AFTER LISELL-B: DRAWING ON ANT TO EXPLORE THE TERRAIN OF SUSTAINABILITY AND PROFESSIONAL LEARNING

by

AMANDA MARGARITE LATIMER

(Under the Direction of Cory A. Buxton)

ABSTRACT

Implementation of science educational reforms in the 21st century has created challenges in science education that have evolved from an assemblage of historical, scientific, educational and political selective pressures (funding, standards, teacher shortages, time and curriculum) which are further complicated by a constant flow of new science information, and recent innovations in technology. Professional learning has become centrally important in helping teachers obtain the knowledge and skills that are needed to address reforms and implement 21st century learning in a constantly evolving environment. But research has only recently begun to bring to light what types and features of professional learning are important for supporting teachers' knowledge, classroom skills and practice that can be sustained over time and our intent is to add to this literature.

This case study uses ethnographic methods and the lens of Actor-Network Theory to explore the long-term sustainability of the practices and materials that were part of a high—quality professional learning network (referred to as the LISELL-B project) during the two years after the LISELL-B network was dissolved. The LISELL-B project was a purposefully constructed professional learning network which supported science learning (both within and

outside of a middle school) over a three-year period. This project comprised of an assemblage of actants/actors. For example: science teachers, workshops, kits, Next Generation Science Standards, students, universities, colleges, General Academic Vocabulary cards, parents, graduate students, and university faculty. The LISELL-B PL provided a collaborative space with teachers, intended to intervene in the conventional paradigm which positions teachers as deficient, in need of training or fixing. Fieldnotes, transcripts, teacher enactment and artifact data were collected from an interview, classroom observations, teacher planning meetings, teacher logs, and virtual observations. This study resulted in empirical data which showed that many of the LISELL-B practices and materials that were part of the LISELL-B professional learning network were still working and supporting science learning with teachers and students in their classrooms during the two years after the LISELL-B network was dissolved.

INDEX WORDS: Sociomaterial, Middle school, Science teachers, Professional learning, Actor-Network and Sustainability.

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by

AMANDA MARGARITE LATIMER

B.S., Oglethorpe University, 1984

M.S., The University of Georgia, 1989

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AMANDA MARGARITE LATIMER

Major Professor: Cory Buxton

Committee: Martha Allexsaht-Snider
Ajay Sharma

Electronic Version Approved:

Suzanne Barbour
Dean of the Graduate School
The University of Georgia
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DEDICATION

Each journey begins with one step and the following steps were not possible without the love and support of my family and friends. So, it is with immense gratitude that I dedicate this dissertation to my husband John, my daughters Samantha & Zoë, my son Daniel and son-in-law Matt Terry. To my brother Joey and his family which has cheered me on from afar, David Latimer and the rest of the Latimer family, my friend Pat Doney who encouraged me to begin the journey and lastly to the memory of my father, Joe who fueled my love of history and my mother, Anita who left me with the tenacity to finish the journeys I begin.

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DEFINITIONS OF TERMS USED

The following definitions are supplied in order to clarify the vocabulary used within this dissertation.

21st Century skills- Usually interpreted differently by educators, employers, school reformers, universities and media; but generally, a broad set of abilities, knowledge, work habits and character traits that are considered to be needed for success in today's workforce and society that is becoming increasingly complex, competitive, knowledge-based, information-age, technology-driven economy. Can include: Critical thinking, general literacy skills, grit, creativity, scientific literacy and reasoning ability, technology literacy and multicultural literacy (Great Schools Partnership, 2016).

Actor -a "working entity" with agency in a network, usually relates to humans (Fenwick & Edwards, Actor-Network Theory in Education, 2010, p. 117).

Actor–Network Theory (ANT)- "Is a disparate family of material-semiotics, sensibilities, and methods of analysis that treats everything in the social and natural worlds as a continuously generated effect of the webs of relations within which they are located. It assumes that nothing has reality or form outside the enactment of those relations." It is grounded in empirical case studies that "explore and characterize the webs and practices that carry them" (Law, 2009, p. 141).

Actant a "working entity" with agency in a network usually relates to non-humans or human/non- human hybrids (Fenwick & Edwards, Actor-Network Theory in Education, 2010, p. 117)

Ambivalence- tracing the contradictions and uncertainties at play within and among networks and the work they do (Fenwick & Edwards, Actor-Network Theory in Education, 2010).

Intermediary- "transports another force or meaning without acting on it to change it-think of a sign that directs visitors to check in at the office" (Fenwick & Edwards, Actor-Network Theory in Education, 2010, p. 11).

Mediator- circulates through a network and "can transform, distort and modify the meaning in the elements it is to conduct-anything that creates possibilities and occurrences for connections"- think- a cell phone or a learning plan (Fenwick & Edwards, 2010, p. 11).

Multiplicity- allowing for multiple ontologies and the relations among them, rather than explanations relying on multiple perspectives (Fenwick & Edwards, 2010).

Obligatory Passage Point- a central assemblage "through which all relations" in a "network must pass at some time" (Fenwick & Edwards, 2010, p. 18).

Professional Learning- "teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their student's growth" (Avalos, 2011, p. 10). Keeping in mind that this is a "complex process, which requires cognitive and emotional involvement of teachers individually and collectively" including reflection,

resulting in enactment of practices that result in improvement or change in the classroom (Avalos, 2011, p. 10)

Reform-Policies, programs, and other efforts that are implemented with the goal of improving public schools and education (Great Schools Partnership, 2016).

Speed Bump- A nonnegotiable point of passage where an actant/actor causes action even when absent. As in a barrier in the road that stops cars from speeding when policemen are not around to do so (Latour, 1994, p. 39).

Sustainability- Professional learning that has lasting effects on teacher learning and practice.

Symmetry- Treating human and non-human elements as equally interesting, important and capable of exerting force upon each other as they come together (Fenwick & Edwards, 2010).

Translation- "Displacement, drift, invention. Mediation- the creation of a link that did not exist before and that to some degree modifies two elements or agents" (Latour, 1994, p. 32). A process that "happens when entities, human and non-human," assemble and "connect, changing one another to form links": a computer, with a program, with a teacher, forming a network of action that can "become stable and durable." (Fenwick & Edwards, 2010, p. 9)

CHAPTER 1

INTRODUCTION

The Origin of Federal Education Involvement

Where to begin? Maybe I should begin at the beginning—not a beginning that takes us as far back in time/history as a James Michener novel (see: *Hawaii, Alaska or Centennial*)—a billion or million years depending on which of Earth's land mass he is tracing the formation of—but only a little more than a few centuries ago—1791 to be exact. Four years after the Constitutional Convention of 1787, state delegates voted to amend the fledgling American Constitution to protect the rights of individuals and states. This Bill of Rights affirmed the delegates' decision to limit the power of government, reasserting the power of the states as articulated in the 10th amendment: "The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people" (National Archives, 1789/2017). Since education was not mentioned in the Constitution, with the 10th Amendment our Founding Fathers relegated the control of education to the states and local communities. By decentralizing all control of education, these delegates set the course of our nation's education system, which in the following two hundred and twenty-seven years has evolved into a massive, fragmented network. The system, presumably responsible for educating American citizens, lacks a national standardized curriculum instructional consensus (Goldin, 1999; The Founding Fathers: A Brief Overview, 2014).

By the middle of the 19th century, America's education system, provided at home by families or by local churches, resulted in a highly literate population of America citizens in which 80 % of white adults could read and write their names; outpacing other industrialized nations (Enslaved Africans and free African Americans were generally excluded) (Goldin, 1999; Sparks, 2017). Though America's early education system showed promise, a growing industrial economy resulted in schools "consolidated, standardized, and removed from lay control" as business professionals were appointed to school boards and schools adopted the popular business efficiency models (Reese, What history teaches about the impact of educational research on practice, 2010, p. 39). Historian William Reese (2010) observed that the proliferation of education research in the 1900s dominated by psychology, placed further evolutionary pressures on education. Educational policy reform became linked with research based on what was seen as more rigorous scientific methods that offered "the best way to understand the complexities of teaching and learning and to provide the guidance to manage and improve schools", and which have shadowed it into the 21st century (Reese, What history teaches about the impact of educational research on practice, 2010, p. 41). Twenty-first century reforms have embraced a new rigorous scientific methods research lens rooted in paradigms adopted from economics that focuses on accountability, value-added metrics, standards implementation and student achievement/test scores (Leana, 2011; Labaree, 2011).

The narrative of the past, enduring today, maintains that local school boards and their states should dictate what students are taught, with little government input. Science teachers alone were responsible for the implementation and achievement of reform goals in the science classroom; their practices encountered intense scrutiny and calls for rigorous professional

learning (PL) (Banilower, Heck, & Weiss, 2007; Drits-Esser, Gess-Newsome, & Stark, 2017; Rudolph, 2002).

This dissertation does not posit centralized governmental control of the American education system or propose a particular approach to PL of teachers, but rather details the history behind the convoluted structure of the educational context in which my research is situated. In this introductory chapter, I provide a brief overview of the salient educational reforms beginning in the 19th century, the rise of the importance of teacher professional learning, with a specific focus on science teacher PL; I also describe the major Education Acts passed during this period and how they affected reforms. Lastly, I consider recent education reforms and their effects on science teacher PL in Georgia. Throughout these chapters, I have included vignettes that trace my own educational journey, permitting the reader to not only travel along in the dissertation research but to participate in my "discovery process" (Marshall & Rossman, 2011, p. 272).

Early Education Reforms

From 1840-1920 a large influx of immigrants into the United States resulted in a transition from a rural, agricultural based society to a predominantly urban, industrialized one and this change helped accelerate the transition of education from a private to public institution (Gutek, 1991; Hunt, Carper, Lasley, II, & Raisch, 2010). In the mid to late 1800's states created common schools to educate children regardless of social class or religion (Hornbeck, 2017). Reforms during the Common School Period resulted in free public schools supported by local taxes in all states, laws that required children to attend school, and the creation of programs and schools for professional teacher development (Gutek, 1991). These "normal schools" for training teachers marked the beginning of the "professionalization of teacher education" (Gutek, 1991, p. 231). The state regarded education as a way to create politically literate and responsible citizens.

Therefore, common schools offered math, history, reading and writing, the principle subjects taught in modern schools (Gutek, 1991). By the end of the 1800's, the corruption and inequality that developed with the industrialization of society with massive urban populations yielded the Progressive Movement (Zainaldin & Inscoe, 2015). Not to be confused with progressive education which also began at this time as progressive educators and others began to criticize "traditional forms of child rearing and classroom instruction" condemning "what they saw as insidious notions about the nature of children and the antediluvian practices of the emerging public school system" (Reese, The Origins of Progressive Education., 2001, p. 2)

The Progressive Era and education.

Progressives maintained that expansion of the federal government would cure social ills. Education needed to prepare citizens to participate in democracy (Hornbeck, 2017). Therefore, by the beginning of the 1900's, the Progressive movement had resulted in a flood of economic, social and educational reforms (Zainaldin & Inscoe, 2015). During this period, the federal government "democratized" education resulting in the adoption of: scientific, methods-based approaches to the research of education, standardized tests, the formation of age-based grades, a static duration of the school day and the formation of kindergarten, middle school and high school (Cuban, 2016; Reese, What history teaches about the impact of educational research on practice, 2010). Officially, the progressive movement dissipated at the end of World War-I in 1918, but many of the reforms lauded during this era did not. For example, states had begun to pass laws requiring children to attend school during the progressive era, and by 1930 all states had such laws, a move that enhanced state and local government control of education (Cuban, 1990). Another example of the persistence of progressive reforms was the consolidation of the multitude of small rural districts into larger ones, governed by school boards (Cuban, 1990).

After World War II (1945), both the incomes and households of white American increased substantially resulting in both an economic windfall and the "baby boom" (Hornbeck, 2017). By the mid 1900's, as the tide of "baby boomers" inundated public schools, public and private anxiety over our nation's educational status surged. The launch of the Russian satellite—Sputnik—in 1957, catalyzed the Federal Government's involvement in education reform, particularly that of science curriculum (Jackson, 1983; Rudolph, 2002).

The National Defense Education Act (1958).

The unexpected launching and success of Sputnik in 1957, followed by the failed launching of a U.S. satellite six months later forced a national "self-appraisal" that questioned our ability "to compete" globally, our science and technology abilities, the "moral fiber of the nation" and the quality of our education system (Mazuzan, 1994, p. 11; Garber, 2007). Congress responded by passing the National Defense Education Act (NDEA) of 1958 that included support for science and math courses in kindergarten through the twelfth grade (K-12). This Act, noted Mazuzan, (1994), "opened the way for future legislation that redefined many of the relationships between the federal government and the education community" (para. 5, ch III). During the 1960's, President Johnson made education a central component of American social policy, further expanding the federal government's role (Hunt, Carper, Lasley, II, & Raisch, 2010).

The National Science Foundation (NSF)

The NSF funded by the National Defense Education Act of 1958 recruited prominent scientists to reform physics, biology, chemistry, and mathematics curricula (Engleman, 2001; Mazuzan, 1994; Rudolph, 2002). In his *book Scientists in the classroom: The cold war reconstruction of American science education,* John Rudolph (2002) described in depth how

scientist reformers realized that science teachers were going to have to teach their newly crafted curricula and questions arose about the quality of the abilities of science teachers that were already in the classrooms. Thus, to assure strict adherence to the new curriculum, the government imposed rigorous science-based PL during this era (Jackson, 1983; Rudolph, 2002). The new rigorous curriculum proved hard to implement in most classrooms due to the lack of time and access of materials, and all was eventually abandoned except for the Biological Sciences Curriculum Committee (BSCC) which still influences the teaching of Biology today (Rudolph, 2002).

The Elementary and Secondary Education Act (1965).

President Johnson's *War on Poverty* of the 1960's, included the Elementary and Secondary Education Act (ESEA) of 1965, a law intended to "improve educational opportunities for children of low income households and became the largest single source of federal funding for elementary and secondary education" (Title-I) (U.S. Department of Education, 2012). Its importance in terms of PL was its mandates that teachers were adequately educated, had access to educational research findings and instructional resources (U.S. Department of Education, 2012). The ESEA and its later reauthorizations significantly expanded the role of the federal government in K-12 education having profound and controversial effects on education over the next 50 years, due in part to state mandates of student assessments and teacher accountability (Cuban, 2016; Leana, 2011; Klein, 2016). By the end of the twentieth century, numerous reports surfaced, most notably *A Nation at Risk*, warning that the ESEA was failing and that America's leadership in education had begun to erode again (Gardner & others, 1983). Published in 1983, *A Nation at Risk* became so popular that it was used to justify many local and state educational reforms in the following years (Vinovskis, 1999).

American Association for the Advancement of Science's (AAAS) Project 2061.

Another reform effort that began in 1985 which has had long lasting effects on science education and teacher PL, was the AAA's Project 2061. The AAAS's Project 2061 website states that in 1985, "panels of scientists, mathematicians, and technologists" met to identify what the next generation of students needed to know to make them literate in science, math and technology and what they envisioned was outlined in the AAAS's publication *Science for All Americans* (Rutherford & Ahlgren, 1990). In *Science for All Americans* the AAAS panel proposed national science standards based on a core curriculum that stressed the importance of conceptual understanding of what the AAAS called the "over-arching" ideas of science (1995). Along with these over-arching ideas of science (for example: cause and effect, life cycles), the AAAS panel stressed that the teaching of science should be focused on in depth learning rather than the more common broader, less in depth teaching of science concepts (Rutherford & Ahlgren, 1990). Project 2061 (so named reflecting Hailey's comet return date in 2061), represented a call for a national standard and provided a framework from which standards could be formed (American Association for the Advancement of Science, 1995). In 1993, the Project 2061 team published another document: *Benchmarks for Science Literacy* which outlined what second, fifth, eighth and twelfth graders should know by the end of their school years in the science, mathematics and technology (American Association for the Advancement of Science, 2018). The National Research Council (NRC) utilized it in 1996 to create the National Science Education Standards and the updated version—the NGSS. The states also incorporated the Benchmarks in crafting their own frameworks and standards (American Association for the Advancement of Science, 2018). The Project 2061 web site informs the public that this project was designed as a long-term project with three phases: Phase 1 defined science literacy and

established the knowledge, skills and attitudes American students should acquire upon completion of secondary education. This phase produced the *Science for all Americans* and *Benchmarks for Science Literacy* documents. Phase II features the development of curriculum and models to support the learning proposed in Phase I. Phase III will implement the developed resources, including the PL of teachers (American Association for the Advancement of Science, 2018). Currently, project 2061 is in its Phase II development.

No Child Left Behind Act (2001).

In 2001, the reauthorization of President Johnson's ESEA—the No Child Left Behind (NCLB) Act produced these results: mandates that affected educational policy; data collection and research initiatives; and funds for local design and implementation of teacher PL (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). The Act mandated that States test students, report on the quality of their teachers and the quality of PL. Furthermore, NCLB supported education research that gauged the effectiveness of PL by measuring student achievement. Digitization made compiling and analyzing this data much more manageable (Klein, 2015). By 2011, due to the lack of reauthorization of ESEA, and the increasing inability of schools around the country to meet the continuous improvement goals of NCLB, then President Obama granted waivers to states in meeting ESEA goals (Federal Education Budget Project, 2014). States became able to propose alternative approaches to NCLB mandated annual evaluations, testing and high-quality teacher requirements (Klein, 2016) in 2015, when Congress passed the Every Student Succeeds Act (ESSA).

Common Core State Standards Initiative (2010)

Larry Cuban (1990) ruminates in his article *Reforming again, again, and again* about the "recurring waves" of curriculum reform over the last century, each time the reformers called

for a common core of academic knowledge (p. 9). This time, the call for a common core of academic knowledge did not originate from academic school reformers or the federal government but rather a committee comprised of the: National Governors Association (NGA), the Council of Chief State School Officers (CCSSO) representation from teachers and citizens (Common Core Standards Initiative, 2017). Even though the Common Core State Standards Initiative focused on English language arts and Mathematics instruction, it was important to science instruction in its call for an integration of 21st century skills into K-12 curriculum, moving away from fact memorization to critical thinking and problem solving; thereby, bolstering the need for PL to help teachers meet the needs of these new modes of instruction (Common Core Standards Initiative, 2017).

Next Generation Science Standards (NGSS)

States now utilize/incorporate the AAAS's *Benchmarks for Science Literacy* (1993) and the NRC's *National Science Education Standards* (1996) to establish their current state science standards (NRC, 2012). In *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012) the NRC relayed that science standards required actualization. This new framework was "designed to make science education more closely resemble the way scientists work and think, the framework envisions that students will gradually deepen their understanding of scientific ideas over time by engaging in practices that scientists and engineers actually use" (NRC, 2012). The Framework is organized around three interconnected sets of ideas: Crosscutting Concepts (such as cause and effect and patterns), Science and Engineering Practices (such as asking questions and defining problems) and Disciplinary Core Ideas, which are the key ideas in science (such as biological evolution and matter and its interactions). Together, these concepts are referred to as Three-Dimensional

Learning (3D Learning) and form the basis of the NGSS (NRC, 2012). In 2012, a 26 state consortium, of which Georgia was a part, along with the National Science Teachers Association (NSTA), the AAAS, the NRC, teachers and the public developed the NGSS (NGSS Lead States, 2013). Released in 2013, the NGSS, which were aligned with the CCSS, contained a focus on career and college preparation and emphasized the coupling of science practice and content (NGSS Lead States, 2013). Previously, content stood alone and simply connected memorization of facts. Importantly, the NGSS are science standards and goals rather than a curriculum, and they identify what students should know and be able to do without dictating the manner in which teachers teach (NGSS Lead States, 2013).

Every Student Succeeds Act (2015).

The ESSA implemented in the fall of 2017 featured new content standards in language arts, mathematics and science and thus marked another national attempt at education reform (Every Student Succeeds Act, 2015; Klein, The Every Student Succeeds Act: An ESSA overview, 2016; NRC, 2012). The ESSA differs from previous reforms as it gives specific direction on what high-quality professional learning for teachers should entail:

> ESSA section 8101(42) defines "professional development," specifically noting that the professional development activities are sustained (not stand-alone, one-day, or short-term workshops), intensive, collaborative, job-embedded, data-driven, and classroom-focused... (U.S. Department of Education, 2016).

In a speech given the Spring of 2017, the present U.S. Secretary of Education Betsy DeVos who championed less federal intervention, reported that her department modified the reporting that States were required to submit under the ESSA Act, providing more flexibility to States and local educators:

> The updated state template will ensure states are able to better serve students with the freedom and flexibility they deserve, and which Congress requires. My philosophy is simple: I trust parents, I trust teachers, and I trust local school leaders to do what's right for the children they serve. ESSA was passed with broad bipartisan support to move power away from Washington, D.C., and into the hands of those who are closest to serving our nation's students (U.S. Department of Education, 2017).

In her speech, she reaffirmed our Founding Fathers' desire to limit the influence of government on the education of America's students by returning full educational responsibility and accountability to states and local school boards as well as teachers and parents.

Reform in the State of Georgia

Since my dissertation study took place in Georgia, I include some background on the structure of the education system in Georgia and the education reform efforts in the state to give further context for this work.

The Georgia Department of Education

Historians report that Georgia's State Constitution provided for the public support of public education since 1777 but not until 1858 when the State established a comprehensive education system (Mewborn & NGS Staff, 2004/2017). Georgia's Department of Education (GADOE) governs all public education in the state. The leadership structure includes an elected superintendent along with a board of 13 district representatives whom the governor appoints (Grant & NGE Staff, 2003/2018). The GADOE oversees/manages: Curriculum, textbooks, assessments, safety, nutrition, transportation and the publication of Georgia's school report cards (Grant & NGE Staff, 2003/2018). Each school district in Georgia is led by a locally elected school board that appoints a superintendent (Grant & NGE Staff, 2003/2018).

The Quality Basic Education Act

The Georgia legislature passed the Quality Basic Education Act (QBE) in 1985, establishing the Quality Core Curriculum (QCC) as the state's official curriculum for K-12 education (Grant & NGE Staff, 2003/2018). The GADOE later revised the QCC in 2003, which were implemented in 2005 as the Georgia Performance Standards (Grant & NGE Staff, 2003/2018). The QBE also increased professional teacher standards and provided for funding for PL (Grant & NGE Staff, 2003/2018). In 2000, concern about Georgia's education system caused the Georgia legislature to pass a comprehensive reform initiative referred to as the A+ Education Reform Act. The Act provided funding for schools that meet their education goals; controls against school board nepotism; and an accountability assessment program for student achievement (Smith Jr., et al., 2000). In the school year 2014-2015, Georgia replaced the Georgia Milestones Assessment System with the Criterion Referenced Competency Test (CRCT) and adopted End of Course Assessments (EOC) (Georgia Department of Education, 2015). Georgia contributed to the development of the NGSS and in 2017 adopted new Science Georgia Standards for Excellence (GSE). Georgia's GSE's include the 3-D Learning model of science based on the NGSS (Georgia Department of Education, 2015).

Reform and the Role of Professional Learning

In 1994, when teacher PL was added to the U.S. National Education Goals, PL became a major part of the enduring effort to reform American education:

> Goal 4: Teacher Education and Professional Development: The nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to ... prepare ... students for the next century. (United States National Education Goals Panel, 1994, p. 9)

Two years later in 1996, a report by the National Center for Educational Statistics (NCES) gave further support to the importance of the PL of teachers when it reported that PL which improved teacher quality was a key component of reform: “PD for teachers effectively conceived and delivered and aligned with other dimensions of the education enterprise, can be a primary support for such reforms” (Mullens, Leighton, Laguarda, & O'Brien, p. 1). The NRC devoted a chapter to science teacher PL including an in depth vision of PL standards in the *National Science Education Standards* (National Research Council, 1996). This vision included professionalism of the teaching profession, ongoing learning throughout a teacher’s career and a call for more teacher agency over their PL (National Research Council, 1996). The authors emphasized the importance of PL in reform efforts: “The current reform effort requires a substantive change in how science is taught; and equally substantive change is needed in professional development practices” (National Research Council, 1996, p. 56).

Anne Tweed (2000), in her commentary, *Developing Professionals,* reported the following PL centered concerns that high school science teachers voiced when attending a town meeting sponsored by the National Science Teachers Association (NSTA): They requested support to:

- Improve their teaching and meet the standards for professional development when they do not have continued opportunities to learn themselves.
- Provide for standards-based instruction and assessments if they do not have access to best practices and excellent programs.
- Supplement their specialized knowledge with the background necessary to become generalists and meet the needs of integrated science initiatives.

- Form networks to support professional development when science curriculum specialists are not available.
- Prepare students for high-stakes statewide testing and assessments.

These high school science teachers expressed that they were not receiving high quality PL; felt that they were not prepared to teach new standards based curriculum; felt isolated from other science educators; and were feeling the pressures of high-stakes testing. These teachers' statements illustrated the potential of professional organizations such as the NSF and universities, with their connections and expertise, to fill in gaps in science teacher learning through PL, to build networks between teachers and industry (scientists), and to address other science teachers' needs. In the most recent report by the National Survey of Science and Mathematics Education (Banilower E. R., et al., 2018), for the 2018 school year, 94 % of the middle school science teachers surveyed participated in a workshop on science or science teaching, 55 % of the PL aligned with elements of effective PL; 47 % of the PL had a duration of 16-80 hours or more and lastly, 61 % of the teachers reported that they were able to collaborate with their peers. Apparently, some aspects of PL, like collaboration between teachers, the learning of content knowledge and access of PL, have improved since Ann Tweed's article in 2000. We know more about the PL itself where 61 % of science teachers participated in a PL community and that 29 % of the teachers reported completing an online course or webinar where none reported doing so in the 2012 report (Banilower E. R., et al., 2018; Banilower E. R., et al., 2013). Thirty one percent of middle school science teachers in the U.S. were completing less than 15 hours of PL (Banilower E. R., et al., 2018). The quality of PL is essential to equip in-service teachers with the skills and knowledge that they will need to achieve the goals of reforms in the 21st century (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2011). Professional Learning researchers

thus began to focus on “best practices” and “high quality” PL (Borko, 2004; Guskey, 2000; Loucks-Horsley & Matsumoto, 1999)

High-Quality Professional Learning.

> *We have much work to do and many questions to answer in order to provide high-quality professional development to all teachers. It will take many different types of inquiries and a vast array of research tools to generate the rich source of knowledge needed to achieve this goal.* (Borko, 2004, p. 13)

Hilda Borko’s (2004) quote above, a challenge that she gave to the educational research community over ten years ago, still rings true today. How can we re-think the role of PL in teacher learning and in meeting the demands of a diverse population of educators? While much has been written about the importance of teacher PL in implementing educational reforms, many of the studies focused on “improving” teachers rather than how to assist teachers in their practice of teaching and learning (Borko, 2004; Hiebert & Stigler, 2017; Jackson, 1983). After an extensive review of the PL literature published in the early 2000’s, Australian researcher Ann Webster-Wright (2009) reported that many of the PL practices that she reviewed, still centered on a teacher’s ability to teach content rather than on enhancing their own learning. She found the research literature, which still embraced a linear model of the transfer of knowledge through which practices were transferred to the teacher who subsequently enacted them in their own classroom, was “undermining inquiry and perpetuating the status quo” (Webster-Wright, 2009, p. 21). In two separate reviews of the PL literature, spanning over 30 years of work, Judith Little (1993) and Mary Kennedy (2016) problematized the extent of PL effectiveness issues. Though these scholars published their findings 23 years apart, they echoed one another by questioning

what was considered to be good PL and suggesting that teachers needed to be treated like professionals and intellectually engaged (Kennedy, 2016; Little, 1993). Webster-Wright (2009), strongly opposed to the notion that PL transferred knowledge in a linear fashion, called for a paradigm shift from terms such as professional development which she labeled as deficiency discourse. She advocated for a more holistic approach where PL research is "situated, social and constructed" and attentive to teacher's descriptions about how and what they wanted to learn (2009, p. 22). This paradigm shift marked a transition from the dominant PL discourse of "delivering and evaluating" to "understanding and supporting authentic teacher learning" (Webster-Wright, 2009, p. 1). Prasad (2005) further suggests that this linear way of thinking about PL isolates teachers from the larger social contexts in which they practice. With these ideas in mind, this research project seeks to avoid evaluative and linear effect paradigm thinking of PL by focusing on gaining an understanding of how a PL model could bridge and support sustainable classroom practice.

Two additional issues that underscored the necessity of PL are: the increased hiring of alternatively certified teachers and the increased incidence of teachers teaching out-of-field; especially with teachers with less than five years of teaching experience (Feistritzer, 2011; Ingersoll, 1999; Nixon, Luft, & Ross, 2017).

Alternatively certified teachers and teaching out of field.

Historically, most teachers teaching in public schools until the end of the twentieth century were college graduates who majored in education and thereby received a teaching certificate (Feistritzer, 2011). By the mid 1980's, teacher shortages led to states creating "alternative routes to teacher certification," an option which allowed individuals who had bachelors degrees in fields other than education to enter the teaching field (Feistritzer, 2011, p.

19; Loucks-Horsley & Matsumoto, 1999). Since then, hundreds of new alternative teacher certificate programs have resulted in an average of 60,000 new alternatively trained teachers a year (Feistritzer, 2011).

