to pass the high-stakes state biology HSA.

The team seemed to work well when Tisha had an outline that she created for the second quarter during the February and April meetings. The group began and organized their discussions around modifications of her outline which provided the group with focus. The team would have increased work productivity by having a school district representative work with Colorado or even a State Department of Education Science liaison to draft a content flow outline for the team. The teachers may have balked at the origin of the document at first, but at least their discussions would have begun as organized with an outline in December instead of still arguing over the content flow in June. At the very least, the teacher subgroup should have had a more open discussion about the biology HSA norms with Colorado in order to open communication between the subgroup and Colorado and to enable the teachers to share more of their concerns regarding how the biology HSA impacted norms from the school district to the classroom levels.

Building Team Trust

The team did not trust Colorado or Steve. Steve exited the group and the teachers rejoiced. Colorado attempted to repeatedly share information and to provide guidance to the team, but the teachers did not follow her suggestions. Colorado tried several different approaches. She emailed teachers, provided documents in different meetings, and finally made a more formal presentation. None of her approaches built trust with the teachers; in fact, her approaches seemed to widen the divide between them. Without further team leadership or school district leadership support, Colorado could not assist the team further. Ultimately, the school district spent money on an external consultant, which resulted in no real improvements or changes to the curriculum. Colorado could have had a more positive impact within the group if she had support from the team members and a clearer expert and editor roles to facilitate the writing process for the biology teachers.

The group also needed stronger leadership from the school district administrators above the science supervisor level. The school district level administrators did not attend any writing meetings. The administrators relied on information about the group's progress from Steve at first and then Grant later. Since the technology infusion, 5E instructional model and IFL principles goals were set by the school district administrators, the group may have worked toward all three goals earlier in the process if a representative from the Director of Curriculum and Instruction or the Superintendent's office addressed the group and set the goals in person during an early writing meeting. During writing meetings, teachers referred to the school level administrators as "they" rather than call anyone by name, and the teachers were slow to incorporate all three goals into the curriculum artifacts which led to more episodic cycles, increased work productivity, and more lesson drafts. The higher level school district administrator did not need to attend each meeting but could have assumed a boundary spanning role between the Director of Curriculum and Instruction office or the Superintendent's office and the team and attended meetings occasionally in order to offer suggestions on the progress of the document and the writing process.

The teacher subgroup grew in membership and strength due to the subgroup autonomy. The teacher subgroup was more comfortable with modification suggestions from fellow teachers and not from Colorado or Steve. Once Steve left the group, the subgroup gained subgroup autonomy under Grant's leadership. Grant allowed the subgroup to make decisions. Even though Grant at first devalued Colorado's comments in the May meeting, he then attempted to have the teachers consider her comments later in the meeting. The conflicting message was not received by the teachers. Once they heard that they did not have to abide by Colorado's comments, they did not indulge his pleads to consider the comments and instead changed the document based on the newest teacher's comment, Will. Trust needed to begin for this group with clarification of goals, roles, and workflow.

Case Conclusion Summary

Over eight months, the biology team teachers created a high school biology curriculum which integrated IFL principles, adhered to the biology HSA assessment limits, adhered to the 5E instructional model and infused technology. The teacher subgroup had high subgroup cohesion and subgroup efficacy. The teachers worked well together relying on each other for advice on how to edit lessons. Although teachers were frustrated with Colorado's suggestions, the teachers made limited modifications, which stemmed from her guidance. Instead, the teachers felt more comfortable and trusted each other for edits to lessons, content flow and technology infusion rather than an external education research consultant.

Although the biology team met the goal of creating an artifact, the team inconsistently infused technology. Technology infusion was based on each team teacher's own use and access to technology resources in individual classrooms. As with the elementary science team, the primary concern for the infusion of technology was the lack of infrastructure throughout the urban school district and the concern was consistent with previous technology innovation studies (Marx, et al., 2004). For this team, technology resources were apparently available on paper, but perhaps not in reality in each high school biology classroom, and therefore, technology infusion was not consistently infused across each school and across the units in the high school biology curriculum.

Chapter 7: Cross Case Analysis

The three cases in this study reflect the diverse real-world contexts in which science education curriculum development groups operated. Even though subgroups formed and tensions emerged within each case, subgroup formation and tension occurred with different combinations of inputs and mediators. In this chapter, I analyzed across all three cases to examine themes of how science education curriculum groups worked to develop technology-infused science curriculum, utilized the Team Effective Framework to categorize the themes, and presented the findings below.

Inputs: Assembling Science Education Curriculum Development Groups

The school districts in this study assembled each science curriculum development group with different contextual and antecedent inputs. I examined input constructs (goals, roles, and norms) across all three cases and determined themes common to all three groups that directly impacted their work process and the resultant technology-infused science curriculum artifacts. The selected constructs provided the structure for me to examine how the teams assembled and began to operate.

Setting Goals: Defining Technology Infusion

As previously described, technology has many definitions in today's Twenty-first Century world. As detailed in chapter one, I began this study by positing a broadly conceived definition of technology: information and communication technologies that include personal computers, the Internet, and handheld devices, such as the new generation of tablets. Although STEM initiatives called for technology-infusion in K-12 science classrooms to prepare students for Twenty-first Century workforce, STEM initiatives to date do not offer specific guidelines of how to best infuse technology into science curricula.

Through the three cases in this study, I learned that the lack of specific guidelines led each group to varied interpretations of how to define technology and how to infuse technology in science curriculum. The elementary team mostly referred to technology as Internet access and use, but they also expanded the definition to include video clips and an engineering definition of technology in order to satisfy meeting the goal of including technology wherever possible. Their inclusion of the engineering definition to satisfy the technology goal was interesting for two reasons. First, the definition that they included reduced technology to a hands-on electricity current lesson, which was a standard part of the school district's curriculum already. Second, the merge of technology and engineering condensed the emphasis of each STEM area and did little to enhance the infusion of either area in a traditional science lesson.[11]

The biology team had an eclectic approach to defining and infusing technology. The biology teachers wrote lessons and included technology into each lesson based on their own existing access to and use of a variety of technologies in their own classrooms. Along with virtual labs, PowerPoint presentations and Internet

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[11] This study only focused on the technology aspect alone and not how engineering has been infused into science curriculum, but by combining the engineering definition of technology with the technology aspect reduces the impact of altering the curriculum to align with both STEM initiatives.

access, the biology team also included video clips as part of the definition of technology. I question whether the use of video clips satisfies Twenty-first Century technology infusion. Television, cable television, and Internet video clips have been used in science classrooms in the previous century and do not prepare students for the Twenty-first Century technology–rich workplace environments called for within the STEM initiatives (STEMED, 2010). While the use of video can still benefit students' learning of particular concepts, the use of video should not fulfill the requirement for school districts to infuse Twenty-first Century technology into science classrooms.

Unlike the other two cases, the chemistry team was the only group that targeted the infusion of a specific Twenty-first Century innovation: computer simulations. The chemistry team adhered to design-based science research methods of technology-infusion. Each simulation targeted student learning objectives and was accompanied by two documents, teacher and student manuals. The technology-infused curriculum was not meant to replace the school district's chemistry curriculum, but was meant as an additional technology resource for teachers to insert into lessons that covered the targeted content. While this method is not the only method that requires more specific technology infusion, the design-based research method provided an example of how to target specific technology-infusion, student interactions within computer interface simulations.