Then, there is the concern of what challenges in practice occur when teachers teach out of field—when teachers teach subjects they were not trained to teach (Ingersoll, 1999). In a recent study, the authors found that 64 % of the surveyed teachers taught at least one out-of-field course during the first five years of their teaching career—this number exceeds those previously reported for the U.S. (Ingersoll, 1999; Nixon, Luft, & Ross, 2017). The authors concluded that this data collected under NCLB illustrated the inability of *top down reforms* to exert change since out-of-field teaching assignments were supposed to be eliminated by NCLB (Nixon, Luft, & Ross, 2017). These studies underscore the need for high-quality PL that is *scaffolded* to teacher's needs with an understanding of the complexity of teaching.

Professional Learning and Sustainability

Finally, there is the question of the sustainability of PL. Little research addresses what happens in the classrooms of teachers in the years following their participation in high-quality PL (Avalos, 2011; Sandholtz & Ringstaff, 2016). After reviewing the literature on PL and how it fosters teacher learning, Mary Kennedy (2016, p. 1), concluded that PL effects were variable and that "many popular design features are not associated with program effectiveness" and that "some widely favored research designs might adversely affect study outcomes." Apparently, much work remains to be done in the area of teacher PL. America's diverse population of students, educators and education systems seem to be better suited for a range of approaches in PL, informed by research that avoids looking for a cause and effect of PL and instead focuses on how to scaffold PL and support educators during and after PL experience.

Summary

This chapter briefly reviewed some of the early education reforms of the 19th and 20th century which included progressive education along with government instigated reforms- the National Defense Education Act and ESEA where government and states vied for control over education. Reformers considered education as a way to solve social problems like poverty and crime, and vital for our national defense. More recent education reforms—the NCLB Act and ESSA have been guided by a discourse that centers on the economic survival of the U.S and have resulted in calls for: Teacher quality, implementation of standards, assessments, along with student, teacher and school accountability. Teacher shortages of the 1980's resulted in the hiring of alternatively certified teachers, which underscored the need for PL scaffolded for the needs of teachers with varied backgrounds. The importance of PL is in its ability to improve teacher quality linked to science reform, and its sustainability. This chapter sets the context for understanding what informed more recent science education reform efforts and science teacher PL in framing this dissertation.

Throughout history, many education reforms confronted by evolutionary pressures created by political, public and economic expectations resulted in change while others did not (Schneider, 2014). Ann Lieberman (1995) argued over 20 years ago, that in order for reforms to result in improved teaching, "teachers must have opportunities to talk, think, try, and hone new practices, which means they must be involved in learning about, developing, and using new ideas with their students" (p. 69). The larger study that my research developed from (the LISELL-B project) attempted to address Lieberman's claims in that its basic premise was to create the type of space in which teachers could be involved in trying out new learning practices with their students along with an added feature of choice. Teachers that participated in the LISELL-B

project chose which PL activities they wanted to participate in during the three years of the project. I became interested in how LISELL-B practices were adopted/adapted or not adopted by the LISELL-B teachers in the two years after the PL and its supports were gone, and that along with the theme of sustainability, became the topic of this dissertation.

PURPOSE

While there is evidence that demonstrates that PL can result in changes in teachers' content knowledge (Minor, Desimone, Lee, & Hochberg, 2016) and practices (Supovitz & Turner, 2000; Yow & Lotter, 2016) during or at the end of the program, very few papers report sustainability of knowledge and practices in the years following the PL. Thus, I have conducted this study in order to examine what traces of a high-quality PL provided to three seventh grade science teachers in a small, rural school in North Georgia could still be found in use in the two years following the end of the project. The PL that these teachers received was unique in that it was non-compulsory and that it consisted of many different types of PL experiences, thus offering a unique opportunity to examine how a network of science teachers, research-based practices and curricular materials fared after the PL and its supports were unavailable.

In consequence, this case study was undertaken to examine how materials along with practices modeled during a high quality, long-term, in-class and out-of-school PL research project supported teaching and learning in the classroom in the year following the end of its funding. To do this work, I took a sociomaterial approach, specifically Actor-Network Theory (ANT), to look at both the material (non-human/human) and social entanglements of PL to push me in a different way of conceptualizing and understanding how a model of high-quality PL—the LISELL-B project—was able or not able to support sustainable practices as an actor or actant—the actor being the "working entity" with agency in a network where the actant enables

the actor's activity (Fenwick & Edwards, 2010, p. 10) –as part of a middle school network (referred to here after as the After LISELL project). This sociomaterial approach is also important in that it departs from the unidirectional discourse of teacher change and effects, that isolates teachers from the larger social context that they work in and de-centers the science teacher, removing them from the center of critique and reform efforts.

Research Questions

In order to examine how three middle school science teachers through their participation/association with a high-quality PL network—the LISELL-B project—were transformed/translated into LISELL-B teachers, I utilized the following research questions:

1) What LISELL-B practices and materials were still active in the After LISELL network, in the two years following the end of the LISELL-B professional learning project?
2) What adaptations were made (if any) to the LISELL-B practices/materials by their association with the After LISELL network?
3) What barriers did the LISELL-B practices/materials encounter in their association with the After LISELL network?
4) How were LISELL-B practices and materials shared among or outside of the After LISELL network?

Dissertation Organization

Chapter two: Reviews the relevant literature to provide a justification for conducting this study and a theoretical perspective from which to determine the methods used and interpretation of results in this After LISELL study. This review is divided into the following

main sections: Education reform, professional learning and the sustainability of professional learning.

Chapter three: Provides a description of the theoretical framework used in this study. It addresses: Sociomaterial theories broadly described, and Actor-Network Theory.

Chapter four: Describes and justifies the study design and context. This chapter is divided into three main sections detailing: The context, the justification for the qualitative methods used to investigate the research questions, and the research design of this study.

Chapter five: Presents the case study results from this study. This chapter is divided into four main sections detailing the results:

1) LISELL-B practices/materials that After LISELL teachers continued to use in their classrooms.
2) LISELL-B practices/materials that After LISELL teachers adopted/adapted for use in their classroom.
3) Barriers the After LISELL teachers found in adoption/adaption of LISELL-B practices.
4) LISELL-B practices/materials shared among/or outside the broader school/county/science education network that the After LISELL teachers were a part of.

Chapter six: Discusses the results of this After LISELL study in terms of how this assemblage of science teachers, student teachers, computers, standards etc. were transformed by LISELL -B practices and materials, and how this relates to rethinking the development and implementing of science teacher PL. This chapter also discusses limitations to this study and possible implications.

CHAPTER 2.

RELEVANT LITERATURE

> As studies have shown, the steps we take to improve teacher skills and knowledge will pay off in better results for students. But I believe that developing more systematic approaches to professional learning will have added benefits. I know of no better way to transform the outmoded factory model of school organization and the egg-crate isolation of teachers than to give teachers the tools and support they need and greater responsibility over what happens in their buildings to ensure that all students achieve. This is an effort that will require—and is worthy of—another decade of school reform.
>
> *Gov. James B. Hunt, Jr., former governor of North Carolina; founder, National Board for Professional Teaching Standards; and 10 -year chairman, National Commission on Teaching and America's Future* (Professional learning in the learning profession: A status report on teacher development in the United States and abroad, 2009, p. 2, forward)

May of 2007- Moving Between Networks

A job-offer enticed this scientist to leave a Biotechnology lab and enter a Technical College to develop and implement a Biotechnology based outreach program for middle and high school teachers. The new outreach coordinator found herself associated with a new nomadic network that moved materials and people among many sites. This network included a summer Biotechnology academy, two technical colleges, a large group of science teachers, middle and high schools, lab kits, equipment, Biotechnology industry labs and Biotechnology instructors.

Introduction

The purpose of this chapter is to examine empirical studies of PL carried out with middle school science teachers, focusing on literature published between 2008 and 2019 to identify what the literature says about the way teachers enact PL practices; what inhibits or supports these enactments and their sustainability over time. This focus is used as a lens to explore relevant studies and findings from which to frame the findings of this study.

The review is divided into the following main sections: Recent education reform with definitions, the importance of high-quality professional learning, characteristics of effective PL, PL and implementation of the NGSS, and finally, what factors affect the sustainability of PL. In the methods section, I describe the criteria used for the review along with the process used for searching and selecting articles to be included in the analysis of the literature.

August 2007
The beginning of the school year was just a few weeks away. All the loan equipment was in place and the lab kits were still arriving but how would all this equipment loan and outreach work? The new nomadic outreach coordinator traveled to San Mateo County in California (the epicenter of high school biotechnology curriculum) to meet and observe how Pioneer (name changed) implemented her curriculum in high school biotechnology classes. Pioneer was one of the first science teachers to develop biotechnology-based science classes in high schools. Because the classes did not fit in the regular school day, they took place after school and included students from both private and public schools. Why would high school students want to attend a science class after school at six o'clock at night? The outreach coordinator drove up to the renovated shop class building and watched as students were being dropped off by their parents as if they were attending an after-school sport practice or event.

Recent Education Reforms

The goal of educational reform is to improve/change the existing educational structure and practice-to ensure that "each child might have a better opportunity to acquire the intellectual and social capital to enable them to succeed in U.S. society" (Hunt, Carper, Lasley, II, & Raisch, 2010, p. xxviii). In 2009, when the report with former North Carolina Governor James B. Hunt, Jr's quote at the beginning of this chapter was published, schools were seen as broken and in need of fixing. This sentiment had long informed reforms that were started before and under the ESEA which eventually resulted in harsh teacher accountability and students who were inundated with tests. The NCLB Act popularized the idea of raising the standards of American education to improve student achievement, which fueled the idea of a standard curriculum throughout the U.S. in the form of Common Core State Standards (CCSS) for Language Arts and Mathematics. By the end of 2012, the CCSS were voluntarily adopted and implemented in forty-two of the states, four U.S. Territories and the District of Columbia (Common Core Standards Initiative, 2017). Opposition to testing requirements and what was perceived as increasing government intervention in public education caused a backlash. A combination of public and political pressure caused lessening of the Common Core reform effort as did the passing of the new ESSA in 2015 which freed States from NCLB and its mandated evaluations, testing and high-quality teacher requirements (Every Student Succeeds Act). By 2017, 35 states had maintained their Common Core initiatives (Ujifusa, 2017). Accompanying these reforms for education were reforms of the science education standards.

In 2012, the Next Generation Science Standards (NGSS), which were collaboratively developed by a large group of states along with the NSTA, the NRC and the AAAS (without federal funds or incentives), added science to the idea of a standard curriculum (NRC, 2012).

Meeting the goals and successful implementation of these new standards is seen to present challenges to science teachers in the classroom due to the radical changes in instruction that NGSS require (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Reiser, 2013)

August 2007 San Mateo, California
On entering the building, the outreach coordinator found herself in a cavernous space that was bustling with student activity. The front of the classroom was filled with students, tables and chairs. Pioneer came up to me and after a quick hearty greeting, took me on a quick tour of the large open classroom space. Pioneer quickly explained that we were in a renovated shop class building. In the middle were banks of computers and to my left along the wall, was a storage area full of lab consumables similar to what one would find in a biotech manufacturing facility. Pioneer (almost breathless by now) excitedly explained how she managed to commandeer most of the used equipment and supplies from the many local Biotechnology companies that inhabited this small area of California. The outreach coordinator felt comfortable around the glassware and humming equipment that colonized the lab benches in this part of the building and tried to envision what experiments where in progress.

The Importance of PL in Science Education Reform

Professional Learning keeps teachers up-to-date on advances in education research, effective practices and available resources. Over 25 years ago, Judith Little (1993) reviewed the literature on teacher PL and found that it was mismatched with reform efforts of the time. She described the reform efforts during the early 1990's as residing in the following five categories:

- Reforms in subject matter teaching (standards, curriculum, and pedagogy).
- Reforms centered on problems of equity among a diverse student population.
- Reforms in the nature, extent, and use of student assessment.
- Reforms in the social organization of schooling.

- Reforms in the professionalization of teaching. (Little, 1993)

After reviewing more recent literature, I found that all the reform categories that Judith Little identified and described still existed today. This literature review is concerned with the intersection of PL and what Little (1993) categorized as reform in subject matter teaching—the adoption of the NGSS.

In a speech at the 2013 Invitational Research Symposium on Science Assessment hosted by the Educational Testing Service, Brian Reiser (2013) professor of learning sciences at Northwestern University, highlighted concerns about the dramatic changes that are going to be needed in science teaching practices, curriculum materials and assessment with the adoption of the new NGSS. But more importantly, he warns that "…without a strong focus on aligned professional development, adopting NGSS and providing these resources will not be sufficient. Supporting students in the type of coherent sensemaking science practices called for in the Framework and NGSS requires a change in teacher's daily practices" (Reiser, 2013, pp. 2-3). Professional learning that just focuses on facts about the NGSS or isolated techniques will not be sufficient and therefore attention will need to focus on how to support teachers in changing their practice (Reiser, 2013). Reiser (2013) identified three main shifts in science teaching practices that teachers are going to need to make:

1. Teachers will need to shift from focusing on teaching facts to explaining phenomena.
2. "Inquiry is not a separate activity—all science learning should involve engaging in practices to build and use knowledge" (p. 7).
3. Teaching will need to involve the building of "a coherent storyline across time" (p. 10).

Thus, in order to meet the holistic demands of the NGSS reforms in science teaching, science teachers are going to need not just high-quality but also effective PL. The goal of this review was to examine what are some of the empirical findings on effective PL, barriers to implementation/enactment of PL practices, and the sustainability of PL in the research literature that can inform my research study on the long-term effects of a standards/NGSS based high quality PL experience.

Characteristics of Effective Professional Learning

The PL of teachers is seen by many involved with education as one of the most important factors in improving American education and student achievement (Borko, 2004; Desimone, 2011; Guskey & Yoon, 2009; NRC, 2012). Yet traditional forms of PL—short, stand-alone workshops—which were described as "inadequate for preparing teachers to meet the educational needs of their students" are still common (Choy, Chen, & Bugarin, 2006, p. iii; Rotermund, DeRoche, & Ottem, 2017). Data from the most recent National Survey of Science and Mathematics Education on K-12 STEM (Science, Technology, Engineering, Math and + Computer Science; NSSME+) gathered from surveys of 10,000 STEM+ teachers, showed that 80 % of teachers had participated in science focused PL within the last three years (57 % within the last 12 months, 11 % -1,100 had none) that lasted 6-35 hours (44 %; 10 % > 80 hours) in the form of a program or workshop (94 %) (Banilower E. R., et al., 2018). The report concluded that many teachers surveyed did not meet levels of training in their respective subjects that are recommended by the National Science Teachers Association (NSTA) and the Clinical and Translational science Alliance (CTSA)-a key element of the NGSS (Banilower E. R., et al., 2018). Apparently, those in charge of PL were unaware of or un-swayed by the 30 years of research on the ineffectiveness of traditional PL models.

In their review of effective teacher professional development Darling-Hammond, Hyler, & Gardner (2017) defined effective professional development as "structured professional learning that results in changes to teacher knowledge and practices, and improvements in student learning outcomes (p. 2). The authors go on to make a distinction between PD and PL where "professional learning as a product of both externally provided and job-embedded activities that increase teachers' knowledge and help them change their instructional practice in ways that support student learning" (2017, p. 2). Formal PL is just part of the many experiences that a teacher may have that could result in professional learning. For this dissertation, I have adopted the more inclusive definition of PL adapted from Avalos (2011) where PL entails "teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their student's growth" (p. 10). Keeping in mind that this is a "complex process, which requires cognitive and emotional involvement of teachers individually and collectively" including reflection, resulting in enactment of practices that result in improvement or change in their classroom (Avalos, 2011, p. 10). In a report prepared for the Colorado Council of State Science Supervisors, Penuel (2014) listed six different key findings based on the literature published from 1996-2014:

1. Professional learning should be focused on disciplinary core ideas and practices as students encounter it in science classrooms.
2 Professional learning should be of extended duration.
3 The process of designing and adapting curriculum materials—when supported by subject matter and curriculum experts—can be a powerful form of PL.
4 Professional learning communities (PLC's) can extend professional learning under certain conditions.

5 Formative assessment can be an effective focus of PL when it helps teachers elicit, interpret, and make use of information about student thinking.

6 The effectiveness of PL depends on vertical and horizontal coherence in systems: the degree of alignment among standards, curriculum, assessments, and PL, as well as support from leaders.

August 2007 San Mateo, California
It was almost time for class, so we made our way back to the front where the students had been checking on their experiments from the previous class and recording their results in their lab notebooks. Students dressed in school uniforms mingled with those in everyday clothes. Students from any of the area high schools could attend and get credit for these classes. The research coordinator found a seat at one of the tables and chatted with the students about their experiments until it was time for the evening's lab to begin. To help save her voice in this acoustically challenging space, the pioneer had donned a "Madonna" like microphone headset before she began her lesson. This night's lab was a pollination lab. Flowering plants that had been started from seed many weeks before, were waiting patiently in their pots. The pioneer moved around the room giving out instructions as the students began to excitedly gather their lab materials. Piles of dead bees commanded the students concentrated attention as they carefully removed the rear end (thorax), of each bee. Mounted on toothpicks, the thoraxes were used to transfer pollen to the waiting flowers.

Review Method

The focus of this review of the literature is to analyze the findings of empirical papers that research the PL of science teachers in middle schools from 2008-2019 in order to identify recent research results in enactment and sustainability that can inform the analysis of the results of this study.

Selection of studies for review.

Criteria for selection of articles that were included in the literature review met the following criteria:

a. A focus on public school science teacher PL:
b. Specifically, middle school teachers (due to the differences in the cultures of high, elementary and middle schools).
c. Main topics: what is effective PL, factors influencing outcomes of PL (enactment or barriers to enactment) and/or mention of sustainability of PL enactment and teacher learning.
d. Written in English and primarily from the U.S. for relevance to our decentralized system of schooling.
e. Peer reviewed empirical research articles, reviews and reports.
f. Studies that focused on mathematics were not included.

Table 2.1. Screening Criteria for the Literature Review

	Description
Focus	The document discusses the effects of science-based PL on science teacher's classroom practice.
Researched group	Public middle schools and science teachers.
Research design	Empirical quantitative and qualitative designs, reviews and reports.
Time frame	Documents published in 2008 and into 2019
Country	United States

August 2007, San Mateo, California
During, the pollination lab, other older students came in and out of the back of the building. Apparently, they were busy checking on their experiments to see how they were progressing and

collecting data. Students were engaged and busy working on their experiments and talking about their results with each other. What a great space! The outreach coordinator couldn't wait to get back and tell the science teachers and Biotechnology science educators about what was going on in Pioneer's classrooms. The excitement of the students combined with Pioneer's creative teaching style propelled the outreach coordinator over the next seven years to help spread Pioneer's vision of science education.

Procedure used to find relevant literature.

In beginning my search of the literature during the fall of 2017, I did a quick computer Google Scholar search using the following keywords: "Science Teacher Professional Learning" and adjusted the date setting to literature published between 2007-2017. Google Scholar promptly rewarded me with 89,000 documents (in 0.04 seconds) from a wide variety of sources which included a mixture of peer-reviewed journal articles, reports (from: government, non-government and education specialty groups), books, periodical articles, dissertations, conference proceedings and reviews; many of which were not relevant to my study but a testament to the wide interest that PL has in research. Using the following keywords: "Science Teacher Professional Learning and Middle School" resulted in 823 articles. I quickly realized that this type of search was not getting me anywhere; so, I changed strategies. I began a new electronic search using ERIC, EBSCO, JSTOR and SAGE and identified 77 seemingly useful articles published from 2007 to 2017. Over a quarter of these articles came from the following journals: *Journal of Research in Science Teaching, American Educational Research Journal (AERA), School Science and Mathematics, Journal of Science Teacher Education, International, Journal of Science Education and Educational Policy and Education Policy.* Again, many of these articles were culled because they did not fit my criteria. But it did help me identify journals that publish articles that I found pertinent to my work. In the fall of 2018 and spring of 2019, I

searched for more recent literature (2017-2019) in the journals that I listed above using combinations of the following keywords: professional development, professional learning, enactment, middle school and sustainability of enactment and drawing from specific searches in the journals I mentioned above along with searching the references mentioned in papers I found along with which a literature review survey done by Darling-Hammond et al. (2017).

Analysis of studies.

In reviewing each of the journal articles that I selected I identified what the findings in the articles revealed about the results of their PL on teacher enactment of practices/materials and sustainability of these practices/materials in their classrooms. I then created a narrative account of the PL and its main features as I made sense of what the authors reported in their findings that relate to enactment and/ or sustainability. Finally, findings from each of the papers will be summarized in a table at the end of the review and how they relate to this study.

August 2013 Networks form and networks un-form.
A mass e-mail from Pioneer arrived. She had retired:

> *"Hi Biotechies, I hope this finds you well and that your summer rejuvenates you for another year of (WHOA) biotech! It has been awhile since I have contacted you and this email has a lot of new info for you about changes in the Biotechnology: Science for The New Millennium, 2012 curriculum and support services. Many of you know that I retired from the classroom in June 2013 after 34 (awesome) years of biology and biotech classes/programs. I retired to be able to attend to some family issues and work on improving my B: S4NM curriculum. I hope you find this info helpful.*
>
> *Best Biotech Wishes! :-) Pioneer"*

So, what happened to her class? Did a teacher from her high school take over?

At the same time funding had ended for my outreach program and I had been recruited into a new network by a researcher that needed a Biotechnology connection for an NSF funded project called LISELL-B.

Review Findings

What makes professional learning effective?

In 2011, Desimone published an update of what has become a widely accepted list of factors that high-quality PL should include:

1. **a content focus** on the subject matter that students need to learn and how they learn it.
2. **an active learning approach** that engages teachers in tasks rather than simply receiving information.
3. **coherence** between topics of teacher learning and the broader goals of the schools, districts, states, etc., in which the teachers are working.
4. **adequate duration** of teacher PL both in terms of total time and the distribution of time necessary for intellectual and pedagogical change.
5. **collective participation** bringing teachers together in school teams, grade level teams, discipline specific teams or other strategic grouping that promotes ongoing interactions, conversations and support structures that may extend beyond the scope of the formal PL interactions.

In thinking about these factors of high-quality PL, the first empirical study of effective PL that I drew from was done by Covay Minor, Desimone, Caines Lee, & Hochberg (2016) where they used in-depth interview data on teachers' content knowledge and classroom implementation along with quantitative assessment of teachers' content knowledge and

classroom implementation of middle school science teachers to understand the differential effectiveness of PL "through teachers' reflections on their learning" (p. 3). More explicitly (and very relevant to my study) they wanted to "unpack why so-called 'high-quality' PD"—based on the first of Desimone's (2011) five features of effective PL—content knowledge "has such varying effects on teachers" (2016, p. 3). The differential effects that they list are increasing knowledge in teachers and students, positive effects on teachers but not students, positive effects on specific groups of students but not all of those in the study and no differences between treatment and control teachers within a study. This study was situated in a larger randomized control trial, where teachers were divided into one of two different groups: strong middle school content knowledge or weak middle school content knowledge. The study teacher's prior college major was used as a baseline content and knowledge score which the researchers surmised was a measure of reasonable attainment of teachers' science content and knowledge. The PL in the original study involved science units in biology, geology and physical science that were taught by "museum professionals, university professors and researchers" (p. 8). There were two types of PL that was presented in exactly the same manner to the study teachers, lasting two years. The first type of PL was described as "pure content knowledge only" with no guidance on how to incorporate what the teachers learned into their practice. The second type of PL integrated content knowledge with pedagogy and included guidelines on how to integrate the principles into their classroom, intense support, and large sets of materials. The control group did not receive any PL. Effectiveness of the PL in the original study was based on students' state assessment scores and an end-of-unit test aligned with the PL content designed by the researchers. The researchers reported that overall, the students in the classrooms of the content knowledge/pedagogy PL group showed more improvement than the other two groups but the

results were not significant. But, in looking at the two types of assessment data separately for this group, there were consistent significant results observed only with state standardized tests and not on the end-of-unit test aligned with the PL. This set the stage for Minor et al.'s (2016) study that used qualitative data to better understand the intersection of content knowledge and teacher learning.

A total of 14 teachers from the larger study were interviewed for this study (six from the knowledge/pedagogy and four each from the control and content only PL). The researchers surmised that there would be richer data from the knowledge/pedagogy PL, so they chose to interview more of those teachers. Fidelity of implementation of the principles in the classroom was scored and interview transcripts were coded based on procedures from the literature. Analysis of the interviews led the authors to conclude that prior science knowledge:

1) affected what teachers learned from high-quality PL that focused on content knowledge; and their classroom practice.
2) affected what teachers learned from the high-quality PL that focused on how to use cognitive science principles in their teaching; and their classroom practice.
3) affected which PL (content focused vs focused on how to use cognitive science principles in their teaching) teachers were more engaged in.

Since my study was focused on a pedagogical model of PL and not a content knowledge-based PL, I focused here on the last two findings in my discussion since these are more relative to my work. Teachers that were designated as having prior strong science knowledge "were able to describe a deeper understanding and higher implementation than prior weak content knowledge group" (p. 16). The prior weak content group were more likely to describe increases in their content knowledge, confidence and risk taking but not their pedagogy.

There was also a positive relationship with those teachers that had a prior strong science knowledge and an ability to understand the "underlying principles behind" the PL strategies instead of seeing the PL "as a source of materials for their classroom" (p. 17). In one example, "Andrew" a teacher described as having prior strong science knowledge "viewed warm-ups as a method for assessing student understanding" which is what the PL intended, while a teacher characterized as prior weak content knowledge saw the warm-ups as a behavioral tool (p. 18). These results are interesting in light that the overall quantitative data (scores on the researcher's created test) from the original study did not support the assumption that teachers with an undergraduate degree in science were strong in content and knowledge (p. 13). This illustrates the importance of qualitative study in science education, which is reviewed in Peter Taylor's chapter in the Handbook of research of Science Education (Taylor, 2014). Taylor referred to the "transformative potential" of qualitative research in its ability to provide more insight as compared to the tradition of quantitative research which is accepted more in science education research which privileges the scientific method research paradigm (2014, p. 38). The authors still felt that their findings were strong enough to provide insights to PL development even after pointing out that their study had some limitations (the study was small and based on self-reported interview and survey data) and they concluded that:

> Translating PD content and implementing new instructional practices so that they can be used effectively in the classroom is a complex process. We know that such translation is moderated by teachers' prior knowledge, beliefs, and practices, even if we do not know precisely how. (Covay Minor et al., 2016, p. 4)

The results of this study support the importance of teachers' content knowledge and aligns with other similar research reviewed by Hilda Borko (2004) and Loucks-Horsley & Matsumoto

(1999) near the turn of the 21st century and by more recent research done by Yang, Liu, & Gardella Jr., (2018) based on concepts of subject matter knowledge and pedagogical knowledge.

In a review of PL effectiveness literature that focused on theories of action rather than design features of PL, Mary Kennedy (2016) found that many "design features were not associated with program effectiveness", and she further suggested that some of the research designs used in the study of PL "might adversely affect study outcomes" (p.1). Kennedy (2016) meticulously analyzed the research papers that she reviewed to find differences and possible reasons for the variable and sometimes negative effects that were reported. Originating from a stance where there is little consensus on how PL works, what happens in PL, how PL fosters learning and how PL alters teacher practice, Kennedy's review sorted the programs that she studied by their underlying theories of action based on teacher learning and supports for teacher enactment unlike other reviews that tend to focus on design features like duration or online PL (Kennedy, 2016).

I was specifically interested in what Kennedy (2016) identified in her review as facilitation of enactment. Kennedy (2016) referred to the *problem of enactment* which she describes is "a phenomenon in which teachers can learn and espouse one idea, yet continue enacting a different idea, out of habit, without even noticing the contradiction" (p. 3). Thus, Kennedy (2016) problematizes PL that is provided outside of the classroom that expects to alter teachers' behavior inside of the classroom which requires adoption of a new approach along with abandonment of a prior one (p. 4). So, what did she uncover about enactment? There were four methods identified in this review that PL programs used to "facilitate enactment of their ideas" (Kennedy, 2016, p. 11). The first and most used was prescription, where the PL program "explicitly describe or demonstrate what they believe is the best way" to implement a practice;

there is no room for flexibility or adaption which can lead to or exacerbate problems in enactment (Kennedy, 2016, p. 11). The second is strategies which are similar to prescription but differ in that they "are accompanied by a rationale that helps teachers understand when and why they should implement these strategies" (Kennedy, 2016, p. 11). The third strategy involved the concept of insight which she explains are "self-generated "aha!" moments" which "force teachers to reexamine familiar events" (Kennedy, 2016, p. 11). Finally, the fourth PL method "presents a *body of knowledge"* similar as a textbook based university course (Kennedy, 2016, p. 12). This fourth strategy Kennedy (2016) equates with more teacher autonomy in that the teacher becomes the expert. Each of these facilitators of enactment represent a level of control over the PL practices resulting in a differential effect on the "student" teacher's autonomy in enacting what they learned in the classroom.

The highly variable nature of PL effectiveness in these studies that Kennedy (2016) reviewed were accompanied by an agreement on the importance of PL but very little consensus on how PL works, what form it should take, how it fosters teacher learning and how it alters teacher practice, which led Kennedy (2016) to ask "how could something this variable be so uniformly assumed to be a good thing?" (p. 1).

Evaluation of professional learning effectiveness.

Then there is the question of evaluation of PL effectiveness. If one doesn't evaluate a PL effort then how would one know if it was successful? Thomas Guskey, who has published many papers on PL effectiveness, makes a case for education researchers to critically assess and evaluate the effectiveness of their PL efforts (Guskey, 2002; Guskey, 2000). His practiced based premise is that evaluation of PL is important in that it gives evidence of success or failure which could then be used to improve PL or to argue for more or less of the PL with school

administrators (Guskey, 2002). Evaluating PL can become confusing without some guidelines. What does one look for? How does one rate PL effectiveness? Fiona King (2014) explored the PL evaluation literature and devised a framework for evaluating PL. She then added measures that addressed the gaps that she perceived in the evaluation methods that she reviewed which included "system factors" that took into account context and added a measure of teacher attitudes, collaborative practices and diffusion (how practices can be disseminated to other teachers to enable sustainability) (King, 2014, p. 14). In testing her framework, King (2014) found it gave a richer form of accountability than other frameworks and that it could help teachers to assess their own PL to know whether they were improving "in their own learning and that of their pupils" and thus lead to sustainability of practice (p. 15).

Professional learning success indicated by change in teacher practice.

Dina Drits-Esser, Julie Gess-Newsome and Lousia A. Stark (2017), investigated the factors necessary to sustain teacher learning in the year following a year-long, medium-length (88 hours) PL intervention with 15 fifth and six grade teachers in a mixed methods study that focused on teacher learning in the context of inquiry. The authors were specifically interested in inquiry teaching and learning "as a tool for assessing the impact of professional development on teacher's adoption of science education teaching reforms and the sustainability of these changes" (Drits-Esser et al., 2017, p. 376). Drits-Esser et al., (2017), concluded the following:

- "Advances in teacher practice and changes in beliefs" can be sustained and continued and must be accompanied by school support.
- Not all teachers are willing or ready to change their beliefs.
- "Materials and training in their use are critical for change".

- Teams made up of same-grade teachers "with strong team leaders can mitigate the effects of an unsupportive administrator in sustaining change".
- "Fundamental change in teacher beliefs and practice take time. One year of PL is not sufficient to advance comprehensive change in most teachers' practice or beliefs".
- Only some parts of the strategies modeled in a PL program that involve belief change are likely to be integrated in the year following PL. (p. 391)

In short, the results from this study suggest that maintenance of teacher "learning is most influenced by same-grade collaboration, support and/or mentorship along with having a personal willingness to change in fundamental ways" (Drits-Esser et al., 2017, p. 390). This mixed methods study which leaned heavily on Quantitative methods, and a structured interviewing protocol (The Teacher Beliefs Interview protocol) and its reliance on the 5E instructional model as its primary model of inquiry instruction, resulted in data with implications for PL that is beginning to address the new NGSS standards (Drits-Esser et al., 2017).

Professional learning success indicated by student achievement.

While change in teacher practice is one of the main indicators of the success of PL, the "Holy Grail" is PL that results in an increase in student achievement (Ladson-Billings, 2006; Yang, Liu, & Gardella Jr, 2018; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). In one of the largest studies of the literature of PL and its effect on student achievement, Yoon and colleagues found that: workshops were not as ineffective as previously reported, outside experts improved learning outcomes, time was important if used wisely, teachers need follow-up support, context is important, and finally, there is no replacement for "thoughtfully planned and well implemented professional development" (Yoon et al., 2007, p. 497). But when looking at the data (1,343 studies) there was not sufficient evidence of effects on student achievement for the

authors to conclude that any method studied was better than another in their effectiveness in improving student learning (Yoon et al., 2007). A more recent study by (Yang, Liu, & Gardella Jr, 2018) which describes a five-year PL aligned with the NGSS looked at fourth through eighth grade teachers and their students. Data collected consisted of PL learning records and teacher performance on a pedagogical content knowledge test as well as student surveys and assessments based on grade level. Teachers in this study provided input on PL topics and participated in professional learning communities along with four to six week long sessions of "summer interdisciplinary research, science curriculum study, or a course in physics and engineering" (Yang, Liu, & Gardella Jr, 2018, p. 271). Findings included a significant increase in student understanding of common core standards that was related to 150 hours of teacher PL, but the authors concluded that how this relationship worked was unknown (Yang, Liu, & Gardella Jr, 2018). Yang et al. (2018) also found that there was no relation of PL on teacher inquiry classroom practices and attitudes. This study supports the literature on the positive relationship between PL, coherence and duration where teachers are consistently involved in PL resulting in positive student outcomes.

These variable results have led some researchers to question the linear/unidirectional way of thinking that has often been assumed in science teacher PL in which teachers attend high quality PL, their beliefs or instructional practices are changed resulting in improvement in student achievement (Deneroff, 2016; Little, 1993; Supovitz & Turner, 2000). Even though these studies point to or suggest that there are a variety of barriers that hinder/modify implementation, most research studies still conclude that teachers are at the center of reform effectiveness (Dogan, Pringle, & Mesa, 2015; Minor, Desimone, Lee, & Hochberg, 2016). As a

result, other researchers have begun to look for alternative ways to conceptualize the professional learning of teachers (Buxton, et al., 2015; Fenwick & Edwards, 2010; Fenwick & Landri, 2012). Buxton et al. (2015), saw their PL (LISELL-B) evolve by empowering teachers in allowing them to make choices about their professional learning, which lead to design changes in their PL. Furthermore, they sought to open up a collaborative space for teachers and students to work together on LISELL-B activities.

Sustainability of professional learning.

In contrast to the attention paid to the immediate effects of PL such as change in teacher beliefs and/ or student achievement in the education literature, relatively little is written about what happens in the classrooms of teachers after they participate in PL (Avalos, 2011; Sandholtz & Ringstaff, 2016). Professional learning that has lasting effects on teacher learning and practice is the desired outcome (sustainability), but most studies of PL only look at the short term rather than the long-term effects of PL. For example, King's (2014) evaluation framework that measures dissemination, indirectly documents a PLs' short-term effects, but not the long-term ones. This dearth of knowledge about the lasting effects of PL is made more visible by a review of the literature from 2000-2010, where Beatrice Avalos (2011) didn't find any articles that reported sustainability of PL. References to sustainability in many of the older articles that I read relating to PL were limited to claims that PL "could have an effect" on sustainability (Banilower, Heck, & Weiss, 2007; Johnson, Kahle, & Fargo, 2007; Desimone, Porter, Garet, Yoon, & Birman, 2002). Thus, it is difficult to get some understanding of what factors are needed to support the sustainability of practices learned in PL. I have summarized some of the more relevant findings in the following paragraphs.

In a study that looked at science content knowledge, the authors described providing 60 middle school science teachers a three-year, standards based, mixed PL that included a summer academy, online, and professional classes in chemistry, geosciences and physics (Clary et al., 2018). This PL, which also included instructional strategies consisted of an "intensive 10-day summer academy and three academic PD days" (provided by university scientists), "extended content instruction through two online content modules (administered by the National Science Teacher Association), and participation in 'share-a-thons' and other PD opportunities at the Mississippi Science Teachers Association annual conference" (p77). This non-random mixed-methods study collected both qualitative and quantitative data such as pre and post assessments and surveys. Both the study and control teachers elected to be part of the study; hence, the non-random nature of the study. Pre and post assessments showed significant increases in content knowledge for the study teachers, while control teachers showed no difference over the same period. These gains were not retained by the study teachers six months after they returned to their classrooms (p.81). In the first and second years after the study, assessments showed a positive trend in chemistry content knowledge but it was not significant. There was a negative trend for physics content knowledge teachers during the same time period. While the geosciences teachers showed a significant increase in content knowledge from the beginning of the study to the end, there were no significant changes from the end of the study until one to two years later (p.81). In their discussion of these results, the authors suggested that some of the variability which lead to the non-significance of the results, was due to the inclusion of teachers who were 'professional workshop attendees' who were more interested in stipends along with teachers who wanted to improve their content knowledge (p.82). Other factors that were brought up included a misalignment of what the teachers taught in the classroom with the content they

were taught and not enough teachers in the end of the study to give a strong statistical result. These results led Clary et al. (2018) to conclude that science teachers need differentiated content support depending on the discipline they are teaching in order to sustain the effects of PL. This study was interesting in that it was so rich in variety in high quality PL and yet the results were disappointing. One problem could be due to the fact that the results of this study were solely based on pre and post assessment data that are not going to tell what the teachers took from the PL and began to use in the classroom. It would be interesting to see what the not published survey data says.

In one of the few studies that looked at students' motivation and achievement after their teachers attended a PL intervention, Allen, Pianta, Gregory, Mikami, & Lun (2011) utilized a randomized controlled trial to assess the effects of a PL program that targeted motivational and instructional quality of teacher's daily interaction with students –the My Teacher Partner-Secondary program (MTP-S). The MTP-S program consisted of twenty hours of intervention spread over thirteen months. The authors found no significant effect until the post-intervention year where they saw a nine percent increase in student academic performance (Allen, Pianta, Gregory, Mikami, & Lun, 2011, p. 1036).

What can we learn from elementary school-based studies of PL and sustainability? A recent case study looked at K-2 teachers and the influence of context on the sustainability in the three years after a three-year science-based PL. Sandholtz and Ringstaff (2016) found that the variability in sustainability of PL across the schools that they studied was highly influenced by the schools' context such as: "principal support, resources, collegial support, personal commitment, and external factors" (pp. 222-223). The authors of his case study, which used teacher surveys and interviews, identified five findings that influenced sustainability:

1) "Principals played a central role in facilitating or hindering K-2 science instruction after the professional development ended (principals control "time allocated for teacher collaboration" and resources allocated for family science night or classroom science supplies) (p. 220).
2) State level programs and Common Core standards impacted schools differently and added "new instructional demands" (p. 220).
3) "Teachers with ongoing collegial support in their school were better able to sustain practices learned in professional development" (p. 221).
4) "Teachers with high personal commitment to teach science and use inquiry-based methods found ways to do so, but schools should not rely on individual drive to overcome contextual factors" (p. 221)
5) "Teachers' most frequently requested forms of support were modest but hold important potential for sustaining science instruction". Teachers were interested in one to two days of PL a year, more collaboration with colleagues, access to consumable science supplies, and support on how to modify activities to fit shorter classroom times (p. 221).

Sandholtz and Ringstaff (2016) reaffirmed the importance of context as a factor in making the learning from PL more resilient. The authors reiterated a need for research in a "range of settings" to better understand how context influences sustainability to inform the best way to support teachers after PL (Sandholtz & Ringstaff, 2016, p. 223). Even though this study did not meet my original criteria for inclusion in this review, I found it important to include since it was one of a few case studies that actually looked at long term sustainability, and its findings

echoed those reported in some older papers on principal support and changes in PL (Banilower, Heck, & Weiss, 2007; Johnson, Kahle, & Fargo, 2007).

Over half of the studies that I reviewed only focused on one year after the PL intervention. From a researcher standpoint, this is not surprising since most research projects have limited funding and after the project, many of the participants scatter, making it hard to follow teachers over many years to assess long-term effects of PL interventions. Those that do though report one or two years after the study is completed and data was mainly observation of the teachers with no student achievement data (Johnson, Kahle, & Fargo, 2007). Interestingly many of the PL sustainability outcomes were attributed to context, followed by support: collaborative peer groups and administration/principal buy in (Drits-Esser, Gess-Newsome, & Stark, 2017; Yang, Liu, & Gardella Jr, 2018).

August 2014

So many things have happened since August of 2013. The outreach coordinator became a researcher and then a graduate research assistant in the LISELL-B network. This was also a nomadic network that moved biotechnology, graduate students, science teachers, family workshops, high and middle schools, assessments, kit development, curriculum, materials, summer teacher and student workshops and University researchers, around multiple sites around North Georgia. This time, there was also a component of the language of science as well. What it means to do "research" had changed for me as well where being objective and totally removed seemed impossible in this new world of pedagogy, epistemology, ontology, praxis where theories instead of computers and PCR machines are used to describe and analyze what is going on around me.

Discussion

This literature still draws on the argument that high quality PL should include a focus on content, active learning, coherence between teachers and their schools' agendas, having adequate duration, and including collective participation. Covey Minor et al. (2016) looked at the effect of previous content knowledge on PL outcomes in a two year study and concluded that Pl is a complex process that is moderated by content knowledge, beliefs and experience but, there is still little known about how they work in PL.

Kennedy (2016), reviewed the literature on PL effectiveness and focused on the theories of action instead of design of the PL and identified four ways that PL providers facilitate the enactment of their programs which she referred to as: Prescription, strategies, insight, and body of knowledge. Each method represents a different level of control for the PL providers and autonomy for their teacher students argued Kennedy (2016). In troubling her findings, Kennedy (2016) came to the same conclusion as Covey Minor et al. (2016) that there was little known about how PL worked, what form it should take, how it fosters teacher learning, and how it altered teacher practice.

The evaluation of PL is also an important part of the PL process and seemingly heeding Kennedy's (2016) call to move away from privileging the structure of PL and Guskey & Yoon's (2009) insistence on making evaluation more practical and useful for administrators; Fiona King (2014) developed a framework, based on the PL literature that took into consideration context, teacher's beliefs, collaborative practices and how teachers shared their knowledge with others; a practice she called "diffusion". In comparison, many studies still use change in teacher practice and student achievement as valid measurements of PL effectiveness (Drits-Esser et al. 2017; Yang et al. 2018).

While much has been written about the immediate effects of PL, little attention has been paid to the long-term effectiveness of PL. While some studies have seen some positive effects over time, a recent study by Clary et al. (2018) showed variable results, which they concluded pointed to the importance of differentiating PL as a way of sustaining PL.

In conclusion, the literature still doesn't offer conclusive evidence of what works best in PL, which supports the suggestion that other methods of inquiry may provide better understanding, than those that have been the standard mode of inquiry in research on PL in education, over the last 30 years.

Summary

In short, while reviewing the literature on science PL, I found that empirical studies on the PL of teachers depended on the researchers' goals or focus. But most seemed to agree that the outcome of PL should ultimately benefit the students. Teachers navigate a complex education system, yet little research has examined PL in light of how PL works, and recent studies give a glimpse of what may work but the evidence is still not clear (Covay Minor et al. 2016; Drits-Esser et al. 2017; Sandholtz & Ringstaff, 2016; Yang, Liu, & Gardella Jr, 2018).

CHAPTER 3.

THEORETICAL FRAMEWORK

August 2013, before graduate school
It was the outreach coordinator's first project meeting. The room was small and cozy, and the outreach coordinator was surprised at how friendly everyone seemed to be. Much friendlier than the outreach coordinator was used to, especially when it came to project meetings. The outreach coordinator listened intently. She had been worried; this was the College of Education and there were expectations that the project was to be less than rigorous. These people didn't perform real experiments. At least that was how scientists viewed outsiders. The outreach coordinator was vigilant, waiting to catch a breach of scientific method protocol. But all was well. The outreach coordinator was overjoyed at the careful attention that part of the research team gave to the collection and analysis of the project's data. Relief, everything was going to be OK in this new project called LISELL-B!

Introduction

This chapter provides a description of this study's theoretical framework and is divided into the following sections: Sociomaterial theories broadly described; Actor-Network Theory and Actor-Network Theory and education research.

Theoretical Framework

If we expect deeply rooted school structures to shift toward more equitable and meaningful practices, then we must build networks that are poised to take advantage of

> *openings and possibilities for change when they become manifest.* (Buxton, et al., 2015, p. 499)

In questioning accepted notions of investigating and evaluating models of professional learning, Buxton et al., (2015) challenged researchers "to consider new ideas such as responsiveness and nimbleness or agility as criteria for quality" while building models of teacher professional learning (p. 501). The present study began in the constructed actor-network described by Buxton et al. (2015), the Language-rich Inquiry Science with English Language Learners-Biotechnology (LISELL-B) project. This LISELL-B actor-network provided a unique context where teachers could: choose the PL that they wanted to attend, help modify the project, work with groups of their peers, try out the practices that they learned with a group of students in an out-of-school context, attend PL focused on looking at student writing, and participate in workshops with students and their families for three years. To help understand how, the LISELL-B actor-network PL informed classroom practices and their sustainability, I chose to conduct a case study using ethnomethodological methods.

Background of Sociomaterial Theories

Patrick Baert & Fernando Domínguez Rubio (2009), in their chapter on the *Philosophy of the Social Sciences*, explained that by the end of the nineteenth century traditional philosophers of the social sciences viewed the term "social" as concerned with the study of humans and their relationships, whereas the study of "nature" (the world of objects and their associations) was relegated to the natural scientists (p. 74). They further explain that this separation of the social from the natural came under criticism by researchers in the study of Science and Technology Studies (STS) who found that excluding objects from their inquiry hindered their ability to explain their research. They found that the separation of humans and objects was also hard to

maintain (Baert & Dominguez Rubio, 2009, p. 74). Actor-Network Theory evolved as a method/theory as STS researchers incorporated the natural and social in their technology studies. Bruno Latour, Michael Callon and John Law, along with their fellow researchers at the Centre de Sociologie de l'Innovation of the École Nationale Supérieure des Mines de Paris were the epicenter of Actor-Network based studies beginning in the early 1980s (Fenwick & Edwards, 2010). Latour (2007) redefined sociology as the "*tracing of associations"* (p. 5) and he explained that sociology lost its way by "trying to imitate the natural sciences" in order to find quick answers to social questions but, in doing so, sociologists ignored the important role of associations (p. 250). Latour is critical of sociologists using overarching labels like culture and society to explain the social. He defines the social as "not a special domain, a specific realm, or a particular sort of thing, but only as a very peculiar movement of re-association and re-assembling" (2007, p. 7). He further explains that a notion of social needs to be thought of as only being produced within associations and that there are no "social ties" or "social forces" but rather a "sociology of associations" (2007, p.7-9). In understanding the philosophical lineage of ANT, Latour (2007) tells us that the theories of Gabriel Tarde (1843-1904), who regarded societies as aggregates of individuals, and of Harold Garfinkel (1917-2011) the ethnomethodologist, were the backbone of ANT (Latour, 2002; Latour, 2007). Latour also brings in the writings of Foucault as well as those of Derrida, Deleuze and Dewey (Latour, 2002; Latour, 2007).

Actor-Network-Theory (ANT)

> …for this small subfield of social theory that has been called—by the way, what is it to be called? Alas, the historical name is 'actor-network-theory', a name that is so awkward, so confusing, so meaningless that it deserves to be kept. …I was ready to drop this label

> for more elaborate ones like 'sociology of translation', 'actant-rhyzome ontology', 'sociology of innovation', and so on, until someone pointed out to me that the acronym A.N.T. was perfectly fit for a blind, myopic, workaholic, trail-sniffing, and collective traveler. An ant writing for other ants, this fits my project very well!
>
> (Latour, Reassembling the Social: An Introduction to Actor-Network-Theory, 2007, p. 9)

> "Things exert force themselves. They do not just respond to human intention and force. In fact, things change and shape human intentions, meanings, relationships, routines, memories, even perceptions of self" (Fenwick & Edwards, 2010, p. 6).

As a "true confession," the outreach coordinator was well trained in positivist/quantitative scientific research and started this journey totally excited to be part of a "real" research project. "Real" because, it included the collection of data—specifically data, in the form of numbers. In the outreach coordinators past association with a biotechnology lab, qualitative methods were referred to as pseudo-science or unscientific. Now, the outreach coordinator was associated with a project that offered a new way to look at the world.

In the above quotes, Bruno Latour and Tara Fenwick and Richard Edwards introduce the main tenets of ANT—its connection to sociology and its embrace of the notion of 'Thing Power' (a term I borrowed from Jane Bennett; see: *Vibrant Matter: A Political Ecology of Things*, 2010), where things/the material can exert force in our lives. In their book, *Actor-Network Theory in Education*, Fenwick and Edwards (2010) refer to actor-network theory (ANT) "as an array of practices for approaching complexity in the world and its problems" (p. viii). They describe these practices as originating from science and technology studies, embracing the messiness of the mixture of the "normal, social or technical" and trying to tease out the webs of

association, how they exercise force, "persist, decline and mutate" (p. viii). Categories like 'the human', 'the social', 'subjectivity', 'mind', 'the local', 'structures' are on an even ontological field with the non-human. With the lens of ANT, education is a "process" that produces "knowledge, practices and subjectivity that involve purpose and pedagogy" (p. ix).

Of course, to complicate things, Fenwick and Edwards (2010) state that ANT theorists describe ANT as not a "theory" nor is it an "explanatory device" (p. ix). It does not explain why a network takes form rather it describes relationships/associations/activities within a network-how these associations form and what keeps them together or what makes them fall apart—more of a method. Actor-Network Theory relies on empirical data and thus can yield useful insights and tools for sociology. Like other post theorists, ANT theorists see their theory as one that is fluid, purposefully complex (recent authors call their work 'post-ANT' or 'after ANT') which has an openness but, contains a temporary and unstable theoretical framework that is hard to domesticate. It is unlike theories such as Critical Theory that can be applied and used as an explanatory device or a way to think (Fenwick & Edwards, 2010, p. ix).

In their book *Laboratory Life,* Latour & Woolgar (1986), offer a rare description of what a network is by using the example of TRF. The authors are careful in not defining TRF for the reader because they don't want them to focus on "what TRF really is" but rather how the "meaning and significance of TRF(H)" changes with the context that it is associated with (Latour & Woolgar, 1986, p. 107). Latour and Woolgar (1986), explain "If we define a network as a set of positions within which an object such as TRF has meaning, it is clear that the facticity of an object is relative only to a particular network or networks. One convenient way roughly to assess the extent of a network is to ask how many people know the meaning of the term TRF (or TRH)" (p. 107). What Latour and Woolgar's (1986) definition explains (which illustrates the

problem with the visualization that the term network presents), is that a network is not a spider web of connections but rather more like a community or a space made up of things that have meaning only when associated with it. They go on to discuss how when TRF is associated with different networks (endocrinologists vs neurologists), it can take on different meanings as Thyrotropin Releasing Hormone (TRH) verses Thyrotropin Releasing Factor (TRF). Outside of the lab network, TRF (TRH) has no meaning at all; leading the authors to conclude that "TRF can take on a different meaning and significance depending on the particular network of individuals for which it has relevance" and where outside of the network, it would just represent a pile of "white powder" (Latour & Woolgar, 1986, p. 110).

Using ANT in Education Research

Fenwick and Edwards (2010) also describe ANT as a "sensibility, an interruption or intervention, a way to sense and draw nearer to a phenomenon" (2010, p. ix). Sensibility gives a researcher the freedom to respond or be affected by things and people; it relies on experience to help with understanding the complexity of a phenomenon. Thus, the researcher is not the objective observer but rather a part of the process. They further explain that ANT approaches are useful for educational researchers in that they "can enact questions and phenomena in rich ways that discern difficult ambivalences, messy objects, multiple overlapping worlds and apparent contradictions that are embedded in so many educational issues" (Fenwick & Edwards, 2010, p. xi). So, what better place for ANT but a school with all its complexities, full of networks of associations made up of humans and things.

Actor-Network Theory can also show how things are attracted to, gathered in, or excluded from networks, how some linkages work and others do not, and how connections are bolstered to make themselves attainable and durable by linking to other networks and things

(Fenwick & Edwards, Actor-Network Theory in Education, 2010, p. 97). This approach can help shift the focus away from the teacher-or as Buxton et al., (2015) suggest 'to grapple with the complexity of how practices are taken up, supported, and discouraged within and against the current policy structures in schools and communities" (p. 500).

In this After LISELL study, I will focus on what was made invisible, ignored, the unimportant, mundane, and attempt to illuminate assemblages, highlighting the role played by different actors and actants, to avoid following a linear idea of PL and teacher learning and classroom practice as Buxton (2015) suggests: "With this structure-agency dialectic in mind, we question the assumptions inherent in research models that presume a linear relationship between effective treatment and fidelity of implementation" (2015, p. 499). Actor-Network Theory can help me answer my research questions by allowing the material as well as the human actors to be identified and traced through the network that my research is a part of. Then ANT will help me understand how these actors/actants are influencing the sustainability/durability of LISELL-B PL practices within this network.

Summary

Originating in the discipline called Science and Technology Studies, ANT evolved from a group of French STS researchers who found that the separation of humans and objects was hard to maintain. Bruno Latour, Michael Callon and John Law are the actors that maintain the ANT network of thought. Critical of the overarching labels that were utilized by social scientists to study "society," they created a new array of practices to research the social that embraced both the material as well as the social. Tara Fenwick has been prolific in her use of ANT in educational studies and she found that ANT's importance lies in its ability to "make visible" the "ambivalences and contradictions" along with the multiple associations of the "material and

immaterial elements" that result in knowledge (Fenwick, 2010, p. 39). This theoretical perspective doesn't answer the why but rather is more adept at tackling the how and what in undertaking how the material and human interact to form the social.

CHAPTER 4.

DESIGN AND METHODS/ROAD MAP

> *In 1966, this researcher was one of an estimated 4.5 million students* (Hunt, Carper, Lasley, II, & Raisch, 2010) *that were attending Catholic elementary schools that year. We were taught by nuns who were generally mentored by their more experienced cohorts. Most took vows of poverty and lived in communities housed nearby. In my school, priests were usually only seen when we attended Mass and disciplinary problems usually brought the Monsignor out. We had a few lay teachers whose presence increased steadily as the number of nuns declined sharply. These lay teachers would eventually take over teaching in Catholic schools by the 1980s.*

Introduction

This chapter describes the design and context along with a justification for each, based on the current literature. This chapter is divided into three main sections detailing: The context, the justification for the qualitative methods used to investigate the research questions, and the research design of the After LISELL study.

The Study Context-Sites Visited

The middle school in this study was one of eight implementation middle and high schools (and four control schools) that comprised the LISELL-B study schools situated in two North Georgia counties. These counties were targeted by this English language learner (ELL)-

centered project due to their large population of Latino immigrants that came to find work in the local poultry industry, construction, landscaping, food services, healthcare and other areas of the local economies.

Science teachers from the sixth, seventh, and eighth grades; their ELL students; and families from this middle school along with the other project schools, had just finished their participation in the 3-year LISELL-B PL project in the spring of 2017. As a graduate student researcher in the LISELL-B project, my assignment was to work with Mountain Middle school resulting in a strong connection with this group of science teachers, especially the seventh-grade science teachers.

The After LISELL study began during the following fall of 2017, just as the implementation of the new Georgia Standards of Excellence began in the state of Georgia. Approved in 2016 (Georgia Department of Education, 2015), these GSE's were adapted from the NGSS and aligned with the NRC's Framework for K-12 Science Education Standards (Georgia Department of Education, 2015).

The LISELL-B Project.

> *From the outset of the project we made it clear to teachers that we were exploring ideas together and we encouraged them to make their own decisions about their engagement in our professional learning and their enactment of our pedagogical model.* (Buxton, et al., 2015)

The Language-Rich Inquiry Science with English Language Learners through Biotechnology (LISELL-B) project a science teacher professional learning model, was a four-year project (year one was a planning year) funded from fall 2014- spring 2017 (with additional

supplemental funding received to continue research activities during 2017-2018) by the National Science Foundation and housed in the Department of Educational Theory and Practice of the College of Education at the University of Georgia. College research faculty were joined by a fluid multicultural-group of masters and doctorial graduate students, as well as undergraduate student workers, forming a network referred to as the LISELL-B staff. Over half of the staff were multilingual, non-native English speakers whose native languages were Spanish, Chinese, Korean, Persian and Turkish. The main component of the LISELL-B research project was a multifaceted approach to PL where science teachers were offered the chance to participate in a variety of different activities that offered unique and sometimes overlapping possibilities of engagement. These activities included an annual teacher institute followed directly by a student summer enrichment academy, ongoing Steps to College through Science bilingual family workshops, teacher workshops for exploring students' science meaning making through writing, and grand rounds classroom observations supplemented by an online teacher activity log.

> *My grade school which carried a religious moniker—Annunciation—was co-ed and it's two-storied brick building housed a library and one classroom for each grade (k-12). In contrast, my study school (renamed Mountain for this study)—referred to as a middle school, was named after its orientation within the county it resided in. Its building was also brick but one storied and it housed multiple classrooms for grades six-eight.*

Rationale for Choice of Methods

I am borrowing from the sociomaterial to understand how LISELL-B practices and materials that were part of the LISELL-B PL project network were maintained or not maintained by the projects LISELL science teachers after a project ended. Since agency is assigned equally

to both the teacher and things (which is referred to as Symmetry), ANT considers all surrounding factors where no-one acts alone; which is illustrated nicely in Latour's (1988) book *Louis Pasteur and the Pasteurization of France*. Bruno Latour shifts focus away from Pasteur, who is historically credited with discovering and implementing pasteurization in France, to reveal the large network of actants /actors (something that acts), both things and humans that allowed for pasteurization to be discovered, standardized, implemented, and thus transformed, or as Latour calls it "translated" into a social norm (2007, p. 108; Latour, 1988). Similarly, ANT can illuminate how LISELL-B practices and materials fared over time in a large network of actors and actants that make up a middle school.

ANT doesn't explain why a network exists but rather how is it formed and /or unformed (falls apart). The After LISELL actor-network in this study is populated by actors and actants whose performance is dependent on their interactions as they move together/apart (enrollment/mobilization). I was interested in how the After LISELL actor-network was maintained/or fell apart, what actors and actants were engaged in the maintenance or deconstruction of that actor-network, what was included/not included, made invisible and what micro-negotiations (Translation) of the LISELL-B practices were present.