Setting Goals: Directive Goal Functioning

Team leaders set group goals differently in each case and how these goals were set impacted group interactions (Locke & Latham, 2002). Claudia set the group goals to create fourth grade science units and to infuse technology wherever possible.

The teachers worked with ambiguous goals and the lack of constructive feedback to produce artifacts. For the biology team, school level administrators set numerous goals; however, Steve and Grant conveyed the multiple goals to the teachers rather than a presentation from higher level administrator. Unfortunately, the teachers struggled to include all of the goals while they wrote: teachers rewrote lessons to include IFL principles, to reformat the 5E instructional model, and to infuse both technology and non-technology options into lessons. The increased work intensity and decreased workflow frustrated the teachers, led to decreased teacher motivation (Locke & Latham, 2002), and led to additional episodic cycles for the team to endure before outcomes were achieved (J. Mathieu, et al., 2008). Since the chemistry team set a specific technology-infusion goal and the chemistry team teachers found value in the innovation for their students, the goal to create computer simulations energized and motivated the team members to deliver the artifacts before the summer institute deadline. Despite increased work intensity to attain the goal, the chemistry team persevered as a group, and group members relied on each other's expertise and assisted each other with task completion.

Supporting Group Assembly: Access to Funds

All three groups required funds to pay curriculum writers. The elementary group relied on state and federal funds to pay the teachers. The chemistry team also relied on a state grant to fund the team members. The biology team used grant funds and school district funds to pay teachers and the education consultant, but the group did not utilize the education researcher to the fullest potential. Although funds are required to support the work to create technology-infused science curriculum, grant stipulations can impact how a science education curriculum development group operates. For example, the chemistry team was required to have shared leadership with a representative from the school district, education researcher, and scientist. Likewise, the elementary group reduced cost and the number of teachers to two per grade level for the second phase of curriculum development. School districts need to be aware of grant requirements when they seek funds for science education curriculum development groups and how such requirements may shape the inputs and mediators of the team.

Assessing Technology: Access to Technology Resources

In addition to struggling with how to define technology, the three groups struggled to create technology-infused science artifacts given that both school districts faced the same concern with the lack of access and infrastructure to technology in the schools, which is consistent with previous technology innovation studies (Marx, et al., 2004). All three groups addressed the constraint in distinct ways. As shown in the elementary case, Lilly and Cindy had access to resources supplied within their school that were not available across the school district. The elementary teachers noted resource disparity, and the team thus limited technology-infusion within the artifacts to include only websites that teachers could read for scientific background knowledge.

The biology team began to infuse technology into lessons until team teachers acknowledge the inadequate Internet access and hardware (outdated computers, insufficient access to computers for large class sizes, etc.) throughout their schools. Given the limited access, the biology group created a menu of technology and non-technology options for teachers to consider as they planned their daily lesson plans. Unfortunately, the technology-infusion in the biology high school curriculum that was created resulted in the possibility of one classroom infusing many lessons with a variety of technology and another classroom infusing no technology given a lack of available resources.

The chemistry team was fortunate to have access to a class set of adequate laptops supplied by the university for teachers to use during lessons that infused the targeted computer simulations. The increased external funding and the access to additional technology resources enabled teachers who were trained in the summer institute to infuse technology into lessons throughout the school year as long as they were affiliated with the grant-funded project. Each group compensated for technology resources and access, and the variation in both resources and access impacted how technology was infused into science curricula artifacts.

Defining Roles: Appointed and Emergent Leaders

Each case also struggled with leadership issues regardless of whether the group leaders were assigned or emerged (Hogg, 2001) during curriculum development activities. The elementary team leader, Claudia, led all of the grade level teams; therefore, her time to devote to each team was limited. She also allowed the fourth grade level team to meet at the schools instead of the school district headquarters and did not reply with constructive edits for the fourth grade team to consider as they developed the fourth grade science units. In Claudia’s absence, Stacey assumed a subgroup leadership role, but she deferred leadership responsibilities such as facilitating task roles for all group members and monitoring group member's work to Claudia. The lack of the leader during writing meetings led to an episodic cycle in which the subgroup of elementary teachers strengthen and made team decisions without input from the middle school teachers or team leader. The workflow changed and only the elementary teachers wrote the remaining unit lessons.

The chemistry team was required by the grant to have shared leadership, but as shown in the case narrative the bulk of the leadership was left to Paul, the education researcher. In fact, the scientist and science supervisor became peripheral members of the group and helped when they attended one and two meetings respectively. Paul assumed multiple roles (writer, editor technology developer, etc.) other than the group leader and eventually he had to hire another technology developer to assist in completing the curriculum in time. The addition of another peripheral team member alleviated additional work for Paul and Jon but did not significantly impact team interactions. The team added the review of the animations to the agenda and discussed revisions during group meetings. The issue within this case stemmed from the mandatory shared leadership model imposed by the government agency which awarded the grant. In reality, the leadership role fell on an individual member, Paul, without an equitable shared leadership between Paul, Dr. Ridley, and Steve.

The biology team had a change in leadership during curriculum development; the new leader, Grant, allowed the biology teachers to gain a new level of team autonomy. The episodic cycle enabled the biology teacher subgroup to set different group goals and norms that led to a complete overhaul of the artifact. After the change in leadership, the biology team struggled to organize under and to establish a new workflow until two teachers assumed multiple roles: program managers, editors, and writers. Due to the tension between the biology teacher subgroup and the education researcher in the biology group, the education researcher was unable to assume a more prominent editor role in the group, and Grant struggled to address and resolve the tension. Although each group struggled with different leadership issues, each team leadership issue directly impacted workflow and group cohesion (Hogg, 2001).

Assigning and Facilitating Group Roles

Across all three cases, group members assumed various task, socioemotional (Bales, 1950) and boundary spanning group roles (Mumford, et al., 2006) that evolved during curriculum development. Group leaders in each case assembled group members and assigned group task roles to varying levels of specificity. Traditional group task roles (writers and editors) were set in each group. Initially, all teachers in each case assumed writer roles, but the writer role also evolved in each case. In two of the three cases as the writer roles transformed, the team work progress was altered and team cohesion decreased (Kozlowski & Ilgen, 2006). The elementary teacher subgroup excluded the middle school teachers from writing the fourth grade activities and began an episodic cycle with fewer writers. The work progress and work intensity increased for the three elementary teachers, but the overall team cohesion decreased.

The biology team cycled through several episodes that included growth of the teacher subgroup by two additional teachers and the redistribution of leadership and editor task roles. The biology teacher subgroup controlled curriculum content and format decisions and excluded contributions from the education researcher. The work progress was unorganized at times for the group and slowed significantly by the change in leadership and constant cycling of rewriting the curriculum. The team cohesion was decreased as the biology teacher subgroup strengthened (J. Mathieu, et al., 2008). For the third case, the change in task roles increased the work progress and team cohesion (J. Mathieu, et al., 2008). In the chemistry team, the teachers' written contributions varied based on the expertise and focus, such as G.W. as the IFL expert, that each teacher shared during meetings.

Beyond the task roles assigned within each case, socioemotional and boundary spanning roles emerged during group interactions. Two particular socioemotional roles, motivator and monitor (Mumford, et al., 2006), were assumed by multiple group members in each group. Group leaders often assumed both roles, but other group members, such as Lilly and Cindy in the elementary team, Tisha in the biology team, and Sally in the chemistry team, also assumed the roles as they felt comfortable interacting with the group and sought to keep the group working while attempting to minimize the tensions.