Ethnographic methods are quite useful and compatible in an ANT study so, I began this study by using a loosely-structured group interview to get the participants together so that we could interact, ask questions, and relay expectations and challenges about the After LISELL study, as well as catch up on what was going on in each other's lives at school and home (Marshall & Rossman, 2011, pp. 168-169). Notes were taken and the initial interview was recorded with the participants' knowledge and later transcribed.

The problematic nature of transcribing interviews and other audio recordings can be decreased by asking the recorded teachers to check if their meaning and intent were correctly captured (member checking) (Prasad, 2005). Long pauses and chosen words can all be interpreted but since there are no visual cues where a lot of meaning is conveyed by such things as hand moves and, facial expressions, describing the context is very important. Ethical issues also pop up during transcription in that I needed to consider whether to transcribe verbatim what is spoken on the recording, including the mistakes, stutters, and half spoken sentences. I chose not to use computer programs like NVivo, QDA Miner Lite or InqScribe to organize my transcribed data and to help find meaning through coding, since my data set is not huge. Instead, I transcribed the interviews and highlighted sections/words in the interview transcripts that were relevant to my research questions.

> *At Annunciation, we studied many of the same subjects as the students in Mountain Middle School, but we also attended religion classes. There were work stations, phonics and speed reading. During many of my observations Mountain Middle School, the students worked at stations when they were participating in labs. Unlike Mountain middle school, at Annunciation we had gym and recess every day and our moms took turns monitoring the playground at noon so that the nuns and teachers could eat their lunch in peace. Teachers in Mountain Middle School monitored their students at lunch, eating their lunch during their break and parents only came to the school for teacher conferences or to pick up kids.*

"Where to Travel" and "What is Worth Seeing There?"

In his book *Reassembling the Social: An Introduction to Actor-Network-Theory*, Latour (2005) does not offer a stepwise procedure to follow but he does guide us and offers suggestions along the way:

> The choice is thus clear: either we follow social theorists and begin our travel by setting up at the start which kind of group and level of analysis we will focus on, or we follow the actors' own ways and begin our travels by the traces left behind by their activity of forming and dismantling groups. (p. 29)

In ANT, the researcher becomes a traveler/nomad that follows paths, taking notes, video, and pictures about the sites that he/she comes across, checking their road map when they get bogged down or lost (p. 17). Latour (2005), favors ethnographic study in which he captures as much as possible in painstaking detail; everything is data where "recording not filtering out, describing not disciplining, these are the Laws and the Prophets" (p. 55). The most important thing to remember is that "We study science in action" (Latour, Science in Action, 1987/1994) and there are no hidden agendas to report; either something does something or it doesn't and what it does needs to be described with "flesh and features" which is referred to as "figuration" (Latour, 2007, p. 53). Latour tells us that he borrowed the words actor and actant from the study of literature because of the "freedom of movement" that they allow (p.54-55). "Actors do the sociology for the sociologist and sociologists learn from the actors what makes up their set of associations" (Latour, 2007, p. 32). Or said another way,

> If I had to provide a checklist for what is a good ANT account—this will be an important indicator of quality—are the concepts of the actors allowed to be stronger than that of the analyst or is it the analyst who is doing all the talking. (p.30)

Of course, every theory has its good and bad side and some of the criticism aimed at ANT is that it is absurd to assign agency to things or that ANT is amoral because all actors are equal- where no power imbalances can be shown or that ANT leads to useless descriptions that seem pointless (Fenwick & Edwards, 2010). I agree with the ANT scholars and feel it is absurd

not to consider *things* in research, especially when teachers and their practice are controlled by their presence: science standards, time, smart boards, desks, and assessments; or their absence as in a lack of equipment (computers or microscopes), space (as in not enough room), time, and agency.

Relying heavily on ethnographic methods, ANT helps the observer see the actions of networks/associations that create society, and thus helped me "Disentangle the networks of connections and other relations that together produce particular effects in classroom activity" (Fenwick & Edwards, 2010, p. 22).

Even though I used ethnographic methods in this research project, I do not wish to claim that this is a traditional ethnographic study either in terms of scope or theme. Instead, I hoped that using ethnographic methods in an ANT framework (referred to as ethnomethodology) would allow me to pay attention to material artifacts and material actors. Studies that focus on humans while ignoring *things* tend to focus on the teacher as individuals and eventually end up talking about what is wrong with the teachers being studied. I did not wish to take that stance. This study is not just about teachers but, rather about the network/associations in which they are situated-no one/thing works alone.

> *Annunciation students wore uniforms—to equalize us—to erase family income differences. Most of my classmates came from families with five or more children. Having ten children was more equalizing than uniforms, even when families had large incomes. Mountain middle school had a dress code that was ignored at times by the students, which caused After LISELL teachers to complain about lack of enforcement during some of the planning meetings.*

Case study

This research study used a case study design that enabled detailed, in-depth information to be collected about the network and its actors and actants (Marshall & Rossman, 2011; Prasad, 2005). Case study research begins with the "assumption that research must begin in natural settings" and it uses data collection methods such as document analysis, interviews, and observation (Marshall & Rossman, 2011, p. 267). The After LISELL actor-network that I chose to study for this case study project existed during the LISELL-B project. The school and its teachers' real names will not be used. Instead, the project school will be referred to as Mountain middle school and the names Kelly, Alex and Charlie (all multi gender) will be used for the teachers.

> *Annunciation was located in the North Western region of Washington D.C. (D.C.) and the demographics of the students did not reflect that of D.C. during the 1960's, where the number of African Americans living in D.C. finally overtook and doubled the white population numbers and stayed that way for the next 30 years* (Gilmore, 2014). *There were very few recent immigrants, but many students had parents or grandparents that were immigrants. In contrast, Mountain Middle School's student demographics reflected the increase in immigrants from Mexico and Central America in a county where many of the students and/or their families were recent immigrants.*

The venue

This After LISELL case study took place at a middle school that is situated in a rural part of Chick County outside of a large city in north Georgia (Table 4.1. contains the school's demographics).

Table 4.1.
Mountain Middle School's Demographics

	2008	2013	2017	2018
Student/teacher ratio	13.1	13	13.8 (Second lowest of district middle schools)	14
Number of full-time teachers	67	70.8	69	68
Number of students	876	924	953	957
Hispanic	45.7 %	47.0 %	51.5 %	51.7 %
White	41.0 %	42.5 %	36.6 %	37.0 %
African American	8.6 %	8.2 %	8.6 %	8.2 %
Free/discounted lunch	74.6 %	82.6 %	81.1 % (Highest in Chick County school district)	79.3 %
State school ranking	56.9 % in 2011	59.2 %	46.98 %	44.96 %

Note. School demographics data taken from School Digger Data Source, gathered from the National Center for Education statistics, the U.S. Department of Education, U.S. Census Bureau and the Georgia Department of Education. Data updated July 27, 2018. https://www.schooldigger.com/go/GA/schools/0261002044/school.aspx

In the mid 1960's, most of the nuns at Annunciation wore long black dresses that draped to the floor with black shoes and stockings. Their necks were covered by a white cloth and their head was totally covered by a white lined black veil that left only their face naked. A white bib covered the front of the dress which was accented by a large cross that hung from a necklace to the middle of it. These outfits were called "habits". All the nuns wore a wedding ring that was in the shape of a cross. By the time I moved on to high school, these habits turned into lighter colored dresses with short veils that allowed some of the nun's hair to peek out. Legs and arms were finally bared but the cross and shoes remained. In contrast, most of the teachers at Mountain Middle School wore various types of colorful

clothing with the administrative faculty dressing more "business casual". Sometimes, during the planning meeting, the male teachers wore ties that were covered in fun designs. Rarely did the female teachers wear dresses.

The teachers

The three seventh grade life science teachers (Kelly, Alex and Charlie) that agreed to participate in this study had previously participated in the LISELL-B study, which ended in the late spring of the 2016 school year. Two of the three teachers (Kelly and Charlie) participated in all three years of the LISELL-B study and one (Alex) participated in the last two of the three years. All were labeled as "highly engaged" in the original study. Teacher engagement was determined by tracking the number of LISELL-B project PL opportunities that the teachers chose to attend during the original three years of the project which generated a number (1= one activity, 6 = six activities etc..). Teachers were then separated into low, medium and high engagement groups based on their composite number (Buxton, et al., 2015). These teachers also completed their LISELL-B logs consistently. The logs were self-reports of enactment of LISELL-B activities where teachers filled out online weekly logs which were then collected and analyzed by the project's external evaluators (for more information see: Caswell, Schwartz, Minner, Allexsaht-Snider, & Buxton, 2017). The LISELL-B project had graduate students assigned to each of the project schools and this school was assigned this researcher.

Table 4.2.

Hours of PL After LISELL Teachers Took Part in During LISELL-B Project.

Professional Learning Activity				
Summer teacher academy	Year 1		Year 2	Year 3
Summer student academy	Kelly	0	32	8
	Alex	0	8	24
	Charlie	32	0	32
Family workshops	Kelly	0	32	24
	Alex	0	40	64
	Charlie	64	0	64
Exploring student writing	Kelly	8	8	8
	Alex	8	24	32
	Charlie	8	8	8

Note. This table shows the number of PL hours that each After LISELL teacher took art in based on their attendance at each of the six different LISELL-B PL activities for each year of the LISELL-B project.

> *Many of the students at Annunciation had a parent that worked in—or did business with—the U.S. government, were lawyers or connected to the military. In contrast many of the students at Mountain Middle School had a family member that worked in the poultry industry. Even one of the After LISELL teachers had worked in a poultry lab.*

Data Collection and Analysis

The process of data collection, analysis, and storage used in this study were approved by the school's local district office and University human subjects Institutional Review Board (IRB). Fieldnote, transcription, teacher enactment and artifact data were collected from: an initial group interview, classroom observations, virtual observations, Thursday teacher planning meeting recordings, and teacher activity logs.

Focus group interview protocol.

At the beginning of the 2017 school year, a semi-structured face-to-face group interview was conducted to introduce the teachers to the After LISELL project, go over expectations and to get to know what was going on in the school, classrooms and with the teachers. Field notes were taken during the group interview that was recorded and transcribed verbatim. Semi-structured interview protocols allow participants to communicate their experiences (Prasad, 2005). Group interviews allow open-ended responses to generate detailed information about teachers' practices and beliefs that is different from statistical data or surveys that offer limited information (Prasad, 2005).

The group interview was recorded and transcribed. Field notes from the interview were added to the transcription. The transcription/fieldnotes were reviewed for mention of LISELL-B practices and their active contribution to the maintenance of the After LISELL network (Cooren, 2004).

Observations

Because my study is centered on a middle school network which is comprised of teachers, students, classrooms, practices, standards and other material objects, I wanted to observe actors in the classroom and in the planning meetings. Other actants/actors were taken note of as they entered and left the After LISELL network, to understand how actors/actants interact to help hold together/or not hold together the After LISELL network. Direct observations add to the richness of the data already collected but can be somewhat problematic due to the observer's bias and variations in their observation ability (Prasad, 2005). These problems can be somewhat mitigated by observation protocols—which themselves could lead to oversimplification of observations or omission of details (Prasad, 2005). An observation

protocol template from the LISELL-B study was used during classroom observations in the After LISELL project. This template helped organize classroom, observation and specific LISELL-B practices data. In the After LISELL project, observations are not used to assess the teachers' practices but rather to help understand the context of the participants in the actor-network. These observations along with other data collected, gave a more comprehensive view of the After LISELL network (Prasad, 2005). Observations include teacher planning meetings and classroom observations.

Teacher planning meetings.

Following the first focus group interview, the After LISELL teachers invited the researcher to attend their weekly planning meetings, which took place on the Thursday of each week. Field notes were written during these planning meetings (which were mandated by the school principal) and a recording of what was said was done with the participants' knowledge. During these planning meetings, the researcher was asked to give input and was treated for the most part, as a member of the team. The researcher also attended a school imbedded PL with the teachers on two occasions.

Teacher planning meetings were recorded and transcribed and fieldnotes from each meeting were added into their respective transcriptions. The transcription/fieldnotes were analyzed by employing the following procedure: Transcripts were read for instances that mentioned use of LISELL-B practices and their active contribution to the maintenance of the After LISELL network (Cooren, 2004). These instances were highlighted and grouped by type of practice or LISELL-B material used. Notes were made from the findings and organized in a notebook. Two examples were chosen to report in the findings under each of the research questions. The transcripts and fieldnotes were also used to reveal the actors and associations that

made up the After LISELL actor-network which was then graphically represented.

Classroom observations.

Teachers and their classes were observed at different times during the After LISELL project. Field notes were taken at timed intervals during a whole class session observation following a LISELL-B protocol for general classroom observations. These LISELL-B observation forms collected demographic information about the observed classroom student population along with a space for adding drawings of the classroom layout. The form also had designated space for general field notes and for notes pertaining to each of the LISELL-B practices if applicable. Artifacts (pictures and classroom handouts) were also collected during these observation visits when available. Classroom observation field notes were handwritten directly onto LISELL-B observation sheets. Notations were taken at timed intervals. Observation sheets, fieldnotes and artifacts were reviewed for signs of LISELL-B practices.

Artifacts collected from classrooms during the journey.

Pictures.

Pictures were taken with a cell phone and downloaded onto a computer and sorted by date and activity into different files. Full face pictures of students were avoided to maintain their privacy and duplicate, fuzzy and out of focus pictures were deleted before assessing the collected pictures for relevance. Pictures were judged relevant if they contained evidence of implementation of a LISELL-B practice (for example-implementing use of concept cards, vocabulary cards or group work) or use of a LISELL-B artifact (Kits, talk moves sheets or language booster sheets).

Handouts.

During classroom observations and teacher planning meetings, handouts that were

given to students or teachers were collected. The handouts were then dated and taped into the After LISELL journal with the same day's observations or planning meeting transcriptions. The handouts were then later reviewed for signs of LISELL-B practice (for example: prompts calling attention to language of science-writing, talk to your neighbor, language boosters etc..).

Teacher activity logs.

"Actors are allowed to unfold their own differing cosmos, no matter how counter-intuitive they appear" (Latour, 2007)

In the LISELL-B study, teacher logs were used to document what the teachers were doing in their classrooms during the project. Teachers were prompted to respond to the log questions every other week. In their chapter *Using teacher logs to study project enactment and support professional learning in the LISELL-B project* Caswell, Schwartz, Minner, Allexsaht-Snider, & Buxton. (2017) claim that the teachers are expected to adapt the LISELL- B framework for their classroom so practices may not be implemented with fidelity but rather more reasonably adapted for the unique classroom environment of each teacher (p. 94-95). Adaptations are seen as beneficial and not a detriment- as the LISELL-B team rejected the fidelity of implementation model common in intervention research. The LISELL-B project's intent from the beginning was to co-construct the PL model with teachers and "rather than viewing fidelity of implementation in terms of program adherence, the project team conceptualized it as the interplay of teachers' engagement with, and their enactment of, the LISELL-B practices" (Caswell et al., 2017, p. 95). Logs were used because they systematically "captured teachers' 'multiplicities of enactment' of the project practices over time (Caswell et al., 2017, p. 96) and on a practical level, the authors found them to make more sense

"theoretically, technically, and economically" (Caswell et al., 2017, p. 97). The LISELL-B logs were administered, collected and compiled by the project external evaluator and paid for with the grant funding. Teachers received a small stipend as compensation for each LISELL-B log that they returned completed. The period chosen for the After LISELL study started at the end of the LISELL-B project when funding for log collection and evaluation had ended. But, since the teachers were used to filling out the logs about their activities in their classrooms, and there was three years of log data already collected, I felt that maintaining the logs was a natural extension of the LISELL-B project. So, I constructed a modified version of the LISELL-B logs using Google Forms (see: Appendix D). Luckily, due to a small amount of supplemental funding, we were still able to compensate teachers for filling out the logs. The After LISELL logs consisted of five parts taken from the original logs: LISELL- B practices; Resources used; technologies used; students talking, reading, and writing about science; and Georgia State Standards usage. The following four questions were added to the After LISELL logs:

1) What lab/s did you do with your class this week and were any of them LISELL-B labs?
2) If you used a LISELL-B kit, did you modify it in any way to meet your needs?
3) Please describe any collaborative work that you did with other teachers this week.
4) Where you part of any professional development this week? If yes, please describe.

These logs were created as a Google form and were adapted from the logs that were developed at the start of the LISELL-B study. The goal of the logs was to collect data on the implementation of science inquiry and academic language strategies in the LISELL-B classrooms in order to provide more data on the impact of the study. In this After LISELL study, the logs' purpose was to help create a more complete picture of activity in the teachers' classrooms.

The teachers were given the following directions at the beginning of the log:

Hello everyone. Thank you for being a part of this project. My interest is two-fold in that I am curious about how you collaborate with each other and if the LISELL-B professional development that you participated in has had any lasting effects in your teaching practices. You will find that this log is a shortened version of the one that you participated in over the last few years. Its purpose is similar to the one you did before (in the LISELL-B study) that it is to gather information on science activities that you are doing with your students in your classroom. I am particularly interested in activities that are inquiry -based.

Thus, the six inquiry activities will be familiar to you:

1-Coordinate hypothesis, observations and evidence.

2-Learn about controlling variables.

3-Explain cause and effect relationships.

4-Use models to construct scientific explanations & test.

engineering designs.

5-Develop general academic vocabulary in context.

6-Own the academic language of science.

I will e-mail the log link to you every other week on a Friday. To help me keep track of the data for each week, please enter your name and the date for the week that you are reporting on since the only information that Google shows me is when you return the form and the e-mail address that sent the form back.

Completed logs were e-mailed back to me and Google forms logged in date and responses by the teacher e-mail. The After LISELL teachers received a twenty-five-dollar

stipend for each log completed. The log data was summarized in a Google spreadsheet. The six different question sections (A, B, C, D, E, and F) are listed as follows:

Part A: Asked the teacher if their students had the opportunity to use the following six LISELL-B inquiry activities and practices.

Part B: Queried the teachers on the resources that they used during science activities for example: charts, language boosters, kits or word cards.

Part C: Queried the teachers on what technology did the students use during science activities.

Part D: Focused on whether their students talked, read or wrote about the science activities.

Part E: Asked specific information about the labs-where they did LISELL-B labs, did they modify them in any way.

Part F: Asked the teacher if they participated in any collaborative work with other teachers and if the teacher attended any type of PL.

Log responses for each After LISELL teacher were combined and Parts A, B, C, and D were graphed, while responses to parts E and F were reported in written summaries. These log data were then reviewed and combined with other project data.

Classrooms in Annunciation were minimalist in décor. This was to keep distraction to a minimum, but the abundance of windows managed to squash that (at least in this researcher's case). Each classroom had chalk boards, a teachers' desk and wooden desks. The desks were very similar to the ones in the After LISELL classrooms but a bit sturdier, built to store books and supplies-we didn't have lockers. Desks were arranged in neat rows to maintain student eyes forward and to control their feet under the desk. Classroom walls were sparse and anything on them was usually handwritten directions for some activity. There was an American flag, a

picture of Jesus or a wooden cross and sometimes, one or two decorations during a holiday. During research observations, the researcher was always amazed at how the classroom walls in the After LISELL school were covered with creative science posters along with the lists of standards and student work. Even the ceiling tiles were decorated with student artwork—as if sensory overload was the new fix for student distraction. Interestingly one classroom staple, the intercom speaker, was still alive and well in Mountain Middle classrooms. It's bodyless voice still called for students to come to the office or listed after school activities. Even though teachers can respond to the voice, they still didn't have control of the intercom.

Validity of Data

Marshall & Rossman (Designing Qualitative Research, 2011) list the following criteria that help to strengthen qualitative research: Triangulation (multiple sources of data), member checking (allowing study participants to read transcripts), prolonged engagement in the field, developing an audit trail, peer debriefing, engaging in reflexivity, and collaboration. Not all are required but, the more areas that are attended to, the stronger the study. A large number of data sources also help provide more description of the network where an "overly narrow preoccupation on network relations can result in bias that will bar from sight some of the more interesting or overly messiness of education phenomena" (Fenwick & Edwards, 2010, p. 20). Variable and inconclusive data can arise from even the most well-designed experiment, so attention to validity can help tighten up some of the loose ends. In this After LISELL study, data were collected from multiple sources (observations, recordings of the planning sessions, interviews, cell phone videos and teacher logs) in search of LISELL-B practices and to increase the redundancy of the information gathered. Member checking was used where study participants were asked to review transcripts, or to clarify what they said and to explain how they used LISELL-B practices. I also discussed data with my peers and professors.

CHAPTER 5.

RESULTS /WHAT MY JOURNEY REVEALED

> *Carrying all their belongings with them from class to class, the students look like nomads. After traveling back and forth to Mountain Middle School, sometimes packing a cart into her pickup to haul materials for the teachers into the school and always carrying a backpack packed with recorder, extra batteries, an assortment of pens, a notebook, snacks, ID and a cell phone, the researcher felt like a nomad also.*
>
> *AML, 2019*

Introduction

This chapter presents the case study results regarding the After LISELL study of an After LISELL actor-network, beginning with an account of the terrain encountered; followed by presentation of the different data results gathered from: an initial interview, teacher planning meetings, classroom observations, teacher logs, artifacts, and virtual observations. The results are then divided into four main sections as they pertain to the After LISELL research questions as first described at the end of Chapter 1 as follows: (1) LISELL-B practices/materials still active in After LISELL classrooms; (2) Adaptations (if any) to LISELL-B practices/materials by After LISELL network; (3) Barriers the LISELL-B practices and materials encountered in the After LISELL network; and lastly (4) The sharing within or outside of the After LISELL network of LISELL-B practices/materials. In addition, an effort was made to follow Latour and Woolgar's (1986) methods in *Laboratory Life* by "placing the burden of" this account on "the researcher"

who generates the accounts presented herein (p. 41). Sections that are taken from fieldnotes and transcriptions are referenced throughout by the date and page number or date and line numbers respectively. Table 5.1 lists the dates and types of data collected within the timeframe of the After LISELL study. Appendix A attempts to visually represent the After LISELL data collection network.

The Terrain

Travel can be limited. In most countries, travel is regulated by rules, time, passports, visas—the ability to stay and work and where one can go—are barriers that the researcher encountered after the end of the project when re-accessing Mountain Middle School. Latour started his lab study as a non-science person entering the largely unknown territory of a research lab where what scientists do was taken for granted (see: Latour & Woolgar, Laboratory life: The construction of scientific facts, 1986). Like Latour the sociologist entering "the foreign environment of the lab", the researcher was a scientist entering the foreign environment of the public school (Latour & Woolgar, 1986, p. 273). Besides being unfamiliar with some of the actors and actants that make up the Mountain Middle School network (e.g. CANVAS, PEPAS, co-teachers & para-pros), there were some speed bumps to deal with. The principal at Mountain Middle School questioned the researcher's reappearance, IRB rules needed to be checked, and the 2017 school year was the official start of implementation of the new Georgia science standards. In addition, the principal had hired all new eighth grade science teachers and enrolled student teachers for Kelly (student teacher S) and Alex (student teacher C) along with a new co-teacher for Kelly (co-teacher Mr. Dan) into the After LISELL network. Student teacher S ended up doing most of the teaching in Kelly's classroom during this study. Charlie started the 2017 school year at odds with the school administration lasting the rest of the year, disrupting her part

of the network. Both of these situations made it hard to get any meaningful data from these classrooms, so most of the researcher's observation efforts ended up focused on Alex and classroom 302 where most of the planning meetings were held. Other transient things that disrupted the After LISELL network were Hurricane Irma, ice, snow and school shootings. But, the After LISELL network managed hold together long enough for the graduate student/researcher/nomad to gather data for this study.

The Messiness of Data Collection

Table 5.1 displays the year and date when data were collected along with ethnographic method (activity) and type of data collected during the After LISELL study. Data were not evenly collected during the After LISELL project, for example, teacher log data was only collected during the Fall of the first year of the project. The bulk of the artifacts were also collected during the first year, as were the field notes and teacher planning meeting recordings. In contrast, the virtual observations only occurred during the second year of the study. The virtual observations were not planned as part of the After LISELL study and their appearance ended up enrolling the researcher into an unplanned second year of After LISELL network activities in room 302.

Table 5.1

Data Collection Table

Year 1 After LISELL Data Collection					
Date	Activity	Data Collected			
9/29/17	Initial interview	Field notes	Recording		
10/5/17	Teacher planning meeting Teacher log	Field Notes	Recording	Enactment log	Artifacts
10/12/17	Teacher planning meeting Teacher log	Field Notes	Recording	Enactment log	Artifacts

10/19/17	Teacher planning meeting Teacher log	Field Notes	Recording	Enactment log	Artifacts
10/26/17	Teacher planning meeting Teacher log	Field Notes	Recording	Enactment log	
11/2/17	Teacher planning meeting Teacher log Professional learning	Field Notes	Recording	Enactment log	Artifacts
12/1/17	Teacher planning meeting	Field Notes	Recording		
12/7/17	Observation	Field Notes			
1/25/18	Teacher planning meeting Observation	Field Notes	Recording		
2/1/18	Teacher planning meeting Observation	Field Notes	Recording		Artifacts
2/15/18	Teacher planning meeting 3 x Observations Professional learning	Field Notes	Recording		Artifacts
2/22/18	2 x Observation	Field Notes			Artifacts
3/1/18	Teacher planning meeting	Field Notes	Recording		Artifacts
3/8/18	Teacher planning meeting 2 x Observations	Field Notes	Recording		Artifacts
3/22/18	Helped teach class Observation	Field Notes			
5/4/18	Teacher planning meeting	Field Notes	Recording		
Year 2 After LISELL Data Collection					
8/14/18	Virtual Observation Bunny-opter Lab (exploring scientific method, outside)				
8/16/18	Virtual Observation Microscope Lab	Field Notes			
8/20/18	Virtual Observation What's Living Lab	Field Notes			
9/7/18	Virtual Observation Egg Lab (cell membrane)				
9/11/18	Virtual Observation Egg Lab (cell membrane)				

9/12/18	Virtual Observation Tree Lab (outside)				
9/13/18	Virtual Observation Virtual Lab Human body (virtual lab room)				
9/17/18	Virtual Observation Egg Lab (cell membrane)				
9/21/18	Virtual Observation Microscope and Cells				
11/9/18	Teacher Planning Meeting	Field Notes	Recording		
12/4/18	Virtual Observation Virtual Lab Human Anatomy (virtual Lab room)				
12/14/18	Virtual Observation Frog Dissection Lab				
1/4/19	Virtual Observation DNA Banana Lab				
1/31/19	Teacher Planning Meeting	Field Notes	Recording		Artifacts

Data Collection Network

The Data Collection Network (see Appendix A) illustrates the flow of data within the After LISELL actor-network using arrows and lines to delineate data traces. Five types of data were collected (recordings/transcripts, teacher enactment, virtual video, field notes, artifacts) from four ethnographic activities (classroom observations, teacher planning meetings, teacher logs, and virtual observations) and each were assigned an icon in the Data Collection Network. The Data Collection Network also includes where the data originated from, the movement of the data in the After LISELL actor-network, and obligatory passage points. For example, an After LISELL classroom observation required the researcher to travel to Mountain Middle School, arrive at a certain time, enter through the school security checkpoint, log into the computer to gain access through locked doors, travel through the school halls before entering After LISELL

classroom 302. Data collected was dependent on the production of field notes, observations, and a voice recorder. In contrast, data from virtual observations (videos posted on Facebook) were able to circumvent both physical and time barriers in that they went straight to the researcher's cell phone. Additionally, they were archived and thus accessible at any time through Facebook. Time was another actor that affected data collected during the After LISELL study. As part of the After LISELL network, it was both a speed bump (teacher planning meetings took place between 11:00 am and 1:00 pm) and as an actor, it moved activity along in that it "doesn't stand still." So therefore, activities in the After LISELL network went on when the researcher wasn't there to collect After LISELL data (for example: classroom observations and artifacts). So, what did the graduate student/researcher/nomad find in the After LISELL network?

The First Interview/ Joining the After LISELL Network

Date: 9/29/2017, 11:45 am,
Place: Mountain Middle School; Room 302
Teachers present: Alex, Kelly and Charlie
Vignette of first interview done with After LISELL teachers.

The After LISELL study itinerary had been laid out. Weekly classroom observations of each teacher needed to begin. A teacher log was crafted in Google and ready to be e-mailed. The researcher planned to do a pre-interview to get an idea of what was going on with the LISELL-B teachers (referred to hereafter as the After LISELL teachers) since the LISELL-B project had ended the previous spring. A list of questions was prepared-10 in all. A University car was reserved, backpack was packed with: recorder, pens, extra batteries, field notebook and snacks. The researcher/ nomad troubled the important reminders on the journey to Mountain Middle School. Remind the teachers to do the logs, ask about a good time for classroom observations and don't forget to tell the After LISELL teachers there is a stipend. At Mountain Middle School

a computer waited to collect a name and reason for visit. No more clip-on Visitor badge. This time a sticker; with name and person visiting printed and placed on a chest. The researcher transformed, became a visitor, and was buzzed into Mountain Middle School. When the visitor entered classroom 302, there was a birthday party for co-teacher Mr. B and the first interview plans were altered. After the party, the interview began, the visitor became a researcher again, producing more field notes and reminding the teachers to fill out the teacher logs as the recorder meticulously recorded every sound and conversation. During this first interview, Alex invited the researcher to join the After LISELL teachers during Thursday planning meetings. Thursdays were set aside by the Mountain Middle administration as the "official" teacher planning day. Alex explained that the teachers met every day for planning at the same time unofficially. Planning started at 11:00 am and ran through lunch which gave the teachers a chunk of time bracketed by two classes in the morning and two in the afternoon. Now committed to teacher planning meetings on Thursdays, the researcher was officially enrolled into the After LISELL teacher network. Thursday teacher planning meetings were also transformed as the new focus of data collection. What better vantage point than to be a part of After LISELL planning with all actors/actants interacting? Classroom observations were planned on the same day, around the Thursday meetings and not once a week as originally planned. Latour was also enrolled into the lab network that he was studying, as a part time lab technician (Latour & Woolgar, 1986, p. 39). Unlike Latour, who had to take notes, a recorder diligently kept up with conversations as the researcher took notes, paid attention to activity going on in the room, tried to interact by asking questions and answering questions. All of this was daunting. Latour must have been a writing fiend, the researcher thought. Transcribing the recordings and dealing with unfinished sentences, hard to understand words and overlapping conversations made the researcher understand the

importance of field notes. The researcher was rewarded though, when reviewing the transcripts, the first recognizable LISELL-B material used by the teachers was the DNA kit (9/29/2017, transcript, line 57-61).

Transformation of Graduate Student Nomad/Researcher to Researcher/Visitor

On Thursdays, teacher planning day, the graduate student/nomad rose early since she needed be at Mountain middle school in North Georgia by 11:00 am in order to observe the After LISELL teachers' weekly planning meeting. The drive was only an hour, shortened by a short-cut that took the graduate student on some rural and scenic back roads with plenty of trees and steep hills characteristic of the foothills of the Piedmonts. The graduate student/nomad loved the shortcut—actually, the whole drive. The shortcut roads passed by a chicken hatchery, modest rural homes, food shops and restaurants with Spanish names, a quinceañera party space, a goat farm and a set of commercial chicken houses. This part of the state is considered to be the epicenter of the chicken industry. After parking her car, the graduate student/nomad became a researcher/nomad when she was joined with the backpack, which held a recorder, extra batteries, a snack, extra pens, and the After LISELL study note book.

The entrance to Mountain Middle School- a one-story brick building- funneled all outside activity into a wall of glass doors-only one is not locked-and it opens into a large space. There are more walls of closed/ locked partial glass doors with halls beyond. The only open door leads to the central front desk and main offices from which the school corridors radiate out like the spokes of a wheel similar to Bentham's Panopticon mentioned in Foucault's *Discipline & Punish The Birth of the Prison* (1995) "Whenever one is dealing with a multiplicity of individuals on whom a task or a particular form of behavior is imposed, the panoptic schema may be used" (p. 205). The library, teacher's lounge and nurse's office also share the center

space of Mountain Middle School. During the earlier LISELL-B project, the office staff would enroll the researcher/nomad into Mountain Middle School by granting the clip-on visitor badge. Then a door unlocking mechanism would be activated, allowing the now visitor access to the inner halls of Mountain Middle School. Now, on entering the school, the staff motioned the researcher to the new computer, which issued a personalized stick-on visitor's badge. After the computer collected information (name, who are you visiting and reason for visit) it logged the visitor into the school's system. A printer then printed a badge displaying the visitor's name. The office staff were then instructed by the computer to press the door unlocking mechanism. Importantly, when exiting the building, the visitor must remember to visit the computer again and log herself out of the Mountain Middle School network. Luckily, the computer remembers you and your information, saving the visitor time but, it doesn't say "hi" and make comments about the weather or ask about your day.

A Visitor has different privileges than others that come to the school. This was illustrated when the researcher returned to the school after a long absence. There was a new office staff person and new computer system, which disoriented the researcher. "Can I help you?" the office staff asked. The researcher responded vaguely "To visit with a teacher". "Alright, does she know you are coming"? the office staff asked, "Yes" the researcher/nomad answered. "Good, then just wait here in the conference room for her." "Should I check in?" the researcher/nomad asked pointing to the computer. "No, just wait in the conference room" she answered. Confused, the researcher tried again but was motioned to the conference room. Eventually, the researcher realized that the new staff member thought that she was a "parent" (a momentary actor change, a correct one but, wrong network). Apparently, "parents" were directed to the conference room and not checked into the Mountain Middle School network. The

researcher then introduced herself, this time remembering to invoke the "University" word. "No problem just sign into the computer and I will buzz you in" came the answer. Following the instructions, it took a few minutes for the researcher/nomad and new log in computer to communicate. This one had a scanner that scanned the researcher's driver's license. Once logged in, the computer printed a Visitor sticker. The researcher/nomad peeled the new Visitor identification sticker—containing her picture and barcode—off the computer's mini-printer and stuck it to her chest. Now, transformed into a "visitor", the staff "buzzed" her into the inner hallway. Granted access, the visitor moved freely about the school hallways where school staff greeted you as they passed. If she stopped too long to look at things instead of moving directly to some point, she would be asked "do you need help?" or "are you lost?" To avoid the questions, the visitor learned to move purposefully past the sixth-grade hallway and the school police officer's office towards the seventh-grade hall. On occasion, a cart full of LISELL-B materials accompanied the visitor, which granted her incognito status, no questions were asked; and she could slow down and checkout the posters that reminded students how to dress and to be thankful. One time, there was a large poster that had pictures of each of the Mountain Middle School teachers and staff with a description of where they went to college. Another time, on the library door, there was a sign—written in Spanish and English—the researcher took a picture of it before heading left down the seventh-grade hall to classroom 302. Once inside room 302, which is part of the After LISELL network, the visitor was returned to an After LISELL researcher role, but visitor status returned if any of the Mountain Middle administration showed up for the teacher planning meeting. In thinking about this transformation of graduate student/nomad, to researcher/nomad, to parent/visitor that took place within the school, the

researcher can see how actors and actants can have different roles as they move through different networks which sometimes overlap or intersect for short periods.

The LISELL-B Kits

One of the main components of PL in the LISELL-B project was a summer teacher academy during which LISELL-B staff and science teachers co-developed science investigations as a way to help the teachers understand and utilize the LISELL-B pedagogical model. These science investigations were enrolled into the different teacher's school networks by the LISELL-B teachers; becoming LISELL-B science kits during the process. Each of these LISELL-B science kits was an assemblage of multiple components that consisted of consumables and manipulatives, and that were partnered with LISELL-B reading (language boosters), language (GAV & science concept cards) and writing (investigation worksheets) instruction pieces. The LISELL-B kits became very popular with the LISELL-B teachers. Over time, these LISELL-B kits began to exert themselves in the LISELL-B project, demanding a large part of the LISELL-B staff's time and energy. The LISELL-B staff (graduate students and student workers) also began to understand that the LISELL-B kits allowed us entry into classroom networks that we previously had trouble entering. The LISELL-B kit actants facilitated and strengthened our connections with the LISELL-B teachers. As a way of demonstrating how the LISELL-B kit actants worked, the researcher provides the following vignette.

Putting Theory to Work (first attempt)

Where to begin again? As in the beginning of this dissertation, which conjures the beginning of a Michener novel—with the forming of the Earth's land masses—this time—let us begin in the middle of a network/assemblage—which is more Latourian. Better yet, let us start thinking and living in a different place where we use a different methodology-one that flattens

the horizon. Where we use terms like the actor and actant to help describe the work that connections of the things that make up the resulting assemblages. So, I will enroll us into a forest where trees are grown specifically for the paper industry. More than 1.5 billion trees are planted annually (American Chemical Society National Historic Chemical Landmarks., 2016). *One tree can produce 151.6 boxes* (Jacob, 2015). *An empty box is waiting—it has potential in its open space like the whole in the center of a wheel's hub or the space within a bowl as the Chinese philosopher Lao Tzu recognized:*

> *Eleven*
> *Thirty spokes share the wheel's hub; It is the center hole that makes it useful.*
> *Shape clay into a vessel; It is the space within that makes it useful.*
> *Therefore, profit comes from what is there; Usefulness from what is not there.*
> Lao Tsu, 6th century B.C., (1972)

A request is made, a date is specified. Into the box, a LISELL-B staff member places gummy bears, tweezers and five jars filled with one of the following: water, vinegar, sugar water, molasses water, 70 % alcohol and 30 copies each of the LISELL-B lab procedure and language booster, and five sets of science concept cards. The box is identified: "Gummy Bear Lab" and decorated with colorful, paper gummy bears. Lastly, a sticky note that bears a teacher's name and its intended delivery school, is attached. The box—now officially a LISELL-B kit—is delivered to a LISELL-B teacher's classroom. The students greet the LISELL-B kit with excitement as the LISELL-B teacher happily takes it from the LISELL-B staff member. For two days, the LISELL-B kit becomes part of a new assemblage that includes 100 children, a classroom, a school and a LISELL-B teacher or two. Latour would describe the kit as an actant that becomes, at least for a few days, an important part of its new network shaping the activity

within science classrooms in that school—an element that causes other actors (students and teachers) and actants (kit components) to do work.

The LISELL-B teacher opens the box and the LISELL-B kits components are removed and are transformed into a LISELL-B science activity. The Language Booster encourages the students to read out loud, talk to their neighbors and write about what they read. The LISELL-B science activity instructions/lab sheet guides the students through the activity. Gummy bears are measured and weighed before they are placed in the different jars. The measurements are recorded on the lab sheet. After a few days, the students excitedly remove the gummy bears from the jars and weigh and measure them again. The students report their findings in their lab report. They write about and finally graph their findings on the board to share them with their classmates.

At the end of the LISELL-B lab activity, items are cleaned and returned to their box to become a LISELL-B gummy bear kit again. A pick-up is scheduled, and the LISELL-B kit is returned to the LISELL-B office. Once it is back at the LISELL-B office, maintenance of the LISELL-B kit is performed, and missing items are replaced. New copies of the LISELL-B lab procedure and language booster are made and placed inside the box. New solutions are made up and the jars are returned to the box. New gummy bears are purchased. Kit information logs are filled out by the LISELL-B teacher and staff. The LISELL-B kit is returned to its shelf and waits for its next journey. We didn't intend for the LISELL-B project to be so focused on boxes/kits. How did they become so important?

The LISELL-B science kits are an example of what Jane Bennett calls thing power (Vibrant Matter: A Political Ecology of Things, 2010). The LISELL-B kits are definitely not passive, in that they make things happen and produce effects and thus are akin to Latour's actant

(Latour, 2007). Bennett (2010), uses the term Deleuzian operator, describing it as something "by virtue of its particular location in an assemblage and the fortuity of being in the right place at the right time, makes the difference, makes things happen, becomes the decisive force catalyzing an event" (p. 9). The LISELL-B science kits are actants, they do something; they bring change to the classroom and open up communication between teachers and LISELL-B staff. All of this would have been overlooked if we didn't use our imagination to try to make meaning of the importance of the LISELL-B science kit actant to the LISELL-B project. Further, if we didn't have the work of Latour, Bennett, and Law we wouldn't have the imaginative concepts and words to guide us and write about in our inquiry. At the end of the LISELL-B project multiple copies of the LISELL-B kits were made for some of the LISELL-B teachers to be permanently added to their networks. Some of these LISELL-B kits traveled to Mountain middle school with the researcher/nomad to become part of the After LISELL network. Figure 5.5 catches a stack of LISELL-B kits waiting to do lab activities in classroom 302's storeroom.

Classroom Observations

Ten classroom observations occurred during the winter/spring of the first year of the After LISELL study in classroom 302 with After LISELL teacher Alex and the After LISELL students (yes, when they walked through the door of 302, they became transformed into After LISELL students). The LISELL-B observation forms were used to capture observation data. The form consisted of many pages which captured information specifically for the LISELL-B project and were not the focus of this study (demographics of class) or just redundant (drawings of classroom space). The most useful pages helped organize the specific LISELL-B practices observed and had lines and space for notes. On a few occasions, observation notes were written directly into the After LISELL field notebook. Artifacts were collected during classroom

observations and taped into the field notebook. It was during the classroom observations where some of the LISELL-B practices/materials were observed doing some work. For example, the GAV and science concept cards which hung on the walls waiting to be noticed would be suddenly pointed to by the After LISELL teacher while engaging the class in discussion activities. When students tried to talk in scientific language, they used the words on the GAV cards to create definitions or the science concept cards to answers to questions they were asked. Other LISELL-B materials, like the LISELL-B kits, were brought out and their contents were scattered over the desks, promoting After LISELL students' investigations. Summarized in Table 5.2. are LISELL-B practices paired with some of the evidence gathered from the After LISELL classroom observations.

Table 5.2

Classroom Observations Evidence of LISSEL-B Practices Acting in the After LISELL Classrooms.

Date	LISELL-B practice Or Material	Evidence of LISELL-B practice
1/25/18	None	None (Genetics review session in library-60 kids)
2/15/18	Develop General Academic Vocabulary (GAV).	Students reading out loud, Vocabulary words written on board.
2/15/18	Develop General Academic Vocabulary (GAV). LISELL-B kit	Students were asked to "talk in everyday language." A new set of vocabulary were displayed. Students were alerted to the new words "Adapt" "Survive". The Hungry Birds Kit was pulled out.
2/15/18	Develop General Academic Vocabulary (GAV). Owning the Academic Language of Science	Activated past knowledge by talking about what students learned about fossils in sixth grade. Students handed writing sheets and were instructed to use new set of GAV cards on wall. "Ok class, what is everyday language for 'Habitat', 'where you live''? "to live"; "Habitat"; "survive". The GAV cards are pointed at.

2/22/18	Coordinating Hypothesis, Observation and Evidence Use Models to construct scientific explanations & test engineering designs. Develop General Academic Vocabulary (GAV). Owning the Academic Language of Science	1st Period "Darwin had to back up his theory with evidence". Alex used pictures and a nine-month old baby model to model development and change during class on evolution. Alex reminded class to use scientific and everyday language throughout the class. Alex reminded the students how evidence works.
2/22/18	Coordinating Hypothesis, Observation and Evidence Use Models to construct scientific explanations & test engineering designs. Develop General Academic Vocabulary (GAV). Owning the Academic Language of Science.	2nd Period "Darwin had to back up his theory with evidence". Alex used pictures and a nine-month old baby model to model development and change during class on evolution. Alex reminded class to use scientific and everyday language throughout the class. Alex reminded the students how evidence works. "Do fossils provide evidence of evolution?"
3/1/18	Develop General Academic Vocabulary (GAV). Owning the Academic Language of Science. Use Models to construct scientific explanations & test engineering designs.	1st Period What are the four steps of Natural Selection?" Use of GAV cards- Alex points to the cards as she explains or gets the students to craft explanations using everyday language. Alex encourages the students to discuss, working in groups and using a framework like the talk moves but for argumentation. Students are informed they need to bring in soda bottles to build a terrarium in class.
3/1/18	Develop General Academic Vocabulary (GAV). Owning the Academic Language of Science. Use Models to construct scientific explanations & test engineering designs.	2nd Period Alex "who wants to write the four steps of Natural Selection on the board?" Alex" Can someone put this in everyday language?" Alex points out the vocabulary cards as she explains or uses a word.
3/8/18	None	None-1st period

		Assessment game Evolution review-using a game and candy; Instant results are displayed real time on Smart board as students answer questions on their computers or cell phones. Class works towards increasing class average- tries again.
3/8/18	None	None- 2nd period Assessment game Evolution review-using a game and candy; Instant results are displayed real time on Smart board as students answer questions on their computers or cell phones. Class works towards increasing class average- tries again.
3/22/18	None	None Consumers and producers. I taught class so I couldn't take notes.

Artifacts Collected and What They Said

During the After LISELL study, there were three types of artifacts collected: cell phone pictures, classroom handouts, and virtual videos. Cell phone pictures and classroom handouts were purposefully collected while virtual videos were an unplanned addition.

Cell phone pictures taken during visits to Mountain Middle School were usually purposeful in that they were used to document LISELL-B practices or materials (kits, objects resulting from kit usage, GAV cards or student lab handouts). At other times they depicted interesting or mundane things that caught the cell phone's attention (desks, computers, posters and microscopes). Figures 5.1, 5.2, 5.3, 5.4, 5.5, 5.14, and 5.15 document some of the LISELL-B practices at work in After LISELL classrooms. Figures 5.11, 5.12, 5.13, and 5.15 depict interesting or mundane things.

Classroom handouts were collected during classroom observations and teacher planning meetings. Eleven handouts were collected and summarized by evidence of LISELL-B practice in table 5.3 (see table 5.1 for relationship of handout collection to study activities). Review of the data in table 5.3 identified evidence of LISELL-B practices in eight of the After LISELL

handouts. All but two LISELL-B practices (Explaining cause and effect relationships, Use Models to construct scientific explanations & test engineering designs) were present in these handouts, which were collected during the first year of the After LISELL study. The last handout was collected during the second year and it showed evidence of the integration of drawing as a choice to promote reasoning instead of writing.

Table 5.3

Summary of evidence of LISELL-B practices in handouts collected from After LISELL classrooms.

Date	Handout	LISELL-B practice	Evidence of LISELL-B practice
10/5/17	Cells assessment	Coordinating Hypothesis, Observation and Evidence	Students were instructed to explain, give evidence, describe and defend reasoning. There was plenty of space for writing
10/5/17	Levels of organization	None	None
10/12/17	Differentiated lesson	Developing General Academic Vocabulary in Context	Focused on vocabulary construction
10/19/17	Pre-assessment-systems of the body	None	None
10/19/17	Skeletal system	Owning the academic language of science	Writing prompts and lots of space for writing.
10/19/17	Cells, human body	None	None
11/2/17	Body system assessment	Owning the academic language of science	Students asked to write and describe. (note: space given for student feedback)
2/1/18	Genetics detective lab	Owning the academic language of science. Developing General Academic Vocabulary in Context	Writing prompts and lots of space for writing. “Use detective terminology.”

2/22/18	Evidence Supporting the Theory of Evolution	Coordinating Hypothesis, Observation and Evidence	Step by step overview -evidence chain of fill in the blank. Similar to a talk move.
3/1/18	Let the fittest survive	Coordinating Hypothesis, Observation and Evidence; Controlling Variables; Owning the academic language of science.	Students asked to write hypothesis, conclusion and Identify the dependent & independent variable, graph results Note: Modified LISELL-B Lab-Hungry Birds investigation (was originally Explain cause and effect LISELL-B practice). Graphing was not part of original lab.
1/31/19	Asexual/sexual reproduction	Owning the academic language of science.	Students were asked to "draw an example," "draw the end result". Plenty of blank space to draw.

Alex's Classroom is Live! Virtual Observations

The researcher begins this section with Latour's suggestion to follow "the traces left behind" by the actors in mind, as she presented field notes written about virtual observations made from Virtual video that were not planned to be made a part of the After LISELL study (2007, p. 29). These virtual observations were literally traces left behind by actors in the After LISELL actor-network—a teacher, Facebook and cell phone. Virtual videos where an unplanned source of data stemming from virtual labs that were posted on Facebook by an After LISELL teacher, during the second year after of the After LISELL-B study. There were 12 virtual videos posted between August of 2018 and January of 2019. All were virtually viewed on Facebook and a listing of date with a short lab description can be found in table 5.1. Altogether, all but four of the virtual videos were of science investigations that took place in After LISELL classroom 302. Two investigations occurred in Mountain middle's virtual lab and two were done outdoors on school grounds. Two of the 12 virtually observed labs depicted use of

LISELL-B kits (LISELL-B microscope and DNA banana extraction). Other LISELL-B related activities observed were students talking, writing and reading about science during the After LISELL investigation, which were practices specifically encouraged during LISELL-B PL. Observed LISELL-B materials that supported LISELL-B practices included the use of GAV cards and talk moves. After viewing the different virtual videos that were stored on Facebook, the researcher chose two representative videos (a LISELL-B microscope and DNA banana extraction lab) and wrote a detailed account of what was observed in the After LISELL classroom, noting LISELL-B practices and materials at work.

In this first Virtual video After LISELL students are working with a LISELL-B kit investigating how to work with a microscope. This was the first Virtual observation of a science investigation in classroom 302.

August 16, 2018- 9:19 am Microscope Lab—Year Two After LISELL-B

Today, while using her cell phone to check on e-mails, it alerted her with a short "ding" and then a message from Facebook popped up on its screen— "Alex's Live!". Well, that was something that this graduate student hadn't seen before. Curious, she tapped on the message to follow the trace and was immediately transported into Alex's classroom (Room 302). Thus, with a tap, the graduate student was transformed into the After LISELL researcher and began her first virtual cell phone observation all at once. Students were moving around the lab bench part of the classroom 302 working with microscopes and the researcher could hear students' voices: "we are having trouble; we can't see anything" and "how does the letter look?" Microscopes could be seen patiently teaching the students how they worked. Students turned the knobs and in response, the lenses moved up and down and the stages from side to side. To answer the lab handout questions, the students needed to get the motions right- to work

with the microscope- in order to see the tiny letters that had been cut from a newspaper. These were special microscopes. They had two eyepieces that moved independently, allowing two students standing across from one another to view things at the same time. Slides, water and coverslips were involved also. The view through the phone was constantly changing. One minute, the students were standing, moving about and asking questions the next, there were familiar sites like standards and the students' and teachers' desks. YES! there were LISELL-B talk moves standing at attention in their plastic frames on the lab benches displaying directions on how to frame scientific answers for the students and LISELL- B vocabulary cards hung in large groups on the wall in the back of the classroom.

The second Virtual video documents a science investigation in After LISELL room 302 where After LISELL students are manipulating things and trying to come up with evidence to determine if they are living or not.

August 20, 2018, 3:06 pm. Investigating Living and Non-Living Things Lab—Year Two After LISELL-B.

Again, the researcher was brought into the frenzy of a lab through a cell phone. Unlike a fly sitting on the wall with an unchanging vantage point, the researcher's vision weaved among the students and became part of their banter/questions/answers with their invisible teacher. Students are standing and leaning on lab benches. The benches are too high for sitting but their height allows the students to get close and personal with the beehives, old bananas, starfish, branches with green leaves, magnifying lenses, cups, beakers petri-dishes that are spread out over their black tops. The students can be seen working in pairs and as the cell phone was moved around room 302, the sound of voices was constant. Some asked Alex questions "Is this alive?", "Haven't you been to Florida?" a student asks another as they handled a bleached sand

dollar. "Actually, they are not living but they had animals living in them" another answered. "How did an animal live in that?" the first student asked. "What are we supposed to put in observations?" a second student asked. Alex responded: "What do you think you are observing?" Suddenly a voice boomed over the classroom's loudspeaker calling for a student to be sent up to the office to check out. Many of the students were writing on lab reports-Alex reminded the class "are we working?" A magnifying lens helped a student look at an object. More laughing and questions. The upright LISELL-B talk moves language frames are there, housed in their protective plastic stands and as the cell phone's field of vision turned away from the benches, General Academic Vocabulary and Concept cards, hanging on the back wall of the classroom come into view.

During most of the virtual cell phone observations (note some were taken during outside activities), the researcher was able to see the LISELL-B GAV and science CC's displayed in the After LISELL classroom 302 (Figure 5.3). These LISELL-B materials support developing the academic language of science in context, which is one of the five practices that make up the LISELL-B pedagogical model. Figures 5.1 and 5.2 show examples of these GAV and science CC's working during a LISELL-B science teacher summer academy. LISELL-B talk moves, another LISELL-B material that supports LISELL-B practices, were observed helping After LISELL students in writing their lab reports. Other observed LISELL-B practices in the Virtual videos that were encouraged by the LISELL-B framework were the After LISELL students working in pairs, talking about science and having space on lab reports to encourage students to write more complex observations and answers to questions about their investigations.

On reflection about this new way of being enrolled (Virtual video/Facebook/cell phone) into the After LISELL network, the virtual videos were easily re-watched from Facebook, which

made field notes easier to write. The virtual videos allowed a continuation (Virtual observations) of the After LISELL study that was not constrained by money, time and physical barriers (distance and school access). They offered a unique way of "participating" in the lab activities in 302 where virtual observations could be made and revisited. Limitations of the virtual observations included that they only documented lab activities, no handouts could be collected, it was hard to see specific wording and writing on objects was hard to read and the observer had no control of what was observed. But, what an ANTish way to enter a network. Latour would certainly approve.

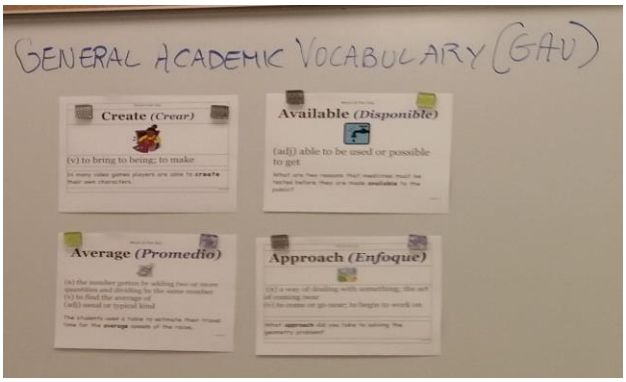

Figure 5.1. General Academic Vocabulary cards displayed on wall during a summer LISELL-B academy.

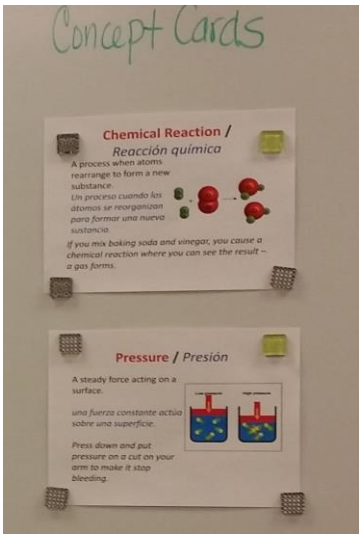

Figure 5.2. Science Concept Cards displayed on wall during a summer LISELL-B academy.

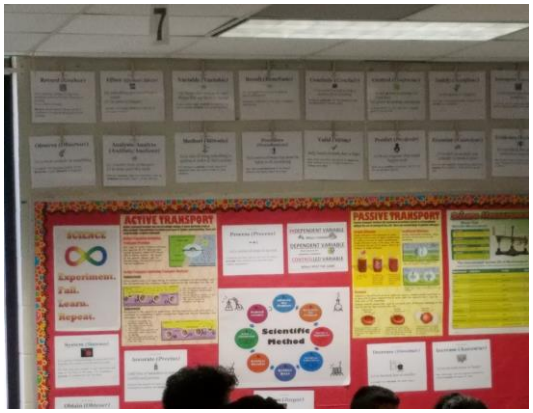

Figure 5.3. General Academic Vocabulary cards posted over board in After LISELL classroom 302, 9/29/2017.

Figure 5.4. Lung models created from LISELL-B kit displayed in After LISELL classroom 302, 12/07/2017.

Figure 5.5. LISELL-B kits waiting to be used in the storeroom between After LISELL classrooms 301 & 302 10/12/2017.

Teacher Logs

The teacher log data represent a snapshot of what LISELL-B practices that the After LISELL teachers were enacting in their classrooms during the month of October in the first year of the After LISELL study. A reminder e-mail with a link to the After LISELL teacher log Google document was e-mailed to the three teachers in the After LISELL network each week during October of 2017. Fourteen responses were recorded by Google Forms from October second until the first week of November of 2017; five each for two of the After LISELL teachers, and four for one After LISELL teacher. Responses for each After LISELL teacher were logged using the After LISELL teacher's e-mail address. Part A Science Activities asked the

After LISELL teachers if their students had the opportunity to use the following six LISELL-B inquiry activities and practices:

1. Coordinating Hypothesis, Observations and Evidence (HOE).
2. Controlling Variables (CV).
3. Cause and Effect relationships (CE).
4. Use Models to construct scientific explanations & test engineering designs.
5. Develop General Academic Vocabulary (GAV).
6. Owning the Academic Language of Science (ALS).

The results from the Part A questions from the teacher log are summarized in Figure 5.6. On reviewing the data resulting from the responses that the After LISELL teachers gave to the question referring to their students use of the six LISELL-B inquiry practices, the teachers responded that their students over 90% of the time:

- Used their senses and tools to make targeted observations and collect data.
- Identified variables in science.
- Identified cause and effect relationships.
- Used one or more types of models (e.g., physical, drawn, simulation, mathematical) to explain scientific concepts.
- Used general academic vocabulary (non-science) orally to support meaningful explanation of science concepts or practice.

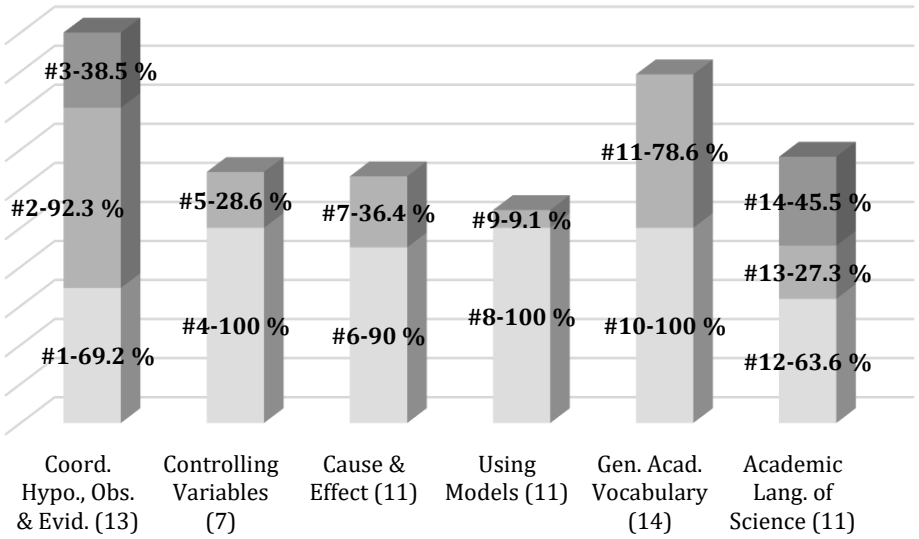

Figure 5.6. Part A. Responses teachers gave to questions about opportunities students in their classrooms were given to practice each one of the six LISELL-B practices. On the X axis, each practice is listed, followed by number of teacher responses in parenthases ( ). The colored bars represent each question number followed by percent of responses indicating the practice was used by the teachers (see Appendix D for teacher log part A actual questions).