Team members in each case assumed socioemotional roles including motivator and monitor roles. By examining which team members assumed motivator and monitor roles and how the team members assumed the roles, team leaders can explore what techniques worked well. Lilly used humor particularly self-deprecating humor to monitor and motivate the elementary team members during writing meetings. Even though she provided moments of laughter, her attempt to lessen the tension in the team did not work. Cindy took a different approach in the elementary team. She monitored progress by keeping the group on task and moving from one task to another. While her method usually worked, she inadvertently disregarded Nelly's comments in the January meeting and moved the group to the next topic quickly. Tension between Nelly and the elementary teacher subgroup increased. Both Tisha in the biology team and Sally in the chemistry team used a similar technique to check in with group members, who were initially in opposition to a group decision, during meetings. They intervened and provided fellow teachers with more time to voice concerns and/or confirm that they agreed with the group's decision. The techniques worked well for both Tisha and Sally, but caution should be taken when drawing the group's attention to one group member who might feel pressure to conform to the group rather than voice concerns. In both of their cases, the other group members, Dorothy and Lady Beetle respectively, demonstrated throughout group meetings that they were comfortable voicing concerns.

Each group member worked outside of the team and assumed boundary spanning roles between the school district or external organization and the team. For example, a chemistry teacher bridged from her classroom, science department and school to the team. Each teacher advocated for time devoted to the team with local school administrators, such as school principals. As shown in each case, teachers who were involved in the curriculum development team often assumed additional roles at the school level such as Nelly who worked with middle school students to review for state testing during an after school program, D. O'Neil who was a coach, or Sally who advised a youth summit student technology team from her school.

Other particular boundary spanning roles required attention outside of the group in order for the team to continue to work. For example, Paul assumed the primary principal investigator for the chemistry team grant, and he needed to interact with the state grant representatives in order to demonstrate the team's progress, to complete the grant process, and to reallocate funds. Likewise, Steve and Grant assumed boundary spanning roles with the school district level administrators to acquire more funding for the teachers and push the workflow timeline from June to July. Groups should identify which members need to assume particular boundary spanning roles external to the group and provide support (Mumford, et al., 2006), such as information to any member with a boundary spanning role or additional communication from other team members to external liaisons.

Establishing Group Norms

The group norms, such as meeting times, document templates, and workflow evolved similarly across the groups as the group members worked together, but group leaders also established group norms early during curriculum development in distinct ways. For example, both the elementary team and chemistry team leaders established the group norm of setting meetings to specified times and adhering to those times. The biology team leaders set times, but leaders allowed for teacher attendance flexibility and required teachers to attend when they did not have other obligations. The relaxed start and ending times for the biology team meetings interfered with group discussions as members entered late, left early, or were absent from meetings.

Group members' absences occurred in all three cases and led to workflow interruptions, decreased work productivity, and at times additional episodic cycles (J.

Mathieu, et al., 2008). Group members' absences meant that expertise needed to make group decisions was lost in each case. Teacher absence due to the additional school responsibilities often contributed to decreased work progress and productivity issues. On the elementary team, Claudia did not attend the writing meetings, and each middle school teacher only attended a single meeting. The elementary teacher subgroup made the bulk of the decisions on how to complete the fourth grade science units and struggled with content issues and concept flow. Biology team members were not always present when the group made particular decisions that resulted in topics repeatedly discussed month after month. With members entering, exiting, or not attending meetings, decisions were made and then addressed again and at times decisions were altered or reversed. The biology workflow would advance and then recycle repeatedly, which resulted in lower progress and increased work intensity due to the constant revisions. Likewise, the chemistry team delayed selecting the third unit to develop for the Connected Chemistry Curriculum for two months until the meeting location was changed to accommodate the school district science supervisors, Steve and Grant. Because of the delay, the chemistry team had to hire an additional Flash animation programmer in order to increase work productivity.

Another norm that each group established was a document template. Both the elementary team and chemistry team leaders provided a template to the group. The elementary team did not attempt to alter the template, but the chemistry team openly discussed any template edits that were needed in team meetings and altered the template as needed. For the biology team, disagreement over the template format increased tension between the teacher subgroup and the education research consultant, Colorado. The biology teachers changed the template several times and happily accepted edits from fellow teachers, but not from Colorado. The lack of consensus and the continued template alterations forced the teachers to rewrite lessons into several different template versions and enter additional episodic cycles. The increase template alterations led to decreased work progress and decreased teacher motivation in the biology group (Postmes, et al., 2001).

Finally, each case established norms regarding workflow in order to meet the goal of creating technology-infused science curriculum and altered the workflow as each team went through episodic cycles. Each case suffered from follow-through issues, but each group managed the issues differently. In the elementary team, Claudia, the science supervisor was tasked with reviewing and editing the units. The teachers received cursory feedback on the lessons (e.g., "looked good"), but the teachers did not receive additional constructive edits that would assist them as they continued to write additional lessons. Instead, the elementary teacher subgroup continued to work and completed the task of creating the units. The biology team suffered from a change in leadership which in turn set the group back to rewrite the entire document. Then, Grant, the new leader, deferred leadership roles such as editing content and format to teachers who were also program managers and writers rather than have the education research consultant assume a more prominent editor role. The group was supposed to have the full year of curriculum written by early June, but by June 24th the group had only managed to assemble and present the first quarter lessons to the school district level administrators.

Within the chemistry team, and as noted earlier, the decision making process that spanned two months to select the third unit set the chemistry team back and interrupted the workflow. The chemistry team increased work productivity by utilizing group member back up behavior and hired an additional Flash animation programmer to lessen the burden of programming tasks on Paul and Jon. Hiring an external programmer also meant that funds which could have been spent on another aspect of the team or summer institute needed to be first approved by the grant advisor and then spent to hire the programmer. The chemistry team also utilized group member back up behavior when Lady Beetle did not submit her analogy collection, and instead, I inserted her analogies from the meeting transcripts into the teacher manual.

Mediators: Managing Group Members to Maximize Group Effectiveness

Three particular themes emerged across the three cases in this study. As shown in each case, tensions emerged within the groups. The selected process and emergent state constructs enabled me to examine each team with multiple constructs and analytic questions. In particular, issues concerning the curriculum intended audience, the multi-level organization norms and group cohesion and trust surfaced in each case. Below, I analyze each theme across all three cases.

The Dual Curriculum Audience Dilemma

In each case, curriculum was written for a dual audience (teachers and students). Even though both education researchers and teachers shared the same goal to create technology-infused science curriculum to increase student achievement, education researchers' process and teachers' process to obtain the goal differed. As shown in the chemistry and biology teams, tensions between teachers and education researchers (Paul in the chemistry team and Colorado in the biology team) created a dilemma in which the teachers and researchers focused on different primary audiences. Across all three cases, teachers wrote curriculum as a resource for teachers to use as teachers developed classroom lesson plans, and the student audience was secondary to the teacher audience. Teachers focused on student actions and learning, but the focus was on how teachers enacted lessons in the classroom with students. In contrast, the education researchers sought curriculum written for students and the learning progression of students with the teacher delivery as a secondary focus. Paul and Colorado initiated conversations about how to link concepts in order to deepen students' understanding of scientific concepts. Paul shared how the Connected Chemistry Curriculum enabled students to understand submicroscopic molecule interactions with previous research completed in other states, and Colorado shared how other school districts in other states altered curriculum in response to research on how students learn biology concepts.