"Using one or More Types of Models to Test and Improve" was reported as the least used (< 10%) of the LISEEL-B practices by the After LISELL teachers during this period.

Part B of the teacher logs queried the teachers on the resources that they used during science activities (for example: charts, language boosters, kits or word cards). The results for Part B are summarized in Figure 5.7. In answer to the Part B question of the log where the After LISELL teachers were asked about resource use in their classrooms, nearly all of the students used vocabulary and graphic organizing resources during science activities, and most students made use of reading and lab forms, but only a small number of students (21 %) used models.

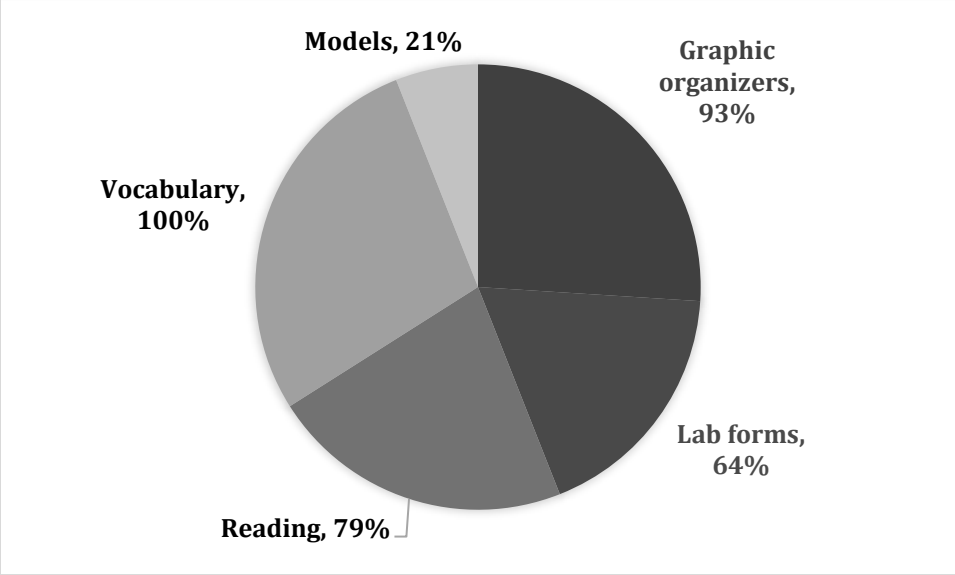

Figure 5.7. Part B. Resources used by students while doing science in the After LISELL classrooms (see Appendix D for part B After LISELL log data).

Part C of the teacher logs queried the teachers on what technology the students used during science activities. The results from Part C are summarized in Figure 5.8. When queried about the types of technology used in their classrooms, the After LISELL teachers reported that online digital games and videos were used the most (>78 %) during science activities while data visualization software was used the least (15%); all the other technology used by the students ranged from 20 to 50% during science activities.

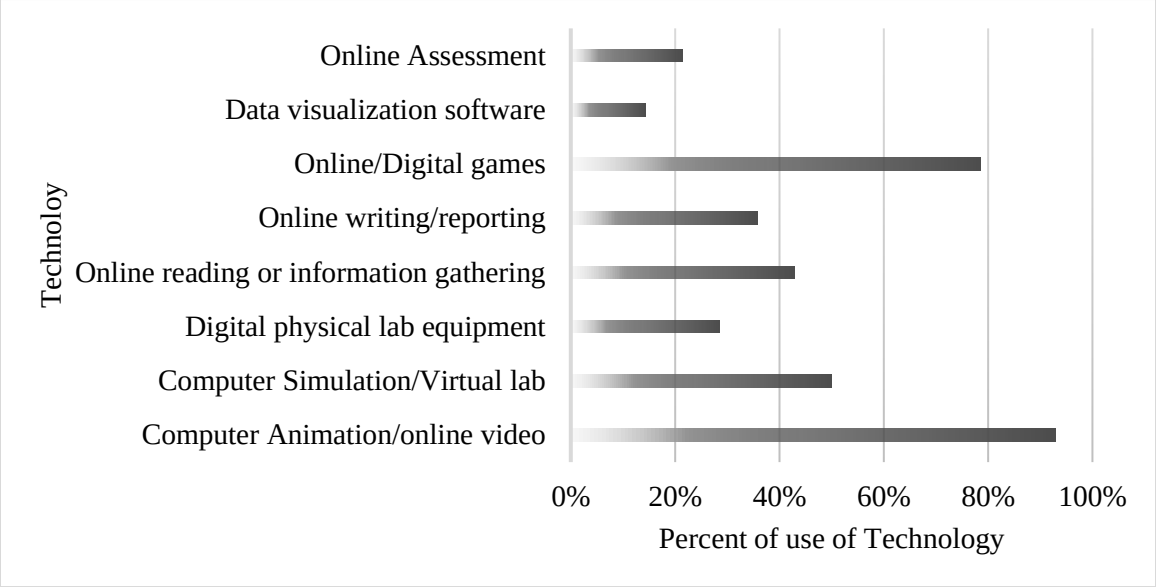

Figure 5.8. Part C. Types of technology Students used during science activities in the classroom as reported (%) by After LISELL teachers (see Appendix D for part C After LISELL log data).

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Part D of the After LISELL teacher logs focused on whether their students talked, read or wrote about the science activities. Figure 5.9 summarizes the results from Part D of the After LISELL teacher logs. When the After LISELL teachers were queried about their students' use of literacy based LISELL-B practices, the responses showed that the students were most likely to write, read and talk in groups. Thus, group work was utilized most in the After LISELL classroom which is a major support of the LISELL-B pedagogical model that encourages teachers to allow students to work in groups or pairs to encourage talking and sharing during science activities. In contrast, the least reported activities were taking notes during lectures and reading out loud.

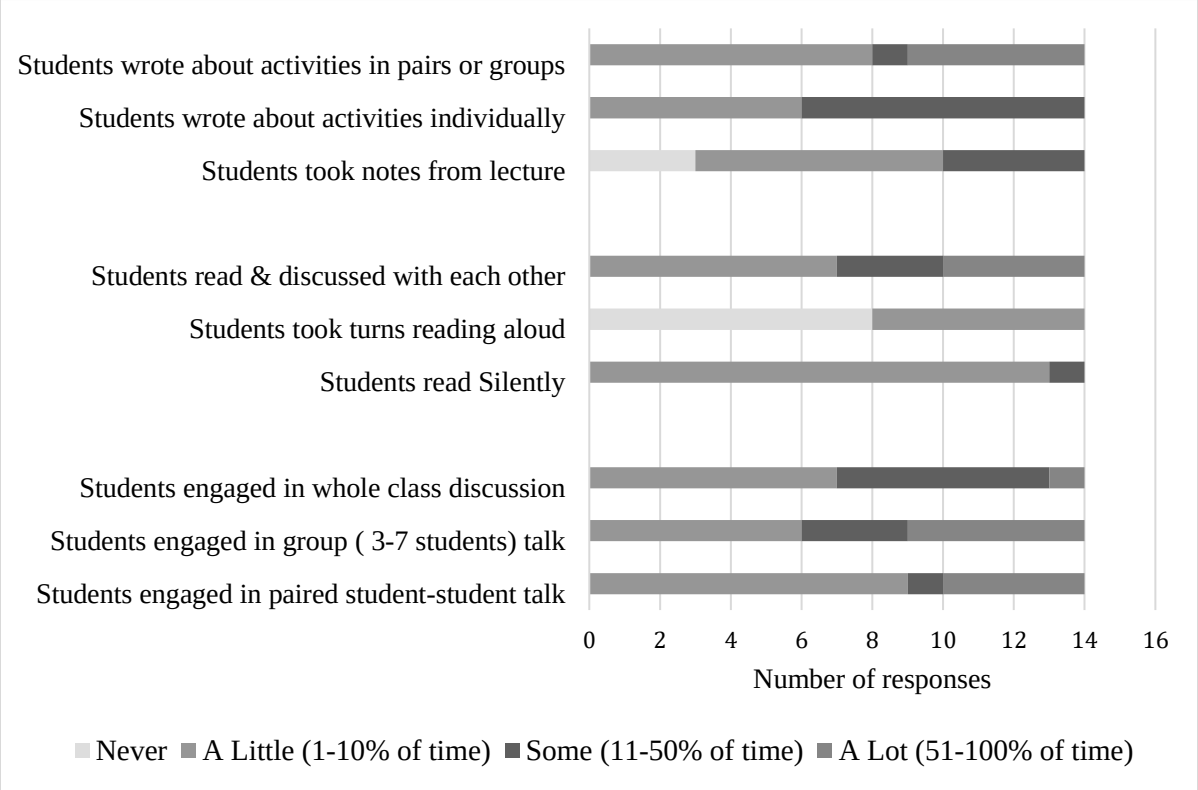

Figure 5.9. Part D. Percent of time students wrote, read and talked about science activities in the After LISELL classroom (see Appendix D for part D After LISELL log data).

Part E of the After LISELL teacher activity logs asked specific information about the LISELL-B labs that they did with their students. If so, did they modify them in any way? One After LISELL teacher reported that they did not use any labs during the time that the logs were collected. Another reported two labs- one was a LISELL-B kit and the other a virtual lab. The third After LISELL teacher reported doing five labs over the same period. While none of the five labs that the third After LISELL teacher reported were LISELL-B labs, the teacher did report using LISELL-B language boosters and vocabulary word cards in three of the labs:

We conducted a lab on blinking-eyes have muscles-it is not a LISELL-B lab, but we did use the language boosters to help with vocabulary instruction and writing about science.

No, we worked on viewing both plant and animal cells under the microscope. We did use the language booster cards to conduct this activity. We compared and contrasted both cells. We also provided students with the opportunity to write.

Lastly, Part F asked the teacher if they participated in any collaborative work with other teachers and if the teacher attended any type of PL.

When queried about collaborative work, Kelly and Alex responded with "we" answers describing working on lab development with hypothesis and writing, modifying tests and the discussion of lesson plans:

We worked on the development of labs and made sure to incorporate hypothesis and more writing opportunities.

We worked together to plan lessons

Charlie did not use the word *we* and reported mostly website type of work with no mention of working with the other After LISELL teachers:

Quizlet quizzes and How the body works website

Activity Multi-discipline boards

The PL that the teachers reported entailed watching a video on "learning about questioning strategies". This video showed two Mountain middle school History teachers demonstrating different questioning strategies: Mastery, interpersonal, understanding and self-expressive- which is further described in the observations section.

Question #1 Results. LISELL-B Practices/Materials Still Active in After LISELL Classrooms.

Review of the results from the multiple sources of data yielded the following evidence that shows that LISELL-B practices and materials were still active in the After LISELL classrooms in the two years following the disbanding of the LISELL-B project network. Representative evidence generated by the multiple ethnographic methods employed by the After LISELL study which support these claims are presented in the following paragraphs; beginning with transcription data collected from the first After LISELL interview.

Evidence from the First After LISELL Interview

The transcript of the initial After LISELL interview captured use of the LISELL-B controlling variables practice, which is one of the six LISELL-B pedagogical practices (see page 93-TeacherLogs); and a DNA Twizzler investigation that had been used during a LISELL-B summer academy. These activities occurred during the beginning of the first school year of the After LISELL study.

Date: 9/29/17; 11:54 am (Year 1 After LISELL study).

Done by: AML

Place: Mountain Middle School, Classroom 302.

Teachers Present: Alex, Kelly and Charlie

First After LISELL Interview. Transcript lines 31-36.

Evidence 1: Showed use of the LISELL-B Controlling Variables practice.

Alex *This year we changed the first two weeks we now teach the scientific method. So, um we now spend some time on variables dependent and*

independent, control variables um we spent time with measurements, because we did measurements too. What else did we do this year?

Kelly *We did experiments, well they had to conduct a scientific experiment was um a bunny-opter where they added, they tried to um make a prediction what an added mass would do to the little copter.*

Evidence 2-Transcription-lines 57-66 described use of the DNA Twizzler investigation done during a LISELL-B summer academy.

Kelly *So we did we had them make a DNA strand out of Twizzlers.*

Charlie *Like we did the summer, summer camp.*

Alex *So we used one of your kits to construct, not construct but to conduct an inquiry lesson on DNA. So, we constructed a strand of it, so we used the sheet of paper that was used in the LISELL-B kit to talk about that as well.*

AML *Cool!*

Charlie *It was good.*

Alex *So I think it was a very good start um because the kids really like it I think they were really looking forward to coming back to school. I would say it was a good initiative, a good way to begin the year vs going over procedures and rules the first day.*

Evidence from After LISELL Teacher Planning Meetings

Transcriptions of teacher planning meeting recordings proved to be another source of evidence of LISELL-B practices and materials that were still active in the After LISELL classrooms. The following excerpts are taken from a transcript of a recording during two After LISELL teacher planning meetings. The first from Year one of After LISELL describes the use of the LISELL-B Arm Model, Lung Model and Chicken Wings investigations in the After LISELL classroom. The second was collected during Year two of the After LISELL study and it

describes how the Lung Model investigation evolved along with After LISELL students' learning.

Date: Thursday 10/12/17, 11:00 am. (Year 1 After LISELL Study)

Done by: AML

Place: Mountain Middle School, Classroom 302- teacher planning meeting

Teachers: Alex, Kelly, Charlie and the Instructional coach

Evidence 1 Transcripts from: line 46-58 showed After LISELL teachers planning on using the LISELL-B Arm Model, Lung Model and Chicken Wings investigations.

Alex	*We are still building the model arm, right? The rubber band, the napkin, toilet rolls*
Kelly	*I don't know if we can get all of this done – last year, they didn't look right*
Alex	*Student work analysis*

The Instructional coach asks if the teachers are using Canvas -Alex confirmed Canvas and said that some of the questions were pulled from the USA test-

Instr. coach	*You only had to analyze benchmarks, you all are going above and beyond doing unit tests.*
Alex	*We have been for a good while -Ok so I put in building the model arm and the model lung and are we doing the chicken wing dissection? Are we going to do the mitochondria in action for this as well when we do the respiratory system? And I was thinking we could probably go outside and do that. And I was thinking we could probably take one of those big orange containers that we could put water in and just set them outside and let them get water.*
Kelly	*For what?*
Alex	*for ah mitochondria in action.*
Kelly	*That could be something we could do outside.*

Date: 11/09/2018; (Year 2 After LISELL Study)

Done by: AML

Place: Mountain Middle School; Classroom 302- Thursday teacher planning meeting

Teachers present: Alex, Kelly, Charlie and co-teacher Mr. B (note: co-teacher Dan was in a wreck and Student teacher Mr. S is taking test).

Evidence 2- Transcripts from: lines 91-100 showed After LISELL teachers talking about how well the LISELL-B Lung Model investigation worked to help the After LISELL students make connections to everyday life and understand how the lung works.

AML	*Where do you like to go look for things Kelly?*
Kelly	*Um STEM, discovery education, if you think of a lab you just search for it- I have found a lot of interactive web sites and try to find virtual labs that they can do. Like the lung model lab that got developed more and more to where not only are they building it, but they got to know what each part is make a connection.*
AML	*How many days did you spend on the lung model.*
ALEX	*Three days.*
Kelly	*two and a half to three days.*
AML	*So you got them to build it and then you actually got them to talk about it.*
Kelly	*They knew what each part represented, and it really helped them.*
Alex	*Oh yeah!*

Evidence from After LISELL Teacher Logs

Teacher logs busily collected data over the month of October during the first year of the After LISELL project. While all of the After LISELL teachers reported that each of the LISELL-B practices had been used in their classrooms, the most used was Coordinating

Hypothesis, Observation and Evidence followed by use of General Academic Vocabulary. The least used was Using One or More Types of Models to Test and Improve (figure 5.6). This finding was further supported by data depicted in figure 5.7, which depicts resources used by After LISELL students during science activities. Vocabulary was used 100% and reading 79 % of the time, while models were used only 21 % of the time. Online writing and reporting (another sign of use of literacy) was only used 35 % of the time (see figure 5.8) by After LISELL students during science activities. Lastly, the After LISELL teacher log data in figure 5.9 shows that all After LISELL students in all of the After LISELL classrooms were most likely to write, read and talk in groups, which is a LISELL-B practice, the importance of was stressed repeatedly during LISELL-B PL.

Evidence from After LISELL Classroom Observations

Another source of evidence for LISELL-B practices and materials that were still active in the After LISELL classrooms were the field notes taken during classroom observations. An example of two such excerpts illustrates use of LISELL-B practices Developing General Academic Language in Context and Owning the Academic Language of Science. These excerpts also contain evidence of LISELL-B kits, GAV and CC cards.

Date: 2/15/18 (Year 1 of After LISELL study)

Place: Mountain Middle School, Room 302; 1st period

Done by: AML

Teacher: Alex

Classroom observation field notes; Introducing students to Evolution.

Evidence of: LISELL-B practices Developing General Academic Language in Context and Owning the Academic Language of Science; LISELL-B kits, GAV and CC cards.

10:14 am Alex stops the video. “Who can tell me in everyday language what overproduction is?” Student “more babies”. Alex points out the videos use of scientific language: “overproduction-far more offspring are produced than can survive.”

The principal uses her key get into the room, she had trouble opening the door—they are looking for a missing student—disruption.

On to variation- Alex reads a scientific definition of variation and then asks: “who can help me with everyday language?” “Ok, what other word can we use instead of members?” class “Organisms”. What is everyday language for “Survive?” class “Live”.

Date: 2/22/18 (Year 1 of After LISELL study)

Place: Mountain Middle School, Room 302; First period

Done by: AML

Teacher: Alex

Classroom observation field notes: The Formation of Fossils.

Evidence of LISELL-B practices: Coordinating Hypothesis, Observation and Evidence; Use Models to construct scientific explanations & test engineering designs;

Develop General Academic Vocabulary (GAV): Owning the Academic Language of Science.

9:36 am Alex “Darwin had to back up his theory with ‘Evidence’.” Student “he is looking for his ancestors.” Alex “Big word, can you tell me what this (Evidence)–pointing to the word—is?” Student “Who came before them.” Another student “If you put the fossils in the correct order, you can see step by step how they change.” Alex “what does this remind you of?” Student “Like the video we saw on skulls.” Alex “Fossils provide evidence for Evolution.”

	Alex talks with the class about how they evolved from a tiny cell. She pulls out a baby model and shows the students what they looked like at nine months old.
9:45 am	Alex "Let me ask you again -Do fossils provide evidence of Evolution?" Class "Yes." Student "The Trilobite looks like a horseshoe crab." Alex "So that means what?" "Evidence of a common" class "Ancestor". Alex pulls up a picture of a horseshoe crab on the smart board. Alex "The Trilobite looks like a horseshoe crab."
10:12 am	Alex "Let's look at communities. On the smartboard is a list of attributes for two different communities A & B. Alex "Which will survive a natural disaster?" "Students talk with each other. Write down three things that support your belief." Each group huddles up. Alex "We are talking with each other; we need to use scientific language and we need to support our claim."

Evidence from After LISELL Artifacts

Artifacts proved to be another source of evidence for LISELL-B practices and materials that were still active in the After LISELL classrooms. In the After LISELL study, artifacts collected were cell phone pictures, handouts, and virtual videos (virtual video data is presented under the Virtual observations section). The pictures and handouts provide evidence for LISELL-B practices and materials still working in the After LISELL classrooms.

Cell Phone Pictures

An example of GAV and CC displayed in the After LISELL classroom can be seen in Figure 5.3. Another picture (figure 5.4) shows evidence of the Lung Model investigation having been done in the After LISELL classroom 302. Figure 5.5 shows a stack of LISELL-B kits waiting to begin investigations. Many of these are referred to in the transcripts that are provided

for evidence in this chapter. Lastly figure 5.15 illustrates Alex talking about the LISELL-B practices that she is sharing with another teacher.

Handouts

The handouts collected during the After LISELL planning meetings and classroom observations showed evidence for LISELL-B practices working in the After LISELL classrooms. All but two of the LISELL-B practices (Explaining cause and effect relationships, Use Models to construct scientific explanations & test engineering designs) were present in the handouts that were collected during the first year of the After LISELL study. Because these handouts were used by at least two of the teachers, we can conclude that at least two of the teachers were fostering the LISELL-B practices in their rooms.

Evidence from After LISELL Virtual Observations

Two of the 12 virtually observed labs depicted use of LISELL-B kits (LISELL-B microscope and DNA banana extraction). Other LISELL-B related activities observed were students talking, writing and reading about science with partners or small groups during the After LISELL investigation which were practices specifically encouraged during LISELL-B PL. Observed LISELL-B materials which supported LISELL-B practices included the use of GAV cards and talk moves.

Question #2 Adaptations to LISELL-B Practices/Materials Used in After LISELL Classrooms.

In answering this second question posed by this dissertation we again turn to the data collected during the After LISELL study beginning with evidence collected from the First After LISELL Interview.

Evidence from the First After LISELL Interview

Evidence of only one adaption of LISELL-B practices can be found in the first After LISELL interview and is captured in the following excerpt from the transcription.

Date: 9/29/17; 11:54 am (Year one After LISELL study).

Done by: AML

Place: Mountain middle school, Classroom 302.

Teachers Present: Alex, Kelly and Charlie

First After LISELL Interview. Transcript lines 494-520.

Evidence 1: Showed adaption of the LISELL-B language practices with addition of content.

AML	*So are there- is there anything off the top of your head that you still do that is like a vestige from the program at all? From the LISELL like I noticed---*
Kelly	*Focus like the Vocabulary focus.*
Charlie	*Yea the vocabulary is good.*
AML	*I see that you have your cards up there Alex, your vocab cards so do any of you use the vocabulary that you picked up.*
Alex	*So, in order to push the literacy influence this year, we are sticking with vocabulary, spending more time with vocabulary. Understanding, um everyday language. They are focusing on the three levels every day, academic and vs the what did they say? They are actually focusing on the three levels which was every day, academic and then content vocabulary right.*
Charlie	*Correct.*
Alex	*So um this is something that we already were doing with LISELL B. We are already doing academic language and everyday language.*
AML	*That goes right along with it, yes.*
Charlie	*What was that professional development that we did the Friday we came back (after the hurricane)? What did Susan Pritchard do?*

Alex	*That was it.*
Charlie	*It was a professional learning.*
Kelly	*We were trying to, we were trying to come up with words and within our content and then try to differentiate between ones that were across, between sixth, seventh and eighth grade science and ones that were specific only to our content.*
Alex	*Those were the content vocabulary.*
Charlie	*What was two and three.*
Alex	*Everyday language, then academic and then content.*
Kelly	*Ok yes.*
Alex	*Those are the three, these are the three levels.*

In this excerpt from the first After LISELL transcription, the After LISELL teachers are still able to use the LISELL-B literacy pieces but they are being adapted or rather having to meld them with a focus on content.

Evidence from the After LISELL Teacher Planning Meetings

Date: 10/19/2017 (Year one After LISELL study)

Done by: AML

Place: Room 302, After LISELL teacher planning meeting

Teachers: Co-teacher Mr. B, Student Teacher Mr. S, Alex, Kelly, Charlie, Mark's Co-teacher and the Instructional coach.

Evidence1 from Transcript lines 224-247 showed LISELL-B Practice- encouraging students to draw pictures of what they observed.

During the After LISELL teacher planning meeting, the teachers and student teacher Mr. S were working on assessments. The researcher asked the group if they ever let the students draw answers for the assessments and the following conversation took place:

Researcher	Do you ever ask them to draw pictures?
Alex	We could ask them -she explains to Kelly- on the assessment I could add.
Kelly	What would they draw- You could either draw or write about it- or they could act out a skit or sing a song about it.
Alex	They are explaining how to kick a ball -so there's that-what do you think? So, we are adding a picture.
Researcher	Illustrate.
Student teacher	It sounds like it could be difficult.
Kelly	Well it depends, some are really good at drawing
Student teacher	It's not just their drawing ability but actually getting them to put the correct terminology.
Alex	You would be surprised how much drawing helps them.
Researcher	Yeah because you have to in your head you have to do a lot to be able to draw it out.
Kelly	So we are talking about having them draw how the nervous or the muscular work together.
Student teacher	They are just going to draw a person just kicking a ball they are not going to- how are they going to show the skeletal system is involved and how are they going to show how the muscular system is involved?
Alex	Well, they provide their picture-they draw it and then they talk about it-right so not only they are your visual kids you allow them to first draw it which activates their thinking and then they can actually write about it – I want to leave the written component to it.
Kelly	But, if they could explain it.
Alex	I would say we do both.
Kelly	Or give them a choice.
Alex	If you give them a choice they are not going to fully explain it -so let's draw to activate that knowledge

Alex advocated for allowing the students to draw answers to the assessment questions which as Alex pointed out, can help students, especially ELL students, activate knowledge which was a pedagogical strategy that was promoted during LISELL-B professional learning. Alex was able to recruit her colleague Kelly in helping override the student teacher's objections.

Date: 1/31/2019 (Year two After LISELL study)

Done by: AML

Place: Room 302, After LISELL teacher planning meeting

Teachers: Co-teacher Mr. B, Student Teacher Mr. S, Alex, Kelly, Charlie, Kelly's Co-teacher and the Instructional coach.

Evidence 2 from field notes page 2 showed LISELL-B Practice- encouraging students to use science vocabulary.

> *Alex still tapes a tiny list of the vocabulary on the student's desk. This was first seen a few years ago. I have pictures of these taped to students' desks somewhere.*

Date: 11/09/2018; (Year 2 After LISELL Study)

Done by: AML

Place: Mountain Middle School; Classroom 302- Thursday teacher planning meeting

Teachers present: Alex, Kelly, Charlie and co-teacher Mr. B (note: co-teacher Dan was in a wreck and Student teacher Mr. S is taking test).

Evidence 3- Transcript from: lines 117-124 showed After LISELL teachers planning on using the LISELL-B DNA investigation. After LISELL teachers used Gatorade instead of water in the activity.

Kelly *What we ought to do is extract the DNA.*

Charlie	*Yeah the little girl said that you did something with the DNA and Gatorade.*
Kelly	*Mum.*
AML	*You can do the cheek cell DNA.*
Alex	*That is your Cheek cell DNA.*
Charlie	*That is what you did with the Gatorade.*
Alex	*Yup.*

Evidence from After LISELL Teacher Logs

The After LISELL teacher log Part E asked the After LISELL teachers if they specifically modified any of the LISELL-labs. The After LISELL teacher's responses were not very enlightening. There were no indications of adaptations to labs, by the After LISELL teachers, just reports of what LISELL materials they used.

Evidence from the After LISELL Classroom Observations

During the After LISELL classroom observations, the LISELL practices that were used were not modified. The researcher did note during an observation done 3/1/18 that Alex had spent time that year teaching the students how to argue and use evidence based on observations. The framework that she used for the After LISELL students to form their answers and replies were very similar to the framework used in the LISELL-B talk moves.

Date 3/1/18

Done By: AML

Place: Mountain Middle School, classroom 302

Source: After LISELL field notebook page 43

Evidence of possible adaptation of talk move framework used to help in argumentation exercise.

> Alex encourages the students to argue, working in groups and using a framework like the talk moves but for argumentation. Alex starts "Using the rules, say what I believe I heard_____"

> Then, I counteract "I agree with_____" a student tries. "What I believe that I heard what Jane said was the left cactus will not survive. And I agree with Jack that the right cactus will survive since it has roots that go deeper." Jane are you counteracting? You can't call out. Face Jack. "I agree___", "I counteract____". In response to a student's statement "It's a proven fact" another student replied "Ms. Alex, look that fact up"

This example taken from field notes describes Alex and her students using a framework of stating a hypothesis and response in rebuttal or support (argumentation) that used words in a similar style to that in LISELL-B Talk Moves. Talk Moves are used in a lot of activities in classroom 302 so they may have influenced Alex's argumentation framework.

LISELL-B Talk Moves were developed by LISELL-B staff and teachers and represent many hours of work. There is a TAL Move foreach of the LISELL-B pedagogical practices. They consist of a written framework with blanks that help guide students as they answer questions. For example- the Student Talk Moves to Support the Language of Scientific Investigation-Talk Move begins with questions that prompt a student to build on their prior experience:

> This question reminds me of_____.
>
> I have seen that before when_____.
>
> My experience with_____ makes me think _____.

The next set of questions are for clarifying and listening carefully:

> Are You saying that_____?
>
> Did you mean_____?
>
> Can you repeat that?
>
> I don't understand_____. Can someone explain it a different way?

Lastly, the student is prompted to challenge or support ideas:

I agree/disagree with _____'s idea because _____.

I would like to addon to what _____ is saying, _____.

I think _____'s idea is only true/not true when _____.

I think a counter-example of _____'s idea would be _____.

These Talk moves are printed on colored paper and housed in upright plastic frames to help with visibility and to use as little space as possible.

Evidence from After LISELL Artifacts

Artifacts showed a number of different instances of evidence for adaptation of LISELL-B practices and materials in the After LISELL classrooms. In the After LISELL study, handouts provided the most evidence of adaptations to LISELL-B practices and materials in the After LISELL classrooms.

Handouts

Classroom handouts collected during classroom observations and teacher planning meetings showed explicit evidence of adaptations to LISELL-B practices in the After LISELL classroom (see table 5.2). The most used adaptation observed in the handouts was in an increased amount of space for writing answers to writing prompts where normally, space given was barely enough to write a full sentence. In one handout, the LISELL-B practice of encouraging the use of scientific language was morphed into "use detective terminology". One of the most striking examples of modification was the "Let the Fittest Survive" handout, which was a version of the LISELL-B Hungry Birds investigation. In this version, Coordinating Hypothesis, Observation and Evidence and Controlling Variables LISELL-B practices were the focus of this investigation. In contrast, the original version focused on the LISELL-B practice Explain Cause and Effect. Also, the graphing of results was integrated, which was not part of

original lab. Another LISELL-B practice of integrating the use of drawing in lab reports was illustrated in a handout collected during the second year that encouraged drawing as a choice to promote reasoning instead of writing. Evidence of drawing was also seen in an earlier transcript (excerpts are presented later in this section) of a teacher planning meeting during the first year of the After LISELL study, where teachers were discussing encouraging students to draw pictures instead of writing answers, on an assessment.

Cell Phone Pictures

Another modification to LISELL practice was seen in a set of cell phone pictures. Cell phone pictures taken during visits to Mountain Middle School were usually purposeful in that they were used to document LISELL-B practices or materials. At other times, things that looked interesting were also photographed. One of these "interesting thing" pictures were of classroom 302's door that was covered in Post-it's. Figures 5.11 and 5.12 show two different times that Post-It's were posted on classroom 302's door. Post-It's walls were created during problem posing sessions at the LISELL-B summer academies. Figure 5.10 is a picture taken of a LISELL-B staff member watching as summer academy students place their Post-it's notes displaying problems that they identified in their communities. Even though these Post-It's were not part of a lesson to specifically teach a LISELL-B practice, they were integrated as a way of adding student voices to the conversation.

Figure 5.10. LISELL-B staff modeling student centered activity using Post-It's to post problems they were interested in. LISELL-B professional learning student academy 6/9/2014.

Figure 5.11. Room 304 door

Figure 5.12. Room 304 door 9/29/17

Evidence from the After LISELL Virtual Videos

During the Virtual observations, no adaptation of LISELL-B practices, were seen in the science investigations in After LISELL classroom 302.

Question # 3 Barriers in the Adoption/Adaptation of LISELL-B Practices in the After LISELL network

Evidence from the First After LISELL Interview

Date: 9/29/17; 11:54 am (Year one After LISELL study).

Done by: AML

Place: Mountain Middle School, Classroom 302.

Teachers Present: Alex, Kelly and Charlie

First After LISELL Interview. field notes – page 60

Evidence 1: Fire Marshall became a barrier to Post-It's placed by students on the After LISELL classroom 302 door as a way to add their voices to the classroom conversation.

Figure 5.13. Student computers in re-charging cart.

During my last site visit, I noticed that 302's door was cleaned of Post-it's. Alex explained that a visit from the Fire Marshal required a clean door. This was a practice that was being maintained classroom 302 as the After LISELL teacher already had plans for new questions and fresh Post-it's

Evidence from Teacher Planning Meeting

During most of the After LISELL planning meetings, computers commanded a lot of attention in that the After LISELL science teachers spent a lot of time coordinating use for labs, classroom activities, and state mandated testing with the other seventh grade teachers, (mathematics, social studies etc.).

Date: 01/31/2019, 11:25 am

Done by: AML

Place: Mountain Middle School, room 302, After LISELL teacher planning meeting

Teachers present: Alex, Kelly, Charlie, co-teacher Dr. C and co-teacher Mr. B.

Evidence 1 Excerpt from field notes – page 57 Newsela becomes a barrier to LISELL-B Language Booster use because it is more acceptable to Mountain Middle School administration for use in the classroom.

Kelly found the Newsela to be better than the LISELL-B language boosters –well more acceptable to administration. Very user friendly, can grade and comes in language versions other than English. The Newsela web site- https://newsela.com/ says they are an online literacy instructional content platform that integrates with Canvas and has embedded assessments. Newsela "solves the problem of reading engagement holistically for students, teachers and principals… all from the comfort of your mobile device".

LISELL-B Language Boosters were short stories that accompanied LISELL-B kits. They were meant to pique students' interest and were aligned with the topic of the activity they were paired with for example a story about genetic testing paired with the DNA kit. The language boosters were imbedded with specific vocabulary and a prompt for students to reflect by writing or talking in pairs. Spanish versions were also available to the LISELL-B teachers as a LISELL-B support of English Language Learner's.

Date: Thursday 10/12/17- 11:00 am

Done by: AML

Place: Mountain Middle School, After LISELL classroom 302-second period

Teachers Present: Alex, Kelly, Charlie and co-teacher Mr. B.

Evidence 2 After LISELL teacher planning meeting transcription; lines 22-30 Administration observations critical of classroom activity as a barrier.

Alex	*What we feared is actually taking place-so if they do not see that the kids are sitting down and being quiet-and they think that the conversation is out of the content – they don't believe that outside conversations can actually be connected to what they are learning. If things look disorganized and a ruckus, and the classroom looks like the kids are not learning then they will dock you down for that. So, it is going to become harder to implement STEM frameworks like what is meant to be you know.*
AML	*So you are going to find it hard to implement inquiry in your classroom because you have too many rules.*
Alex	*Exactly-*

This excerpt shows evidence of a barrier that the After LISELL teachers mentioned several times in conversations. Mountain Middle administration is in charge of observing and assessing the After LISELL teachers. The After LISELL teachers noted that the administrators write ups/feed-back to the teachers focused on student behavior in the classroom where moving around and talking with your neighbor are noted as being "not learning". This is problematic when one considers that the LISELL-B practices and science investigations encourage students to work in groups and talk to one another. Outsiders to the After LISELL network would not recognize and may misunderstand the LISELL-B activities.

Another barrier that was talked about a lot in the After LISELL network was money. The After LISELL teachers had a hard time getting money from Mountain Middle School to attend PL and purchase materials. One such occasion is especially memorable in that the After LISELL teachers spent most of the teacher planning meeting negotiating with Mountain Middle

administrators, trying to purchase chicken wings for the LISELL-B Chicken Wing Dissection science investigation. Parts of the excerpt follows.

Date: Thursday 11/2/17- 11:00 am

Done by: AML

Place: Mountain Middle School, After LISELL classroom 302

Teachers Present: Alex, Kelly, Charlie, Instructional coach, Co-teacher Mr. Dan and co-teacher Mr. B.

Evidence 3 After LISELL teacher planning meeting transcription; lines Negotiations with Mountain middle administrator over money as a barrier to performing the LISELL-B Chicken Wing Dissection science investigation.

Kelly to Instr. Coach-	*Is there some way I can get the credit card to buy chicken wings?*
Instr. Coach	*Did you talk to Funk? Her husband works--* Everyone was talking over each other, so It was hard to make out the conversations
Kelly	*He knows some people that work at the hatchery.*
Alex	*In a side conversation-No I recorded it so that if the kids needed to be read to, they could click on it and it reads it to them, and it reads the question and the answers.*
Alex	*She got them from Wal mart we told the lady it was for an experiment -we paid for them with our own money last year.*
Kelly	*The school can pay for them.*
Charlie	*They were good last time.*
Co-Teach. Mr. B	*Because you ate the left overs.*

Alex and I leave to go visit another classroom- Spanish for native speakers. Charlie, Kelly and Instructional Coach discuss how many wings they were going to need and how much -$120.00 while I left the recorder going-

Kelly *Can we use the ice cream $- I have sold enough ice cream.*

Charlie *Any trips fall through?*

Instr. Coach *Well, if you do SAMS- you can get a card and the school pays. You need to give the po # on the sheet …they keep our card there …. but let me ask-I am sure they will cover it. When do you all need them by?*

Kelly *Next week*

Instr. Coach *You can use the ice cream $.*

Kelly *You can get a case- what does a case mean- 35-50 lbs.*

Instr. Coach *If it can't come out because it is food like the 6th grade science wanted Oreos- you just have to sign and bring the receipt in.*

Kelly *Sounds good-the case price is $2.20 a pound.*

Alex and I came back-they are still talking about the chicken wings-where they are going to be stored.

AML *You said they are getting HS credit for that class-to Alex*

Alex *Yes and it is called Spanish for Native speakers*

Instr. Coach *You are documenting this test so you can get credit-if you are all doing a unit test make a word document you can put in unit test analysis or in your unit notes. That way they can know that you all did it.*

She also talked about the professional development videos and what they need to fill out about them.

Instr. Coach *Let me put in (Canvas) about the test next week. I will show you how eighth grade is doing it.*

Principal came in and they asked her about paying for the chicken wings. Instr. Coach explained about purchasing them from Sam's -she asked about cost-Kelly filled her in- $120 for a case and it is cheaper. If you have sold ice cream like you have.

AML *You would think a chicken packing plant would donate some chicken wings.*

Instr. Coach thought they would need more time to get through the process.

Kelly *I should have asked the University guys.*

Charlie *I have connections at Mo Jay-*

The After LISELL teachers must have obtained the money for the chicken wings because there is a Virtual video of the LISELL-B Chicken Wing Dissection science investigation.

Evidence from After LISELL Teacher Logs

The After LISELL teacher logs do not show any evidence of barriers in adopting or adapting LISELL-B practices and materials within the After LISELL network.

Evidence from the After LISELL Classroom Observations

One barrier that I observed was access to space to engage in After LISELL activities. One way the After LISELL teachers create space is by changing the desks to form groups of four. This desk formation provides more space for activities, but it also forms one that is sloped, and materials easily roll off at times.

Date: Thursday 3/1/18- 9::25 am

Done by: AML

Place: Mountain Middle School, After LISELL classroom 302.

Teachers Present: Alex

Evidence 1 After LISELL classroom observation field notes; page 41. Desks are oriented in groups of four forming a larger work area.

Warm up "What are the four steps of Natural Selection?" is on the smart board at the front of the room. Today, the students' desks are in a different pattern. The first time I have seen in this classroom. Groups of four with tables in together-their tops forming a larger work area- 29 kids today. …. Yesterday- they did the Hungry Birds lab-they added different foods to the original lab…..it occurs to me the desks are that way due to the lab yesterday when the students worked in groups.

In thinking about the desk formation, the LISELL-B Hungry Birds investigation requires the interaction of the students in stationary groups of four where they need to face each other. The lab benches in room 302 are long and run along parts of the walls on two sides of the class forming an "L" shape. This is fine for working in twos at stations but not in stationary groups of four. The only drawback (as I began to discuss above) is that the table tops are sloped. This causes problems during the lab when there are materials that can roll or slide off the table. The Hungry Birds lab has all sorts of materials that love to slide from the table like seeds, peanuts, pencils and tweezers.

Evidence from After LISELL Artifacts

The artifacts collected during the After LISELL study did not show any evidence of barriers to the adoption/adaptation of LISELL-B practices and materials within the After LISELL network.

Evidence from the After LISELL Virtual Videos

The After LISELL Virtual videos did not show any evidence of barriers to the adoption/adaptation of LISELL-B practices and materials within the After LISELL network.

Question #4 LISELL-B Practices/Materials Shared Among/or Outside the After LISELL Network.

Evidence from the First After LISELL Interview

The first After LISELL interview did not show any evidence of sharing of LISELL-B practices and materials with or without the After LISELL network.

Evidence from Teacher Planning Meeting

This first excerpt comes from a teacher planning meeting from the second year of the After LISELL study and shows After LISELL teachers sharing how to implement a LISELL-B DNA extraction investigation with one another.

Date: 11/09/2018; (Year two After LISELL Study)

Done by: AML

Place: Mountain Middle School; Classroom 302- Thursday teacher planning meeting.

Teachers present: Alex, Kelly, Charlie and co-teacher Mr. B (note: co-teacher Dan was in a wreck and Student teacher Mr. S is taking test).

Evidence 1- Transcripts from: lines 190-212 showed After LISELL teachers planning on using the LISELL-B DNA investigation. After LISELL teacher sharing of LISELL-B practices within the After LISELL network.

Alex *For a student work analysis – so guys, for a student work analysis, I put D – Are we still sticking with our cell pitch? This unit the DNA extraction are we still doing strawberries?*

Kelly *We are doing strawberries and banana – we are showing them the human DNA, but we are also showing them that plants have DNA too.*

AML *So you do the same thing with that one as you do with the cheek cell -you have the same solutions?*

Charlie	*Discuss how it's done.*
Alex	*Hey, how about tomorrow, we extract our cheek cells.*
Charlie	*That would be good.*
Alex	*That way you will have an understanding because it is a little hard to understand until you do it*
Kelly	*In a nutshell, they get a little cup and then you squirt a couple of squirts of Gatorade with a big pipet and then you swish it- Then they spit it in the cup and pour into the test tube, you only want the test tube half full and then they will add the lysis solution.*
AML	*Which is the salt solution and then you put some of that in there.*
Kelly	*Then you invert it- you don't want to shake it because it bubbles – I got a flip chart that goes through step by step what to do.*
AML	*Then once you do that you add some alcohol to it -and the alcohol denatures the DNA just like you know when you have egg white and the egg white is clear and you throw it into a pan and heat and it turns it white, well the alcohol does the same thing to the DNA that the heat does to the egg white – so it turns it white.*
Kelly	*It will float-and precipitate into the layer. You can take the pipet –*

Date: 01/31/2019; 11:25 am (Year two of the After LISELL study).

Place: Mountain Middle School; room 302, Teacher planning period.

Done by: AML

Teachers: Alex, Kelly, Charlie, co-teacher Dr. C and co-teacher Mr. B.

After LISELL teacher planning meeting.

Evidence 2 -Excerpt from field notes – page 57 After LISELL teacher sharing LISELL-B practices outside of the After LISELL network.

Kelly's student teacher graduated and was a long-term substitute teaching Math at Mountain middle. Co-teacher Dan was not re-hired. There was a new individual in the meeting, so the researcher asked Alex who he was. It was Kelly's new co-teacher Dr. C. Alex introduced me to Dr C. Dr C explained that he had been a LISELL-B teacher from one of the other project schools. He shared with the group that he had used the GAV and science Concept Cards in his classroom all of the time during the LISELL-B project and he especially used the Cause and Effect related materials.

After the meeting, Alex and the researcher were walking towards the front of classroom 302, catching up on what had been going on in the school since their last visit. A stack of plastic framed LISELL-B talk moves were sitting on a counter there in front of us and caught the researcher's attention. Pointing to the talk moves, the researcher commented to Alex that they had been seen working in all of the Alex live! Virtual videos.

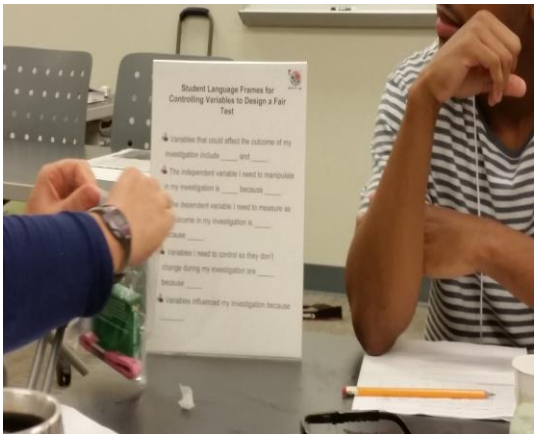

Figure 5.14. Talk Moves LISELL-B professional learning. Teacher institute 6/6/2016.

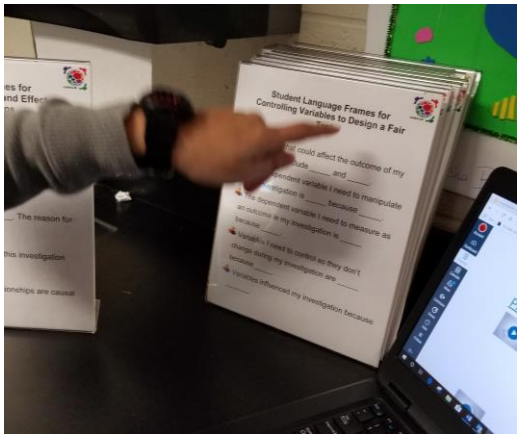

Figure 5.15. Talk Moves in classroom 302 1/31/19.

Alex grabbed the stack and went through the different ones (for example: Explaining Cause and Effect, Controlling Variables, Owning the Language of Science) and explained how "the students would follow the talk moves prompts to fill out their lab reports". "The Talk Moves helped the students organize their thoughts," she explained further. Alex then described how a sixth-grade science teacher who was relatively new at Mountain Middle asked her for help with her ELL students and her class's writing. Alex showed her how to use the talk moves and now she has adopted using them. "I trained her on the building a model one and writing a hypothesis. She picked up on how to use the pre-fix and suffix one. She is focusing on vocabulary." A new teacher has been enrolled into the After LISELL network.

LISELL-B Talk Moves & Writing Moves are a set of explicit questioning and responding strategies meant to guide the oral and written science dialogue in the classroom and to mentor students into using more productive science talk and writing. This teacher is new to Mountain Middle School and did not participate in the LISELL-B PL. Figure 5.14 shows the talk moves being used during a LISELL-B summer teacher academy; note that the talk moves are housed in an upright plastic support to save space and add visibility. Figure 5.15 shows Alex explaining the work that the talk moves do in her After LISELL classroom.

Evidence from After LISELL Teacher Logs

The After LISELL teacher logs did not show any evidence of sharing of LISELL-B practices and materials within or without the After LISELL network.

Evidence from After LISELL Artifacts

The After LISELL artifacts did not show any evidence of sharing of LISELL-B practices and materials with or without of the After LISELL network.

Evidence from the After LISELL Virtual Videos

The After LISELL Virtual videos did not show any evidence of sharing of LISELL-B practices and materials, within or without the After LISELL network. But it could be argued that since the Virtual videos were "shared" to the public on Facebook, LISELL-B practices and material use were also shared outside of the After LISELL network. Other teachers within Alex's Facebook network could potentially have seen the Virtual videos and result in conversations about the LISELL-B practices and possibly sharing materials especially when working with ELL students. The number of views each virtual video generated on Facebook are reported in table 5.4. One of the labs that was a LISELL-B Microscope investigation got 210 Facebook likes.

Table 5.4

Virtual Observation Videos Views on Facebook

Date	Virtual Observation Lab	Views
8/14/18	Bunny-opter Lab (outside) Exploring scientific method	110
8/16/18	**Microscope Lab**	210
8/20/18	What's Living Lab	44
9/7/18	Egg Lab Cell membrane	105
9/11/18	Egg Lab Cell membrane	64
9/12/18	Tree Lab (outside)	78

9/13/18	Human body (virtual lab room)	97
9/17/18	Egg Lab (cell membrane)	72
9/21/18	**Microscope and Cells**	57
12/4/18	Human Anatomy (virtual Lab room)	97
12/14/18	**Frog Dissection Lab**	34
1/4/19	**DNA Banana Lab**	69

Note: **Bolded** labs are LISELL-B labs.

Further evidence that other teachers may have watched these videos is in the following excerpt from the "popup" comments imbedded in the Virtual Egg Lab 9/7/18.

R- I'll bet your room stinks…lol

R- I'm not a big fan of vinegar. I had a few kids making penny batteries last year and it used vinegar. Smelly!

S- What did you put them in?

Networks are hard to visually represent without conjuring webs and networks of connecting lines and nodes, which Latour (2007) describes as "simple-minded visual representations" (p. 132). Latour (2007) tells us that networks are more fluid and are constantly changing where:

> everything is an actor/actant anything that does modify a state of affairs by making a difference is an actor—or, if it has no figuration yet, and actant. Thus, the question to ask about any agent is simply the following: Does it make a difference in the course of some other agent's action or not? (p.70)

Table 5.5 represents a list of the actors/actants that these data describe in the After LISELL network. Some have a status (are they working?) that could be questioned, but since networks are fluid, I have included them all.

Table 5.5
Actors That I Met in the After LISELL (AL) Actor Network

Actor/Actant	• What the Actor/Actant did in AL Network.	AL network study questions (Q) evidence provided for.	Weakness/Strength
First AL Interview	• Generated data (field notes & transcriptions).	Q1, Q2 & Q3	• All Al teachers present. • Needs to be scheduled. • Took time.
AL Planning Meetings	• Generated data (field notes & transcriptions). • Collaboration of teachers.	Q1, Q2, Q3 & Q4	• All AL teachers present. • Transcription transcribing.
AL Teacher Logs Part A Part B Part C Part D Part E Part F	• Generated data (A, D & E) • Generated money for AL teachers. • Professional Learning-Reflection?	Q1 & Q2	• Need a computer partner. • No cost. • Didn't use B, C & F. • Provided specific data of teacher enactment of LISELL-B practices. • Data from all AL teachers. • Took time.
Classroom Observations .	• Generated data (field notes).	Q1	
Artifacts Picture (P) Handouts (H)	• Generate visual data. • Documentation. • Assess students (H). • Provided content to students (H).	Q1, Q2 (H)	

	• Supported LISELL-B practice (H). • Differentiated student support (H). • Provided visual documentation of LISELL-B activity (P).		
AL Teachers Kelly (K) Charlie (C) Alex (A)	• Partnered with LISELL-B science activities (A & K). • Provided Virtual video (A). • Communication with AL network (A). • Partnered with talk moves (A & K). • Partnered with GAV cards (A). • Partnered with science CC (A). • Partners with room 302 (A). • Enrolled teacher from outside network (A). • Enrolled researcher into After LISELL planning meetings (A). • Shared AL practices within AL network (A & K).	Q1 (A & K) Q2 (A) Q3 (A & K) Q4 (A & K)	
Co-Teachers Dan (D) Mr. B (B)	• Allowed Kelly to Observe Alex-supported sharing with-in network (D). • Supported Alex & Charlie (B).		• Interfered with observing Kelly in classroom (D).
Instructional Coach	• Mediated & provided PL for Mountain MS and AL teachers. • Computer support for AL teachers.		• Did not provide instruction support.

Computers	• Obligatory Passage to CANVAS and Mountain MS. • Collects student and teacher data for Mountain MS. • AL teacher calendar. • Communication. • Connects AL teachers to the internet. • AL student's classroom activities. • Curriculum gathering • AL student assessments (classroom and state mandated). • Source of materials. • Stored AL data. • Collected and graphed AL log data.		• Short supply.
Talk Moves	• Guide students use of science language within and outside of AL network. • Supports ELL's. • Partnered with science investigations. • Partnered with teachers. • Enrolled a teacher into the network. • Immutable mobile.	Q1, Q2 & Q3	• Most popular AL material. • No cost. • Best when paired with plastic frame ($).
Student Teacher Dan	• Taught in Kelly's Classroom.		• Taught instead of Kelly in classroom.
Mountain MS Principal	• Enrolled teachers, co-teachers, student teachers into AL network.		

AL science investigations (kits)	• Negotiated for time. • Worked with teachers. • Guided LISELL-B practices during science investigations. • Provided materials that produced objects/models used in learning. • Shared within network. • Provided language boosters. • Provided instructions and lab handouts. • Supports ELLs. • Each kit embodies a LISELL-B practice. • Bridged with NGSS.		• Cost money. • Must be scheduled. • Caused activity in AL classroom that caused trouble with Mountain MS administration. • Short burst of activity. • Many use food. • Fun.
Researcher	• Provided AL kits. • Collected data. • Analyzed data. • Helped provide information for lessons.		
Lung model	• Modeled. • Connected students with every-day life. • Ambassador-went home with students & was recruited to show off at science night in classroom 302. • Encouraged teacher inquiry. • Student assessment.		• Low cost. • High, visible impact. • Lends self to inquiry learning.
Library	• Hosted AL teacher planning meetings. • Virtual Lab. • Hosted a classroom observation.		
Classroom 302	• Hosted teacher planning meetings.		• Gets a lot of Mountain MS

	• Hosted virtual videos. • Provided space for AL science investigations. • Home for talk moves, GAV & science CC cards. • Hosted classroom observations. • Provided space for learning. • Stores the AL kits.		teacher traffic from outside of the AL network to use its "kitchen"/storage room.
GAV cards	• Immutable mobile. • Support LISELL-B practice. • Partnered with teacher. • Partnered with kits. • Visual language support. • Supports ELLs. • Invite/support interaction of teacher and students.		• Have pictures. • Words are purposefully chosen. • Used daily. • No cost. • Have definitions. • Come in Spanish.
LISELL-B practices and materials	• Framework. • Supports NGSS. • Support ELLs. • Supports the writing, reading, drawing and talking of science. • Supports student collaboration. • Supports inquiry.		• Was a framework purposefully constructed in a now dispersed, network. • Sustainable.
Virtual videos	• Generated visual data. • Documented science activities. • Documented AL kit use. • Possible mode of sharing LISELL-B practices and materials.	Q1, Q4?	• No cost. • No barriers. • Recorded only science activities. • Observer has no control over field of observation. • Accessible/stored at Facebook.

Titan & University cars	• Transported LISELL-B materials & kits to Mountain MS. • Transported the researcher to Mountain MS.		
Mountain Middle School	• A large network that intersects the AL network. Contains things such as principals, staff, computers, CANVAS, instructional coaches, vice principals, policemen, students, desks, a library, hall ways and a lunch room. • Added general literacy to AL network. • PL for AL network teachers. • Controls money. • Assess teachers. • Hosts science nights. • Hosts parent/family nights. • Enforces county rules.		• Causes strain on the AL network.

One last example was relayed during a review of some of the data with Alex. The researcher asked about the use of the LISELL-B talk moves and found that Kelly had taken time to observe Alex (on three separate occasions) using talk moves to teach about heredity while co-teacher Dan watched Kelly's class. Now Kelly uses the talk moves when teaching heredity, but not with any other lessons.

After LISELL Associations Map

The After LISELL Associations Map (See Appendix E) is an attempt to visualize the complex associations of the different actors and actants (listed in table 5.5) within and outside of the After LISELL network. The After LISELL Associations map also brings in some of the different networks that the After LISELL network is situated in or may encounter. This is not meant to be a static "flat Earth" map but rather a snapshot of just one frame of time. The arrows represent movement and not linear linkages. In thinking how the different actors are functioning within the After LISELL network, I use the following ANTish terms: Intermediaries, mediators, immutable mobiles and obligatory passage points. In the following paragraphs, I will introduce some of the actors/actants that populate, move through, disrupt and help maintain the After LISELL Network.

The Administration network is embedded within the Mountain Middle school network. The actors: money, principal, vice principal and instructional coach reside here. This network is an obligatory passage point for students, student teachers, money, policy, co-teachers and teachers to enter and become enrolled in the Mountain Middle school network and thus, the After LISELL network. This idea of enrolment was proposed by Callon (1984) in one of the earliest ANT papers that dealt with the domestication of scallops.

> This example illustrates the different possible ways in which the actors are enrolled: physical violence (against the predators), seduction, transaction, and consent without discussion. This example mainly shows that the definition and distribution of roles (the scallops which anchor themselves, the fishermen who are persuaded that the collectors could help restock the Bay, the colleagues who believe in the anchorage) are a result of

> multilateral negotiations during which the identity of the actors is determined and tested (p. 214).

The Administration network also helps maintain the After LISELL network in that it mandates that the After LISELL teachers meet each Thursday for teacher planning. It is also during this time when administration actors are likely to enter the After LISELL network where they become intermediaries of school board policy, and money or mediators as recruiters for science night. Other times, they enter the network and become observers of teacher practice and classroom activities which resulted in reviews that were emailed to teachers. One such review reprimanded a After LISELL teacher for students talking and moving about in the classroom during an activity, illustrating that the administration was not familiar with LISELL-B pedagogy. This unfamiliarity is why the administration is not shown as part of the After LISELL network in the After LISELL Associations map. Latour and Woolgar (1986) in *Laboratory Life* used this knowledge check as a way to "roughly assess the extent" of the TRF network by asking "how many people know the meaning of the term TRF" (p. 105). Where their association to the network is illustrative of their association to the network as in many have no idea, some know it has an association with science, while others know exactly what TRF means.

Another actor which moves through the After LISELL network are the students. Enrolled by the Administration network who designates which classroom they are to attend class in. Teachers are not a part of this enrollment and this causes disruption in the classroom and agitation among the After LISELL teachers as students are moved in or out without any notice. The students are only exposed to LISELL-B practices and materials only when they enter the network through their teachers who act as intermediaries. As the students partner with the LISELL-B kit materials, Talk Moves, GAV cards and Concept cards, they can become mediators

as they do unexpected things. For example, the students assemble the lung models in ways not instructed by the kit or in how they turned the lung models into ambassadors by taking them home to show their parents. Which demonstrates how things morph as they move into different networks. The lung models connect the students to the "real world" forming a hybrid agency with the students and become a model for what the students are doing in class when the move into the student's home or how a lung works in the science night networks.