The competing worldviews of academic researchers and teachers (Carlone & Webb, 2006; Labaree, 2003) began to unpack the tension between teachers and education researchers as they collaboratively wrote science curriculum. Labaree (2003) described transformations that individual teachers undergo as they developed into education researchers; among these transformations is the observation that teachers move away from the experiential in the classroom to theoretical research as their experience grows. The biology team teachers acted as Labaree described by inserting their classroom experiential knowledge about the biology HSA. But instead of using the knowledge to "automatically trump any claim made by an author" in a graduate class, the biology teachers used their knowledge to control curriculum development decisions (Labaree, 2003, p. 20). This multiple case study extends the previous research by demonstrating how the varied worldviews impacted group discussions and curriculum artifacts. The worldviews of researchers and teachers not only differed but also impeded workflow and forced both the chemistry and biology teams to cycle through episodes and alter how the team operated.

The teachers across all three cases in this study worked under varying norms even though they worked within the same larger school district organizations. The norm enforcement variation from school district levels above to the classroom level and teacher's interpretation and enactment of multi-level norms in the classroom accounted for some of the pragmatic approaches to curriculum development that teachers inserted into each curriculum artifact. For example, the type of technology-infusion in each group demonstrated how teachers responded to and changed the types of technologies included and excluded from the science curricula. Teachers in all three cases also further discussed and split the teacher audience for the document into two teacher audiences, novice teachers and veteran teachers. Within in all three cases, teacher discussions of writing for a novice teacher as opposed to a veteran teacher concluded in each case with the group writing for a novice teacher and providing more detail for teachers rather than less details. The increased level of detailed artifacts resulted in decreased work productivity and increased work intensity.

Along with writing more details for novice teachers, teachers also wanted flexibility embedded in each document to account for teacher's classroom autonomy during curriculum enactment while the educational researchers wanted uniformity in teacher delivery to assist students' learning progression. Penuel et. al. (2007) also called for flexibility for classroom contexts, and Paul, encouraged flexibility for teachers in terms of access to materials for the wet lab components of the Connected Chemistry Curriculum. However, in terms of technology-infusion, Penuel et. al. (2007) called for refinements to the technology and Paul provided detailed approaches of how to incorporate the simulations in the teacher manuals; the researchers sought uniformity of technology enactment in classrooms. Interestingly, Paul led the chemistry team to create two separate documents. He began each team meeting by focusing on the student document and computer simulations that accompanied the activities. Then, during discussions, team members shifted back and forth between the teacher and student documents. Having the two separate documents helped Paul facilitate the discussions between student learning and actions and teacher delivery. When the group focused on the student manual, Paul focused the group on students' learning progression, but when team discussions turned to classroom anecdotes, the teachers focused on teacher enactment of the curriculum. Teacher's classroom anecdotes, such as Sally's suggestion to include colored pencils in the materials list for diverse students or Lady Beetle's analogies, were acknowledged and written into the teacher manual. Paul's facilitation allowed for discussions to ebb and flow between the two documents and increase workflow and productivity for the chemistry team.

For the biology team, Colorado attempted to focus the teachers on how to link concepts for students and challenged the teachers to provide details regarding how the curriculum was structured to maximize student learning, but the teachers did not welcome her comments. The biology teachers attended to how to link concepts for students during the team meetings, but their focus was primarily on how teachers would pragmatically use the information as teachers planned classroom level activities and adjusted their own classroom norms. Grant, the ostensible biology team leader, was unable to ease the tension between Colorado and the teachers. In fact, he reinforced this tension when he advised the teachers that they "owned the curriculum."

Navigating Group Discussions of Multi-level Organization Norms

The groups in each case acted as bridges spanning across schools within the same school district organization and between two distinct organizations, as shown in the chemistry and biology teams. Teachers operated under different enforcement of norms from varying levels within and beyond the school district. Within each case, teachers discussed conformance to and departure from multi-level norms. Teachers shared their experiences with each other during and between meetings and advocated for classroom teacher autonomy to be written as options for teachers to select from within curricular artifacts. To further explore how artifacts were impacted by multi-level norm group discussions, I examined each level across all three cases from the federal and state levels down to the classroom levels.

The Federal law, No Child Left Behind, required the state to test students in science at varying grade levels. The biology team was the only group in this study that was directly pressured to conform to the Federal law and the Mid-Atlantic state's high-stakes biology assessment. Discussions about content covered by the biology HSA not only dominated group meeting interactions, but the knowledge of test content was used by the biology teacher subgroup to control curriculum content decisions. For the elementary team, the law was briefly discussed since the assumption at the school district level was made that students remained in the school district and would eventually take the fifth grade science test with content covered from both grade levels. Since the fourth grade units were not directly tested within the fourth grade school year, teachers found areas to depart from the content covered on the state test. Since the State Department of Education only tested biology at the high school level, the chemistry team also did not have direct added pressure to comply with the federal and state content. The chemistry team listed the state core learning goals that aligned with the Connected Chemistry Curriculum, but the chemistry team content decisions were not determined or motivated by the state core learning goals. Instead, the chemistry team made Connected Chemistry Curriculum content decisions based on research motivated by how students learn chemistry concepts.

Curriculum artifacts were written and approved at the school district level. School district level administrators required technology infusion into science curriculum and within all school district classrooms. Unfortunately, and as described in the technology infusion section above, technology resources, access and use varied across the school district. Variation led to group discussions and altered how technology was infused into each document. Without technology resource consistency across either school district, teachers who wrote the curriculum sought classroom teacher autonomy for technology use. For the education researchers, school district administrators such as the science supervisors told them that all classrooms had access to technology, but teachers' complaints during group discussions revealed the issues, such as outdated equipment or software or inconsistent daily access to the Internet, that teachers faced.

Variation in the enforcement of norms also occurred at the school and department level within each school. School principals often conduct lesson observations and teacher evaluations, and teachers felt pressured to conform to the norms set by school administrators. For example in the biology team, the group discussed whether to include objectives and warm-ups in the document and also how closely the warm-ups should reflect the high-stakes state biology HSA. The discussion revealed how school level principals enforced norms differently across the seven high schools in the school district. Some principals required teachers to list and to keep objectives and warm-ups visible during the entire class period, and others principals did not enforce this requirement. Although such a discussion may at first appear to be minor, differences in school level norm enforcement increased tension in the biology team and required several discussions through several meetings before the biology team decided to include objectives and warm-ups in curricula artifacts. Likewise, science department chairs acquired and controlled science equipment. Teachers in both the biology and chemistry teams discussed variation in how science department chairs managed equipment. For example, Sally and Lady Beetle discussed how they selected wet labs as a function of what chemicals a department chair purchased and stocked in the school. In the biology team, Grant insisted that all schools were given a set of laptops and CPS for biology teachers' exclusive use, but Rita complained that even after asking to use the equipment, she was denied access. Although the elementary team did not have department chairs, they had team leaders at each grade level. For this team the disparity of equipment was between school levels. Cindy and Lilly has access to more supplies in the affluent school where they taught than Stacey who described using her own money to purchase science classroom supplies.

The last and perhaps most complicated level was variation in curriculum enactment at the classroom level. Although design-based researchers (Barab & Leuhmann, 2003; Edelson, et al., 1999; Penuel, et al., 2007) acknowledged classroom norm variation, the analysis in this study demonstrated that teachers decision making accounted for some of the norm variation but teachers adherence to norm levels imposed on them above the classroom level also impacted the classroom level decisions. Teachers accounted for variation across classroom levels in all three cases by invoking a "teaching style defense." Emma and D. O'Neil equated the IFL accountable talk principle to a classroom management technique. In fact, D. O'Neil described how he would adjust his delivery of the same content to different classes based on the group behavior, such as too much talking between students in one class as opposed to another class. For the chemistry team, teacher anecdotes such as how to facilitate class discussions or what materials to use with diverse student populations given by G.W., Sally, and Lady Beetle were captured and noted in the teacher manual as helpful hints for teachers to consider when they used the curriculum and computer simulations. The elementary team also shared with each other how teachers changed lessons from year to year and as Cindy explained, “I don’t want to tell someone else what to do in their classroom.” Different teaching styles can be better explained by classroom teacher autonomy to set classroom norms. Classroom teacher autonomy allows teachers to determine which of the multi-level norms to conform to or depart from on a daily basis in the classroom.

In addition to retaining classroom teacher autonomy, teachers’ comfort and experience using technology in the classroom also shaped how technology was infused into the science curricula. As shown within the biology team, Rita infused interactive PowerPoint presentations in her lessons while Emma used a variety of technology that included virtual labs. Teachers needed time and training to increase their understanding of the capabilities of varying technologies and to increase their comfort levels in using a wider variety of technology. Grant attempted to champion technology use and exposed the biology team teachers to a broader variety of technologies, but the group did not even discuss school district-wide technology use until seven months after the group formed. The lack of assessing technology use at the classroom level meant that the previously written technology-infused biology lessons were rewritten again with non-technology options embedded as a menu of options for teachers, and the biology teachers were not able to move forward to write additional lessons resulting in a loss of work progress.

The chemistry team did not have the same technology use and comfort issues as the elementary team or biology team. Since the chemistry team had increased resources and funding, the chemistry team approached classroom technology use differently and provided equipment and training for chemistry teachers who implemented the Connected Chemistry Curriculum. But within the chemistry team, the use and comfort level differences between teachers and students were discussed. Lady Beetle expressed her own acknowledgement of the divide between herself as a teacher and her students as technology users during the January chemistry team meeting, “Because I'm going to be honest, they'll (students) probably figure this out way before we (teachers) did.” Lady Beetle referred to her initial interaction with buttons and sliders in the computer simulations and acknowledged that her students would navigate the simulations easier than she did. Likewise, during the same chemistry team meeting, Sally acknowledged that her special education students would find added value in the simulations, which showed the submicroscopic interactions of molecules, and she thought that her students would equate the simulations to video game interactions where students could “see the parts.” The chemistry team discussed the differences and altered the written directions in both the student and teacher manuals accordingly.

Building Team Cohesion and Trust

Unlike teams who plan to work together daily and over longer periods of time in an organization, the three science education curriculum development groups assembled to create a document, met periodically over a specified time period and disbanded after document artifacts were created. Therefore, the time to build trust among team members and strengthen team cohesion was limited. Group discussions can build team cohesion and trust or create tensions between group members. Marks, Mathieu, & Zaccaro (2001) noted that teams, if properly managed, can employ humor or complaint sharing within a team to improve trust.

> Team activities such as joking, relaxing, and complaining may also be considered forms of affect management, if implemented in a manner that builds cohesion, breaks tension, vents frustration, or manages stressful situations. However, it is also possible that such activities, if managed ineffectively, may lead to increased negative affect, wasted time, and performance problems. (Marks, et al., 2001, p. 369)

In each case study, participants utilized humor and shared laughs during curriculum development, which built trust in some cases, but not others. For example, the elementary team used humor with an embedded joke in their report to the science supervisor. Claudia did read the joke, but did not respond with any additional edits to the document that the elementary teachers sought. Instead, her response to the joke fueled the teachers' frustrations about insufficient feedback. The joke also further isolated Mindy who did not know about the joke until the last meeting. In contrast, the chemistry team shared laughter and anecdotal stories of the teachers' and Jon's classroom experiences and Paul's past classroom simulation implementations. The time spent sharing the experiences enabled group members to better understand classroom contexts, such as the Lady Beetle's Kool-Aid discussion or Paul's technology constraints and alterations discussions. Similarly, each group shared complaints of how technology can or would be infused into science curricula. As noted earlier, each group infused technology differently and the complaints of technology resources, access and use shaped how groups infused technology. Within the elementary team and biology team, complaints limited technology infusion and wasted writing time, which resulted in multiple episodic cycles and additional versions of the same lesson.

Within the elementary team and the biology team, members' complaint sharing led to the formation and strengthening of subgroups. In the elementary team, the elementary teachers complained that the middle school teachers wrote middle school level lessons and not fourth grade lessons. As Mindy joined the group for the final writing meeting and introduced herself as middle school teacher, the elementary subgroup dismissed her contributions. The biology teachers were willing to make additional changes to the biology template when a new teacher entered the team and offered suggestions, but they were resistant to make changes that Colorado suggested. Instead, the teachers complained about Colorado's comments, which strengthened the subgroup through the complaint discussions.

Outcomes: Assessing Science Education Curriculum Development Groups beyond the Artifact

Previous technology-infused science curriculum studies (i.e. Brown & Edelson, 1998; Reiser et. al., 2000; Stieff, 2005) focused on the end product and the use of the product by teachers and students. This multiple case study demonstrated that the process of how groups worked to create the curriculum artifacts shaped how technology was infused into each science curriculum artifact. The Team Effectiveness Framework provided a lens into two selected group outcome constructs: goal attainment and group performance.

As noted, all three teams met the intended goal to create an artifact and to infuse technology, but interpretations of technology infusion varied within each team.

For both the elementary team and biology team, the definition of technology infusion evolved during group interactions. The chemistry team was the only group that focused on a specific technology innovation, computer simulations, and did not change the intended goal during curriculum development. Both the elementary team and the biology team began with the goal to infuse technology and altered how to infuse technology during curriculum development. As discussed previously, each group operated under similar constraints and responded to the constraints. The elementary team responded by reducing technology infusion to listing websites for teachers to use for scientific background knowledge, and the biology team listed a menu of technology and non-technology options for classroom teachers to consider as teachers planned classroom lessons and activities. The biology team had an additional input advantage and contained two technology champions, Grant and Emma, who at least advocated for the use of a variety of technologies. Exposure of technology use and explanations of technology capabilities in the classroom provided the biology teachers with a wider variety of technologies to list within the curriculum.

Team performance varied across all three cases. The elementary team and biology team contained strong teacher subgroups that worked together and persevered to create artifacts, but at the same time, the strength of each subgroup increased tension between subgroup members and other group members (middle school teachers and education researcher respectively). In contrast, the chemistry team contained a varied subgroup with three university representatives and three high school science teachers. The chemistry subgroup completed the bulk of the task to create the artifact, but relied on peripheral members, the chemist and school district science supervisors for decision making, editing and boundary spanning roles.

Workflow and work productivity challenged each team, but ultimately, all three teams created artifacts. Tensions emerged within each team and revealed themes across all three diverse real-world science education curriculum development teams. All three teams met the goal of creating technology-infused science curricula, but each team followed a different process to create the artifacts. As mentioned previously, I analyzed how groups worked to create technology-infused science curricula and examined each artifact to triangulate data of how the artifact was created without evaluating each artifact product. In the next chapter, I provide the study limitations, implications and areas of future research.

Chapter 8: Study Limitations, Implications, and Areas for Future Research

This multiple and exploratory case study provided a lens into how different science education curriculum groups infused technology into science curriculum. I began this study by asking: According to the Team Effectiveness Framework (including group inputs, mediators and outcomes), how do science education curriculum groups work to develop technology-infused curriculum? I utilized the Team Effective Framework to examine how three science education curriculum development groups worked to develop technology-infused curriculum. As shown in the four previous chapters, the school districts in this study assembled each science curriculum development group with varied contextual and antecedent inputs, and those inputs were transformed differently through group mediators resulting in varied group performance and goal attainment outcomes. Even given the variation within each case, themes of group tensions across all three cases emerged. Origins of tensions included group inputs (how the groups defined technology-infusion, assembled group members, assigned group roles, and established group norms) and group mediators (facilitated dual curriculum audience discussions, addressed multi-level organization norms, and built team cohesion and trust) that shaped the science curriculum artifacts. Below I discuss the study limitations, implications, and areas for future research.

Study Limitations

This multiple case study contained several limitations. First, the study was an exploratory multiple case study in which I applied the Team Effectiveness

Framework to science education curriculum development groups to examine tensions that occurred as groups worked to create technology-infused science curriculum. The Team Effectiveness Framework had not been applied to science curriculum development groups previously. I selected constructs based on recommendations in the team literature from the past fifty years of team research and also based on the studies that documented known tensions within curriculum development groups. The Team Effectiveness Framework contains many more constructs that were not included in this study. The study is thereby limited by the scope of each selected construct that accounted for the variations in how each team operated.

Second, although I attempted to gain access to more than three cases for the study, the other cases did not meet the criteria that I set. Additional cases in this study may have strengthened the cross case analysis for this study; however, the three cases that are presented represent unique cases (two cases with different types of external partnerships and one case without any external partnership).

Finally, although individuals may find common issues within their own research projects or school districts, this multiple case study is not meant to be generalized to all other science education curriculum development groups. The study can be replicated to examine other science education curriculum development groups, but the contextual and antecedent inputs, mediators, and outcomes will likely vary as was found with the three cases presented here.

Study Implications

This study utilized the Team Effectiveness Framework and provided lessons learned from tensions within each case and across all three cases. The school districts in this case assembled each science education curriculum development group with different contextual and antecedent inputs. In particular, groups inputs such as how groups defined technology-infusion, assembled group members, acquired funding, set goals, assigned and facilitated group roles, and established group norms set each group on a course to goal attainment, but groups also contended with group mediators, including how groups facilitated discussions regarding the dual curriculum audience of teachers and students, addressed multi-level organization norm variation and attempted to build team cohesion and trust. Understanding how group members engaged in the collaborative process of science curriculum development and by examining various combinations of inputs, mediators and outcomes, science education curriculum development groups can increase group effectiveness.

Science education curriculum development groups can begin group interactions by specifying what types of technology need to be infused into science curriculum. Once technology-infusion is identified and defined, science education curriculum development groups should account for technology resources that are used within each science classroom where the intended science curriculum will be implemented. I am not suggesting that all science curriculum groups secure adequate technology like the chemistry team, but in order to infuse technology, groups need to know and plan for what types of technology can be infused into the science curriculum and used in each classroom across the school district. To address this issue, my recommendation is similar to Penuel et. al's (2007) call for taking stock of current practice and classroom contexts, but I would add a more detailed analysis of what technology is available and used across school district levels and within each classroom where the intended technology-infused science curriculum will be implemented.

While contextual and antecedent inputs varied across the three cases here and will likely vary with any additional cases, lessons learned from this multiple case study inform science education curriculum development group leaders. In order to maximize group performance, group leaders may benefit from careful consideration of group members and assignment of group task roles, but also attend to socioemotional and boundary spanning roles. For both the elementary team and the biology team, technology resources and access were limiting factors that contributed to how technology was infused into the science curriculum artifacts. Technology champions or technology developers (Bielaczyc, 2006) can assume critical technology expert roles to explain technology capabilities and use by both the teacher and student audiences. By including at least a technology champion who advocates for the use of a technology and can explain technology capabilities, the group can increase the likelihood of infusing the types of Twenty-first Century technology that will enable teachers to prepare students for the future workforce.

In addition, group leaders need to allocate group roles (Bales, 1950) and set group norms (Postmes, et al., 2001) quickly and early in the curriculum development process. Group task roles such as writer roles for teachers can be set and evolve based on teacher's interests and strengths that emerge during the group interactions. If group leaders select to have face-to-face meetings, group members' attendance and punctuality are crucial to enable the group to discuss issues, make decisions, and increase work productivity within each meeting. Groups can also include remote meetings with modern technologies such as video chat or instant messaging formats in order to accommodate group members' other obligations.

Socioemotional roles evolve during group interactions, and group leaders may benefit from observing and attending to when and how group members assume socioemotional roles. If leaders attempted to assign socioemotional roles to any particular group member, other group members might not take the intervening comments to monitor and motivate the group as sincere and may find the statements scripted, redundant, or annoying. Instead, group leaders need to be aware of socioemotional roles and how to assume the roles in order to keep the group members motivated and to monitor group members' comments for possible tensions between group members. For example, Sally and Tisha were genuinely concerned that Lady Beetle and Dorothy agreed to group decisions after previous disagreement with the group, and their sincerity was acknowledged and appreciated. Had Sally and Tisha been assigned publicly to monitor and address these concerns, I question whether their efforts would have resulted in similar outcomes.

As teams worked together over time, the mediator themes in this study provided implications for maximizing group effectiveness. First, groups can attend to the dual curriculum audience dilemma and negotiate contributions from both teachers and researchers in science education curriculum development groups. Science curriculum development groups should address the audience dilemma during curriculum development and find ways to discuss each audience (teachers and student) without alienating or dismissing contributions from group members. This multiple case study extended the previous research (Carlone & Webb, 2006; Labaree,

2003) by demonstrating how the varied worldviews impacted group discussions and altered curricula artifacts. The varied worldviews forced teams through additional episodic cycles and impeded workflow and work productivity.

I am not suggesting that all science curriculum development groups should ease tensions over curriculum audience focus by prescribing to the split document approach that worked well with the chemistry team. Rather, group leaders need to consider potential tensions over curriculum audience and explore techniques of how to discuss both teachers' and education researchers' contributions during science curriculum development. Colorado attempted numerous techniques such as providing documents, discussing issues during meetings, and making a formal presentation; however, the lack of support within the group and from the school district level administrators further marginalized Colorado's contributions. Merely providing time and opportunity for Colorado to voice her issues and share her information was not adequate. The school district administrators' expectations of Colorado's group roles and acknowledgement of her expertise was needed for the biology teacher subgroup to at the very least consider some of her contributions.

Edelson, Gordin, and Pea (1999) and Penuel et. al. (2007) concur that teacher involvement strengthens the artifact by improving local adaptation of the technology and curricula. Although communication and team interaction between teacher and researchers may at times create tensions within a team, essential tensions (Barab & Leuhmann, 2003) can lead to discussions and revisions that strengthen the curricula. The chemistry team demonstrated how teacher input strengthened the curricula and adapted the curricula to the local needs of the school district. As the gatekeepers of curricula enactment in the science classroom, teachers are stakeholders whose contributions are needed during the curriculum development process.[12] Some design-based researchers (D'Amico, 2005) postponed inclusion of classroom teachers in the curriculum development process until after initial drafts. However, school districts, as shown in the biology and elementary teams in this study, hire classroom teachers to write initial drafts. Outside of larger grants, school districts may not have the financial resources to hire researchers to write curricula. Instead, team leaders may attend to tensions that emerge within group interactions to work through issues and strengthen artifacts rather than ignore tensions and/or marginalize either the teachers (elementary team) or a researcher (biology team).

Group norms established when and how groups operate. Group leaders can set the norms early in the curriculum development process and reinforce norms during group meetings. Leaders can also adjust norms such as altering workflow to accommodate group member back up behavior in order to increase the group’s work productivity and forward progress toward goal attainment (Kozlowski & Ilgen, 2006). Each level from education policy makers at the federal, state, and local levels to school level administrators, education researchers and teachers either directly or indirectly set norms that influence how science education curriculum development groups work to create technology-infused science curriculum. Conformance to and departure from intended norms at each level emerged during group discussions and at times created tensions within groups. Group leaders’ facilitation of discussions can

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[12] The scope of this dissertation did not include an examination of how artifacts were used by teachers on each team in the classroom or by other school district teachers.

assist in increasing team cohesion and build team trust rather than further divided subgroups and increase group tension (Postmes, et al., 2001). School districts need to supply each science education curriculum development group with data of technology resources, access, and use in each school district classroom in which the intended science curriculum will be implemented. How groups facilitate multi-level norm discussions can strengthen group cohesion and build team trust while minimizing marginalization of group members. By incorporating attention to the process science education curriculum development groups undergo to create artifacts, the groups can maximize group effectiveness and strengthen group members' contributions in order to improve group performance.

In order for groups to understand and utilize multi-level norm variation as assets to strengthen group discussions and curriculum artifacts, group leaders can not only take inventory of classroom norms (Penuel, et al., 2007) but can also take stock of the multi-level organization norms that group members operate under. Leaders may find value in team discussions regarding conformance and/or departure from multi-level norms. As shown in the chemistry and biology team, researchers may not acknowledge differences between enforcement of norms above the classroom level and within the classroom level for individual teachers. For example, technology access, use, and resources need to be discussed early in the development of the group in order to better understand classroom technology constraints. Since the science curriculum is intended to be implemented across all schools in the school district, group members should represent different schools and levels within the school district in order to maximize the norm variation discussions. For example, if Stacey had not been a member of the elementary group, Lilly and Cindy might not have acknowledged the norm variation in resources and access to technologies that other teachers faced in other schools. Likewise, in the biology team, teachers from the seven high schools shared different experiences with technology resources, access, and use across the schools and within science departments. Also within the biology team, the biology HSA warm-up discussion revealed how school level principals enforced norms differently across the seven high schools in the school district, but the biology group did not include any school level administrators, such as a principal or multiple science department chairs.

As noted by Marks, Mathieu, & Zaccaro (2001) groups need to gauge the utility and tradeoffs of humor and complaint sharing. Group leaders can increase work productivity and forward progress of the group members' work by managing and facilitating group discussions to build trust and cohesion while relieving tension and stress. The initial sharing sessions can include purposeful sharing of multi-level norms with scenarios of norm conformance and departure at various levels such as principal enforcement of lesson structure and content covered during teacher classroom observations or what types of technology (i.e. video clips or computer simulations) satisfy technology-infusion according to the school district or school level administrators. When group leaders do not successfully manage discussions, tensions increase and subgroups can form. As seen here, Grant attempted to motivate the teachers but inadvertently devalued Colorado's comments, which led the biology teachers to ignore his later appeals for them to consider and value Colorado's comments. By focusing on the process to create science education curriculum development groups, group can maximize group cohesion and build group trust.

Areas of Future Research

This multiple case study provided an initial lens into how science education curriculum development groups operated and how each group infused technology into science curriculum differently. Since this study is an exploratory case study that employed the Team Effectiveness Framework as a means to examine tensions in science education curriculum development groups, more studies are needed to further explore the utility of the Team Effectiveness Framework in educational settings. I selected particular constructs based on the recommendations found within the Team Effectiveness Framework and the tensions described in previous education research, but additional constructs, such as team learning or team cognitive models, can also be used to further study how curriculum developers (researchers and teachers) learn new technologies and make decisions on how to infuse new technologies into science curricula. In addition to studying new constructs, studies that follow groups which include additional members with expertise, such as policy makers, school principals, or even students, or different types of partnerships can further examine how groups work to create technology-infused science education curriculum.

Likewise, previous studies (Blumenfeld, et al., 1994; Maldonado & Pea, 2010; Marx, et al., 2004; Penuel, Fishman, Gallagher, Korbak, & Lopez-Prado, 2009; Stieff, 2005; Williams & Linn, 2002) focused on teacher enactment of and alterations to curricula in classroom settings. Additional studies are needed to explore how research on teachers who adhered to or departed from intended norms set by the school district through polices, initiatives, and curriculum documents during classroom enactment is utilized within science education curriculum development groups. Simply, how can science education curriculum development groups utilize research data from classroom teacher curriculum enactment and technology use?

Teachers in each of the three cases sought to retain classroom teacher autonomy and were reluctant to limit teacher's decision making and setting of classroom norms. Research (Barab & Leuhmann, 2003; Dede, 2000; Penuel, et al., 2011; Reiser, et al., 2000) has shown that teachers are reluctant to adhere to prescriptive curriculum and to critique other teachers. To that end, questions remain about how classroom teachers who do not participate in curriculum development respond to new technology-infused science curriculum that was developed by teachers and researchers?

The issue of how classroom teachers respond to technology-infused curriculum also relates to another body of research within design-based research that focuses on scaling-up the use of technology innovations across classrooms within the school district and beyond the school district to other school districts (Daly & Finnigan, 2009; Penuel & Haydel DeBarger, 2011). Understanding how teachers respond to norms set at various levels above the classroom level and how they then set their own classroom level norms will provide an additional data source to understand why some technology innovations and not others are utilized in classrooms and how technology innovation use differs from one teacher to another teacher. The information can assist science education curriculum development groups as they write technology-infused science curricula for the school district.

Today, we are faced with a similar situation as described by Welch (1979) and echoed by recent studies (Amiel & Reeves, 2008; Dede, 2000) that science classrooms might be flooded with technology, but have little educational impact on student learning. If we intend to engage in President Barack Obama's "Race to the Top" of the Twenty-first Century workforce, we need to study how science education curriculum development groups work to create technology-infused science curricula. This multiple case study provided an initial glimpse into what occurred during science curriculum development and utilized the Team Effectiveness Framework to examine tensions within three cases. Tensions occurred due to how the groups defined technology-infusion, assembled group members, assigned group roles, facilitated dual curriculum audience discussions, addressed multi-level organization norm variation, and built team cohesion and trust. In each case, these tensions shaped the resultant science curriculum artifacts. Thus, the findings here demonstrate the ways in which technology was infused in science curriculum and how diverse expertise of team members, multi-level norms, and local technology resources shaped science curricula artifacts.

Appendix A: Team Effectiveness Framework Selected Constructs

Inputs	*Definition*	*Dimensions*	*Case History Questions*	*Effectiveness Criteria*	*Data Sources*
Group Goals	refers to the mission of the group's work and the group orientation which effects the mediators (i.e. group efficacy) and outcomes (i.e. group performance) (J. Mathieu, et al., 2008).	Goal Setting	How does the group set goals? Which group members stated goals to the group? Who participated in setting group goals?	High: Group goals are clearly defined and either assigned by the leadership or derived by the participation of all group members Low: group goals are "do your best."	Initial group meetings Field Notes Artifacts
Group Composition	refers to the "the constellation of individual characteristics and resources at multiple levels (individual, team, organization) (Kozlowski & Ilgen, 2006, p. 79)."	Group members' background Group members' resources	Who are selected or recruited to participate in the group? Which institutional representations are sought and valued by the group?	High: several types of expertise with varying access to resources are represented in the group Low: group contains similar expertise with limited availability to resources	Meetings Field Notes Artifacts
Group Roles	refer to the three broad categories of group roles: task roles, socioemotional roles, and boundary spanning roles. Well-defined task roles are often assigned within structured institutions, such as schools and universities, in order to establish	Task roles Socioemotional roles Boundary spanning roles	Which group members assume particular task roles in the group? How are tasks assigned in the group? Are task roles assigned or assumed? Are task roles clearly defined? Which group	High: Group roles are clearly defined and are either assigned by the leadership or negotiated between group members Low: Group roles are not defined and group members are confused on who is doing what toward the	Meetings Field Notes Artifacts

	who is doing what toward the goals of the institution (Wenger, 1998). Within a small group, task roles are patterned behaviors directly related to accomplishing group goals while socioemotional roles are patterned behaviors that focus on the interpersonal relationships between group members (Bales, 1950).		members assume socioemotional roles during group meetings? How do the socioemotional roles relate to how conflict is managed within the group? Which group members assume boundary spanning roles? How do boundary spanning roles impact group interactions?	goals of the group	
Group Norms	Group norm is defined as “a standard or rule that is accepted by members of the group as applying to themselves and other group members, prescribing appropriate thought and behavior within the group (Postmes, et al., 2001, p. 919).	Initial norming stage of the group	Which group norms are established within the first few group meetings? How are group norms established within the group in the first few meetings?	High: The group sets norms quickly. Group norms provide stability to group interactions. Low: The group struggles to establish group norms that are acceptable to most group members. Time and resources could be lost due to the instability.	Meetings Field Notes Artifacts
Mediators: Processes					
Monitoring Progress	refers to monitoring the group’s progress towards goals (Marks, et al., 2001)	Referring to group goals Adjusting/refining group norms or working with group members who do not follow group norms	Who in the group primarily monitors progress and refers to group goals in group meetings?	High: group members work well together and progress toward goals. Low: Group member/s consistently do	Meetings Field Notes Artifacts

			How do group members respond to references to group goals within group meetings? What happens in group meetings when group member/s do not accept or follow a group norm?	not adhere to group norms and slow the group's progress toward goals.	
Team Monitoring and Back up Behavior	Assisting team members to perform their tasks. Assistance may occur by (1) providing a teammate verbal feedback or coaching, (2) helping a teammate behaviorally in carrying out actions, or (3) assuming and completing a task for a teammate. (Dickinson & McIntyre, 1997)	Monitoring roles throughout the interactions	Who monitors task completion? How do group members respond to assistance from other group members?	High: Group members are open to assistance from each other in order for the group to move forward toward goals Low: Group members take offense to assistance from each other or particular group members	Meetings Field Notes Artifacts
Conflict Management	refers to "whether teams actually engage in open discussion of conflict and are prepared to manage it when it arises	Relationship Conflict Task Conflict	When does conflict occur within group meetings? Who initiates discussions about a particular issue?	High: Groups openly discuss and resolve conflict within the group. Low: Groups either ignore conflict or do not allow for all	Meetings Field Notes Artifacts

	(Tekleab, et al., 2009, p. 177)."		Who supports or refutes ideas during discussions? How, if at all, does the group resolve conflict in group meetings?	group members to participate in conflict resolution.	
Coordination	Orchestrating the sequence and timing of interdependent actions (Marks, et al., 2001)	Meetings Tasks	How do groups coordinate meetings, schedules, and generation of artifacts?	High: Group members work together to generate artifacts. Low: Groups break down with very few group members attending meetings and/or generating artifacts.	Meetings Field Notes Artifacts
Mediators: Emergent States					
Group Efficacy	is "defined as a shared belief in a group's collective capability to organize and execute courses of action required to produce given levels of goal attainment (Kozlowski & Ilgen, 2006, p. 88)."	Shared Perception	How often, it at all, do group members reference the group as a whole in group meetings? (use of terms such as us or we when referring to the group) How, if at all, do group leaders model a shared perception in group meetings?	High: Groups members refer to the group as a whole during group interactions and externally to other colleagues. Low: Groups refer to subgroups rather than the current group.	Meetings Field Notes Artifacts
Group Cohesion	is defined "as the tendency for a group to stick	Task Cohesion Interpersonal Cohesion	How, if at all, does the group overcome	High: Groups overcome subgroup issues	Meetings Field Notes

	together and remain united in the pursuit of its instrumental objectives (Tekleab, et al., 2009, p. 174)."		initial subgroups to unite as one whole group? Which members, if any, work well together during group meetings? Which members, if any, do not work well together during group meetings?	early and unite to complete goals. Low: Groups have subgroups that continuously divide the group and disrupt progress toward goals.	Artifacts
Team Autonomy	"define team-level autonomy as the extent to which a team has considerable discretion and freedom in deciding how to carry out tasks (Langfred, 2005, p. 514)."	The extent to which the group determines how to perform tasks	How and to what extent does the leader assign tasks to the group members or allow the group to make decisions?	High: Group members work together Low: Leader "micromanages" the team or neglects the team	Meetings Field Notes Artifacts
Trust	"the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party (Mayer, et al., 1995, p. 712).	Level of confidence and trust in group members' abilities	How and to what extent do group members trust the abilities of each other to perform tasks?	High: Group trust is high and members work together well. Low: Group trust is low and group members take over other tasks from "weaker" members routinely.	

Outcomes					
Group Performance Outcomes	are the results of the actions and behaviors of team members while working towards goals (J. Mathieu, et al., 2008).	Team Performance Role-based Team Performance	How has the group worked together to create the curriculum artifact? How have group members assumed roles within the group throughout the group meetings?	High: Group members consistently work well together during group meetings. Low: Groups struggle to work together during group meetings.	Meetings Field Notes Artifacts
Goal Attainment	also referred to as goal accomplishment is the extent to which the group achieved its mission (Marks, et al., 2001).	Goal attainment	Has an artifact been produced? How has intended goals been achieved? Has the goal shifted during or completely changed overtime?	High: Group creates artifact with input and coordination of group members. Low: Group fails to generate an artifact.	Meetings Field Notes Artifacts

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