The Talk Moves are an example of an immutable mobile which stays the same no matter where it goes. Other examples are money, engineering drawings and maps (Fenwick & Edwards, 2010). Fenwick and Edwards (2010) tell us that Immutable mobiles can also 'function as the delegates" to other networks by "moving into new spaces and working to translate entities to behave in particular ways" (p. 18). Talk Moves enrolled a teacher outside of the After LISELL network which could possibly pave the way for other LISELL-B practices to colonize their classroom. The Talk Moves, which look deceptively simple, were developed by teachers and researchers, represent many hours of development undergoing revisions and adaptions. They are meant to partner with students in effecting writing and thinking which would give them mediator status, but this study does not have empirical evidence of student lab reports that show how they effected student thinking and writing. The student's interaction with the LISELL-B practices and materials could also help support (if they learn) or disrupt (refuse to use them, show no learning) the After LISELL network.

The different classroom networks that the After LISELL teachers teach in also show different relations with the After LISELL network based on activity. Classroom 302 is totally associated, while classroom 312 is partially, and classroom 301 is almost negligible. Even though all the teachers attended LISELL-B professional learning, only two enrolled LISELL-B

practices and materials into classroom networks. The LISELL practices also display different agency within these classroom networks that are embedded within the After LISELL network. For example, in classroom 302, LISELL-B activities are commonly observed as are the GAV cards which are always displayed on the walls. It was the Virtual videos that originated from this classroom that re-enrolled the researcher into the After LISELL network and possibly other teachers from other classroom and county networks. Classroom 302 also hosted most of the teacher planning meetings.

The last actor that I would like to talk about is the Science Investigation Kits. These kits, only stored and used within the After LISELL network, are a carefully structured network of practices and materials that help draw student interest, thought and understanding of the science activity and basic understanding of science practices. The kit materials support science reading, talking and writing which align with the literacy focus of Mountain Middle school. The complexity of the kit results in multiple enactments where not all of the parts of the kits are used, and modifications were observed during the study. The kits were used as a hook, an activity which was different then envisioned by the teacher developers (Buxton, et al., 2017).

In this discussion of the actors that can be found associated with the After LISELL network, the After LISELL network begins to be visualized. It can be argued that it is a functioning network that is being sustained by active enrollment, obligatory passage points that show stability, and there are active mediators and intermediaries that are only present and working within the network itself. Many of these actors play different roles within the after LISELL network that help to stabilize or will eventually un-stabilize it.

CHAPTER 6.

DISCUSSION/WHAT IS WORTH SEEING THERE

> *The bottom line is that in this way of imagining how they relate together, theory is woven into ethnographic practice while ethnographic practice is woven into theory. The combination is difficult, infuriating, rewarding and beautiful, all at the same time.*
>
> (Law, Notes on fish, ponds and theory, 2012)

The unexpected is what makes travel exciting. AML, 2019

Introduction

This chapter serves to discuss the results of this study in terms of how LISELL-B practices/materials were sustained in an After LISELL actor-network that included middle school science teachers who elected to be enrolled in an intentionally formed professional learning network (the LISELL-B project), during the two years after the disbanding of the project, and how this relates to rethinking of the evaluation of PL. In addition, limitations to this study and possible implications are also discussed. To this end we consider the following research questions first posed in Chapter 1 of this dissertation:

1) What LISELL-B practices and materials were still active in the After LISELL network, in the two years following the end of the LISELL-B professional learning project?

2) What adaptations were made (if any) to the LISELL-B practices/materials by their association with the After LISELL network?
3) What barriers did the LISELL-B practices/materials encounter by their association with the After LISELL network?
4) How were LISELL-B practices and materials shared among or outside of the After LISELL actor-network?

In this discussion, we will consider what we have learned in light of the results and theory outlined in the previous chapters. The development of this case study utilized multiple ethnographic methods (An initial interview, observations, teacher logs and virtual video) in various spaces within the After LISELL network (classrooms and teacher meetings) to generate data (recordings/transcriptions, artifacts, enactments, and field notes). All of the methods were decided on at the beginning of the After LISELL study except for the unexpected virtual videos. Also access to Thursday teacher planning meetings for observations had not been negotiated before the After LISELL study began. Thus, the After LISELL study generated a heterogeneous collection of data. Latour (2007) tells us that for a sociologist to do their job, they "need as much variety in 'drawing' actors as there are debates about figuration in modern and contemporary art" (p. 54). When all of the collected data were analyzed, evidence emerged suggesting that LISELL-B practices and materials were still at work in the After LISELL network. And that in their association with this After LISELL network, there was evidence that some of the LISELL practices and materials were adapted, encountered barriers in their ability to work, and were shared within and without the After LISELL network. These findings are discussed in the following paragraphs organized around the four questions posed in this dissertation.

Question #1 What LISELL-B practices and materials were still active in the After LISELL network, in the two years following the end of the LISELL-B professional learning project?

Let us consider the first question that pertains to the LISELL-B practices/materials that continued to be active in the After LISELL classrooms and what we learned.

Data were collected from within the After LISELL network during an initial interview; observations (classroom and virtual); during a planning meeting; teacher logs; from artifacts; provided evidence in different ways (visual, audio and tangible) that documented continued/ sustained presence and activity of LISELL-B practices and materials in the After LISELL network. For example, the first interview which resulted in field notes and transcriptions from audio recordings provided evidence of the LISELL-B practices as relayed by the After LISELL teachers. The After LISELL teachers provided descriptions of LISELL-B activities and science investigations that engaged their students. Also, the interview provided confirmation of the origin of the activity in that the After LISELL teachers reported that they were first introduced to it when they had attended a LISELL-B summer academy. Interviews are utilized by many studies that declare themselves Qualitative or mixed methods and most of the empirical studies that I reviewed all included interview data as well (Drits-Esser et al., 2017; Minor et al., 2016). While this study's interview was focused on the LISELL-B practices and materials, the studies of Drits-Esser et al. (2017) and Minor et al. (2016) were focused on what the teachers said about their learning—beliefs, deeper understanding, confidence and risk taking. There was nothing about what their PL practices are doing in the classroom.

Answers generated by the questions posed by the After LISELL teacher logs capture the After LISELL teacher's engagement with LISELL-B practices and materials in the After LISELL classrooms. In the LISELL-B project, teacher logs had two purposes. The first was to collect data on LISELL-B teacher's implementation/engagement of/with LISELL-B practices in their classrooms and the second was to be a part of the LISELL-B PL where the teacher logs helped teachers reflect on their classroom engagement with the LISELL-B activities (Caswell, Schwartz, Minner, Allexsaht-Snider, & Buxton, 2017). While implementation of the After LISELL logs was based on the process used during the LISELL-B project, where teacher logs were implemented throughout the whole project, these logs were only used to document five weeks of After LISELL teacher activity. This short window of log implementation was due to many factors both within and without the After LISELL network such as time (it takes time to do logs), holidays (there are many between Thanksgiving and New Year's Day), snow (school closed=no activity) and money (paperwork and multiple changes in University accounting personnel and uncertainty of available funds complicated getting the teachers paid; no money for year two). Thus, the log data represented a snapshot of activity during a month at the beginning of the After LISELL study. Some of the log data collected did not generate useful data in answering our study questions specifically Parts B (redundant), C (technology use) and F (PL done). This was due to the alignment of the After LISELL logs with the LISELL-B logs and the intent of the researcher to be able to compare log results from the studies, but answers generated did not pertain to my research questions for this study. In addition, results from Part E (documentation of adaption of LISELL-B kits) was counter (none reported) to what was observed and noted in field note and artifact data (lots of changes were made to LISELL-B practices and materials).

These data are encouraging since they show that the LISELL- B pedagogical model which aligns with the NGSS and thus the new GSE is supportive of After LISELL classrooms, which are beginning to implement the new GSE standards (Georgia Science Standards, 2014). In addition, we can't totally dismiss the ongoing potential that these logs could have had on PL in the form of reflection of practice for the After LISELL teachers but, this LISELL-B PL practice was not specifically examined.

Classroom observation data supported the findings of other data that reported the presence of LISELL-B practices and materials, but they differ in that they provided a more rich account of the work that LISELL-B practices and materials did in an After LISELL classroom (the classroom observations were done in only classroom 302). Furthermore, these classroom observations were done during everyday classroom activity and not during a science activity, where one would expect to see LISELL-B practice or materials in action. Even though these data represented observation of only one of the After LISELL teachers (due to changes in the other After LISELL classrooms), mostly occurring during the first year of the After LISELL study, they provided an opportune opportunity to watch this interplay of teachers/students, GAV and science cards while forming definitions or using evidence and science language to argue for their hypotheses. Future observations in other After LISELL classrooms where the LISELL-B kits are active would provide more data in understanding the work that the LISELL-B practices and materials are doing in other networks.

Artifact data collected during classroom observations and teacher planning meetings also provided evidence of LISELL-B practices and materials in use. Pictures were mostly used to document the presence of LISELL-B materials as in GAV, Concept Cards, kits and Talk Moves (see figures 5.3 & 5.5) but sometimes, random pictures showed connections to non-

official LISELL-B PL practices that resulted from the After LISELL teachers' past involvement in summer academies as in the use of Post-It's to elicit student conversations (see figures 5.10, 5.11 & 5.12). On the other hand, handouts documented and supported LISELL-B practices by providing space for writing and drawing. Handouts also showed recruitment of some of the LISELL-B pedagogical practices in assessments, such as writing longer responses or having the choice to draw an answer for an assessment. This is quite unusual in that most of the assessments in the After LISELL network are done on computers to be collected by CANVAS for the Mountain Middle school's network, which scores, records and graphs the answers. Writing and drawing answers must be scored by the After LISELL teachers, thus showing some resistance/slippage in the After LISELL network. At first, the ability of handouts to generate meaningful data was underestimated by the researcher who avoided analyzing them until the last weeks of the study. Yet, they provided not only evidence of the work of LISELL-B practices but also adaption of them.

The most surprising evidence came from the virtual videos. The virtual videos provided the researcher with the ability to participate in virtual observations of science activity in After LISELL classroom 302. More importantly, these unplanned videos re-enrolled the researcher into the After LISELL network. Like the classroom observations, virtual observations resulted in data that showed LISELL-B practices and materials working in the After LISELL network. These videos afforded the researcher the ability to maintain connections with the After LISELL network teachers and classrooms; allowing the collection of data for a second year of the After LISELL study. A second year of data collection had not been planned due to the end of the LISELL-B project and its funding (which supported travel, graduate student support, and teacher stipends); thus, hindering the researcher's ability to attend planning meetings, conduct

classroom observations and collect teacher logs and artifacts. As an aside, Money is an example of what Latour refers to as an "immutable mobile" in that its non-negotiable effects don't change within a network- or as it moves between networks (Fenwick, 2010). Some limitations of this data were in that these videos were only done during the second year of the After LISELL study and were only taken of lab activities. Other limitations were that lab forms were out of focus and thus couldn't be read, and artifacts could not be collected, and the researcher did not have control over what was focused on. Again, most of these virtual videos were only done with After LISELL students from different periods of After LISELL classroom 302 but some did occur outside or in the virtual lab. Even though these videos supplied redundant evidence of the presence of LISELL-B practices and materials, they did provide an opportunity to see the work also. These virtual videos added much possibility in the evaluation of sustainability of PL at no cost and very little effort.

As a collection, the data from the After LISELL study shows that LISELL-B practices and materials were still busy doing work in the After LISELL network at Mountain Middle School. In thinking of the many research projects that are described in the PL literature that are solely focused on fidelity of implementation in evaluating PL effectiveness, or that depend on pre and post-tests; this researcher questions the narrow interpretation that these methods offer in evaluating PL effectiveness. Data herein show that much can be learned by using any one of these ethnographic methods to evaluate PL outcomes but that together a much more nuanced and detailed picture can be made.

Question #2 Adaptation of LISELL-B practices/materials by the After LISELL Teachers.

On review of transcription of the recordings and field notes taken during the initial After LISELL interview only one example of adaptation to the LISELL-B practices was

identified. Mountain Middle School adopted a school-wide focus on literacy that includes every day, academic and content vocabulary. The After LISELL teachers explained that the content vocabulary is vocabulary that is only specific to their content (seventh grade science). LISELL-B practices align with this focus on specific content vocabulary while also expanding to include general academic vocabulary. Thus, the Mountain Middle School mandated literacy focus limited the flexibility that was built into the LISELL-B language practices.

More clear evidence of adaptation of LISELL-B practices was illustrated in a transcript taken from an audio recording of one of the After LISELL planning meetings. In this transcript, After LISELL teachers negotiated with one another about allowing students to draw answers on their assessments. Drawing was one method encouraged during LISEL-B PL and modeled by the LISELL-B kit investigation lab handout. Alex argued that drawing helped students, especially ELL students, activate previous knowledge—another LISELL-B pedagogical strategy. This adaptation was a radical change to the short answer, multiple choice computer mediated assessments commonly found in the After LISELL classroom network where the Mountain middle school network's CANVAS program, made tracking, grading and graphing of assessment results easier. Again, these types of assessment results would require After LISELL teachers to hand grade them and enter grades into CANVAS. The drawing on assessments, mini cards and Gatorade are examples of the *flexibility* of LISELL-B practices.

After LISELL teacher logs did not provide any information on adaptation of LISELL-B practices. This was noteworthy since the After LISELL teacher log specifically asked the After LISELL teachers if they had modified any of the LISELL-B investigations. This is contrary to the evidence from other sources of the After LISELL data. It is possible that this contrary finding, for example the Gatorade adaption to the DNA investigation referred to earlier in this

chapter, was due to when the data was collected. The Gatorade observation originated from Year two, while the teacher logs were collected during year one of the After LISELL study. Or it could have been that the teachers did not interpret modifications the same way that the researcher did, as in the case of adding drawing to assessment with came from a transcript during the time the After LISELL logs were collected. Thus, illustrating the importance of interpretation and the use of multiple different methods of data collection.

Handouts collected during the After LISELL project were originally thought of as just mundane worksheets by the researcher. But, on closer inspection, they turned out to be a wealth of evidence that showed adaptations of LISELL-B practices such as addition of space on handouts to encourage writing, or drawing, or a prompt that asked students to "use detective language" instead of the LISELL-B "use scientific or everyday language" terminology. One of the more noticeable adaptations were to the LISELL-B Hungry Birds investigation. In the LISELL-B network this investigation highlighted the practice of Explain Cause and Effect. In the After LISELL network, the investigation was changed to practicing Controlling Variables. Again, illustrating the flexibility that was built into the LISELL-B network and also the ability of a network to change the identity of actants. Cell phone pictures also provided some evidence of adaptation of a non-official LISELL-B practice (using Post-It's to elicit student voice) taken from a LISELL-B summer academy, which illustrates how things (Post-It's) can be enrolled into the After LISELL network by After LISELL teachers. Virtual observations did not provide any visual evidence of adaptations of LISELL-B practices and materials.

Data from the various ethnographic methods used in the After LISELL study provided evidence of adaptations of LISELL-B practices and materials in the After LISELL network in the two years after the LISELL-B PL. Most of these were captured by the artifacts (especially

handouts), which surprised the researcher. In the education PL literature, implementation of practices/methods are used as a measure of "fidelity" where the more a teachers' practices mirror what was modeled in the PL, the better is confirmation of PL effectiveness. This fidelity of implementation was used in the study done by Minor et al. (2016) to assess their PL's effectiveness. Thus, many of these adaptations would have escaped notice or been discounted by the researcher, had she been focused on looking for exact implementation of LISELL-B practices. Drits-Esser et al. (2017) did report that only some of their strategies were integrated in their teacher's classroom, but this was seen more as a negative as they concluded that teachers need to be willing to change. Again, focusing on teachers took away from noticing what practices were working in the classroom and how. This researcher argues that these data show that much is missed in such a narrow lens of implementation of what is learned during PL.

Question #3 Barriers the LISELL-B Practices/Materials Encountered in the After LISELL Network

Evidence of barriers that were encountered by the LISELL-B practices and materials originated from the initial After LISELL interview, teacher planning meeting transcripts and from two of the After LISELL teachers (Alex and Kelly). These barriers mostly originated from outside of the After LISELL network and were imposed by other networks like Mountain Middle's administration and the Fire Marshall. Examples in the results section illustrate negotiations about buying chicken wings for a LISELL-B investigation with Mountain Middle's administration while another illustrates how Mountain Middle's administration (after classroom observation and evaluation of teachers) were "docking points" on After LISELL teacher evaluations; where After LISELL students seen talking and moving about during After LISELL science activities/investigations were considered to be "not learning". This example of the

Mountain Middle administration "seeing" the After LISELL students as "not learning" brings to mind Latour and Woolgar's (1986) example of TSH (thyroid stimulating hormone) in *Laboratory Life*. What they argue is that actors that are not part of networks (without) are easy to recognize because, they don't understand the role that certain actors within the network play (To an endocrinologist, TSH is a hormone; to the average man on street, it is just a white powder). This is also a way to "see" the boundary of a network. Apparently, Mountain Middle's administration is not part of the After LISELL network since it doesn't recognize LISELL-B practices as learning. This is problematic for LISELL-B practices and science investigations since they encourage students to move and work in groups and talk to one another (act). Outsiders to the After LISELL network would not recognize and thus may misunderstand the activities that accompany learning in the LISELL-B framework.

The next barrier is associated with the GAV cards. The LISELL-B project supplied bilingual GAV and science content cards to the LISELL-B teachers but only the English versions were used in classroom 302 during the first year. This is surprising in one sense since the school's student population is fifty one percent Latino (see table 4.1). But it is not surprising in another way, when one considers other data collected during the After LISELL study that is associated with the After LISELL teacher Alex. Alex is Latina and Spanish speaking yet, she is not allowed by Mountain Middle's administration to speak Spanish to her students when she is in front of her class.

Another problematic barrier is Money, an actant that could change from one type of actant to another. In the After LISELL network, Money from the LISELL-B network started out as a catalyst (funded activity within the network) but as it moved out of the network with the dispersion of the LISELL-B network, it soon became—or rather the lack of Money—a barrier.

Money is also usually thought of as an immutable mobile in that it has the same meaning across networks but in this case, it became a type of barrier, which Latour called a speed bump (Latour, 1994, p. 39). Speed bumps are non-negotiable, in this case, when it left the After LISELL network there was little available (from the Mountain Middle School network) to resupply LISELL-B kit materials (e.g., chicken wings, cheerios, bird seed and gummy bears). The problem was that many of these materials are foods (a cheap source of lab materials the LISELL-B team reasoned) and extra funding from the Mountain Middle school network (Title I funds), which could have supplied funds, were not allowed to be spent on food. The example in the results section illustrates how After LISELL teachers spent time negotiating for money and one After LISELL teacher sold ice cream at lunch to generate extra money.

Computers proved to be a major actor that played different roles in the After LISELL network. During the planning meetings, computers commanded everyone's attention since they were the teachers' only link to CANVAS. All meeting minutes and calendars of classroom meetings were maintained on CANVAS, as were student assessment data. Mountain Middle administrators mandated that the teachers in its network use CANVAS in order for them to keep track of "learning" in the classrooms (assessments and what curriculum is being taught). Latour would call them an "*obligatory point of passage* "—"a central assemblage through which all relations in the network must flow at the same time" and in this case connects the After LISELL network to the larger "school" network (Fenwick & Edwards, 2010, p. 18). At times, computers were a barrier in that they were constantly in short supply and After LISELL teachers spent a lot of time juggling them around within and from without the After LISELL network. In January of 2019, all Mountain Middle students were issued computers. Students couldn't take these computers home so, at the end of the day, computers were returned to homerooms and plugged

into their docking stations to recharge. If students missed school, they were expected to access their lesson plans from their home computers. In the Fall of 2017, school was closed for a week due to Tropical Storm Irma and students were able to catch up during three days of online learning. Office 365 is now offered for free to Chick County students and the county implemented a new bad weather "School from Home" days. Students won't miss school during bad weather (ice and snow typically) anymore.

Other barriers observed were more short term and involved actors from other networks that intermittently overlap the After LISELL network, such as state assessment officers who had the GAV cards removed in room 302 during state mandated testing and the Fire Marshall who had the Post-It's notes removed from room 302's door. The After LISELL teacher maintained the network by replacing the cards after the testing and posting a new question on room 302's door, inviting students to start placing Post-It's back on the door when the other actors moved on.

These data illustrate the varied negotiations that LISELL-B practices and materials must overcome within the After LISELL network. Many come from outside the After LISELL network (Mountain Middle School administration, bad weather, Fire Marshall, and Money). Evidence was mostly supplied by the transcriptions taken from the first After LISELL interview, After LISELL teacher planning meeting, and observation of two of the After LISELL-teachers (Alex and Kelly). In the studies I reviewed, barriers were mentioned, but they were still human focused for example, Drits-Esser et al. (2017) reported that teachers' willingness and unsupportive administrators were barriers. They did acknowledge that "materials and training in their use" were "critical for change" which was ANTish sounding, but focus returned to human agency, not the agency of the materials (391). Clary et al. (2018) blamed their negative

statistical results on teachers who they described as “professional workshop attendees” (p.82). The data from this study shows that there are many possibilities for interference from sources not human that were overlooked in these studies.

Question # 4 LISELL-B Practices/Materials Shared by After LISELL Teachers Actor-Network.

In comparison to the abundance of data that provided evidence for the first three questions, evidence of sharing LISELL-B practices and materials proved to be the most elusive. All of the examples originated from the last After LISELL planning meeting and two of the After LISELL teachers (Alex and Kelly), during the second year of the After LISELL study. There were two occasions in which LISELL-B practices where shared within the After LISELL network (Implementation of LISELL-B Cheek Cell DNA investigation and implementation of talk moves; see next paragraph) and one where an After LISELL teacher shared talk moves with a teacher outside of the LISELL-B network. The Virtual videos could be argued to be also another way of the sharing the LISELL-B practices and materials with others outside of the After LISELL network through Alex’s Facebook network.

These data have optimistic implications for the After LISELL network. Law (2012), in uncharacteristic clarity (well sort of), lists some possible ways that an Actor-Network maintains itself. One of these is by enrolling allies and the other is by being fluid and having the ability to change shape, be flexible. Both of these attributes can be found within these data, which may pertain to the sustainability of LISELL-B practices and materials.

Summary

As a collection, the data from the After LISELL study shows that LISELL-B practices and materials were still busy doing work in the After LISELL network at Mountain Middle

school. Many research projects that study the effectiveness of teacher professional learning experiences are overly focused on fidelity of implementation or else depend on pre and post-tests to evaluate PL. The current study shows that much can be learned by using a range of ethnographic methods and Actor Network Theory. Data also provided evidence of adaptations of LISELL-B practices and materials, which would have escaped notice if the researcher had been focused on exact implementation of LISELL-B practices. The researcher argues that these data show that much is missed when taking such a narrow research focus. These data also illustrate the varied negotiations that LISELL-B practices and materials have to overcome to remain sustainable within a network. The LISELL-B practices and materials are not meant to be an immutable mobile that attempts to standardize classroom practice. Rather it is their ability to negotiate within networks, changing in response to the creative abilities or needs of other actors (such as by aligning with Mountain Middle's literacy push or NGSS standards) that allows the LISELL practices to survive in some form within these evolving networks.

Limitations

Ethnographic work normally is accompanied by years of detailed observations and fieldnotes where the researcher becomes immersed in their study (Marshall & Rossman, 2011). We knew that time, funding and distance were going to limit our ability to reach the lofty goals of an ethnographic case study, in that my dissertation needed be finished in a timely fashion, Actor-Networks are notoriously unstable, funding had dried up, and there was the hour-long drive to the After LISELL school and back. Hence, we borrowed from Latour (1986) and described this work as more of an "ethnographic" approach. The empirical evidence that showed LISELL-B practices and materials working, being adapted and shared within and without an After LISELL network, in the two years after the LISELL-B network was dissolved, is

suggestive of their sustainability. These findings were based on a small network of actors, a fraction of the networks that were a part of the original LISELL-B network. This, one could argue, limits its ability to conjure general effects. But Latour cautions against the general, the overarching, when describing the social, which is what spurred his interest and immersion into ANT (Latour, 2002)

Research using ANT can be messy (Law, 2012). Latour (2007) suggests that "everything is data: everything from the first phone call to a prospective interviewee" which can be problematic to the lone researcher who has managed to generate piles of data to analyze (p. 133).

While undertaking this After LISELL study, I underestimated the transient nature of the teachers within the various networks and the importance of the administration who controlled the addition/deletion of some of the After LISELL actors, specifically co-teachers, student teachers, professional learning within the school, the schools focus (literacy) and money (for lab/classroom materials and PL). I even found that negotiating entry into the school after the LISELL-B project was technically finished was becoming problematic especially with all the heightened security concerns due to recent school shootings. This limited the researcher to following just the actors contained in room 302. The researcher avoided interviewing the administration in order to draw less attention to the After LISELL study and the other actors involved. Whenever you enter a research project, you are going to illicit some kind of change; but much can be avoided with a little care.

Implications

The fact that in 2019, more than 200 years after the humble beginnings of the U.S. public school system, all 50 states still have a public-school network, is a testament to the

enduring importance that education holds for citizens, states and government. The complex diverse education system that resulted from these actors has proven to be highly resistant to overarching reforms that rely on governmental control and support. Both State and Federal government, school districts, think tanks (for example Learning Policy Institute, Brookings Institute, the Carnegie Foundation), business, professional organizations (the NSF, the National Academy of Science and AAAS) and now entrepreneurs like Bill Gates and Jeff Bezos (Molnar, 2018; Sawchuk, 2019) have spent an excessive amount of time and money trying to mold/make teachers fit into idealistic expectations of how teaching and learning in schools should be implemented/practiced.

As a result, teachers have been entangled in an endless array of reforms with differing objectives and goals that have resulted in for example: standards, evaluations, notions of rigor and inadequate professional development. Teachers are under constant evolutionary pressure to change and adapt to new educational reforms. But, rather than include teachers in professional learning, PL providers still cling to the idea that teachers need to be melded/fixed (Darling-Hammond, Hyler, & Gardner, Effective Teacher Professional Development, 2017).

Many different scholars have explored the connections between PL and its outcomes on teachers and students (Darling-Hammond et al. 2017; Yang, Liu, & Gardella Jr, 2018; Yoon et al. 2007). Even though they represent different paradigmatic perspectives (change in belief, policy, knowledge, student achievement and duration), these researchers all agree that PL is important (Covay Minor, Desimone, Caines Lee, & Hochberg, 2016; Kennedy, 2016). Yet, the variability in the effects from one study to another shows that we still don't know how PL practices can be sustained in the classroom (Kennedy, 2016; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007).

> We now have thousands of textbooks, handbooks, and journal articles that have secured *qualitative methodology* by repeating that structure in book after book with the same chapter headings so that we now believe it is true and real. *We've forgotten we made it up*. (St. Pierre, 2011, p. 613)

As St. Pierre alludes to in this quote, the qualitative methodologies that are deemed acceptable by the establishment are not on any more of a solid footing than the concepts presented by Latour, Callon and Law—they are all made up, they are all products of imagination. So why not see what these new concepts have to offer us in envisioning the world around us? The accepted tools/methods fail us when we begin to move away from the human centered and enter the realm of Bennett's Thing Power and Latour's Net-work assemblage which give us a way of thinking about things and the nonhuman. In her book *Vibrant Matter: A Political Ecology of Things*, Bennett (2010) warns that "without proficiency in this countercultural kind of perceiving, the world appears as if it consists only of active human subjects that confront passive objects and their law-governed mechanisms" (p. xiv). In reflecting with Bennett's (2010) warning on the empirical studies that I chose to review, and after doing this study, the sole focus on teachers in previous studies seems to have blinded the researchers to data that may have helped them answer their questions. These studies remind me of the Indian parable of *The Blind Men and the Elephant* (Baldwin, 2019) where each describes what an elephant is by the part they touch, where each study describes outcomes of PL by "touching" only teachers.

In their book *Actor-Network Theory in Education* (2010), Fenwick and Edwards argue that education is not stable and that you need a framework that is malleable, able to accommodate the messiness of education research-yet, give it some structure (but not stability)

and they found that Actor-Network fits. While the public-school classroom is widely accessible—most of us were students at one time—the researcher's job was to make the familiar unfamiliar like Latour and Woolgar (1986), who set out to make the science lab—we all assume scientists follow the scientific method in the lab—unfamiliar. That is, we take for granted what goes on in schools and the lab, but we really don't know how science is done in the lab and how practices are taken up by teachers—a black box of practice was what Callon and Latour would call it (1981). To begin to peer into this black box, I offer what insight this After LISELL study might have to offer.

Data herein show that much can be learned by using any one of the ethnographic methods used in this study to evaluate the sustainability of LISELL-B practices and materials in networks outside of their origin in a purposefully created PL learning network. Evidence from the After LISELL study shows that LISELL-B practices and materials were still busy doing work in the After LISELL network at Mountain Middle School.

Findings from this research study that have implications for future research are:

Interviews, observations (classroom, teacher planning meeting and virtual), teacher logs and artifacts (pictures & handouts) have promise in assessing the long-term effects of science teacher PL. Also, focusing on the material and following what activity it does draws focus away from centering the teachers in ways that can be useful.

Interviews, observations (teacher planning meetings), teacher logs, artifacts (handouts)and teachers themselves generated data that showed adaption of LISELL-B practices and materials.

Interviews, observations (teacher planning meetings) and teachers generated evidence of barriers that affected LISELL-B practices and materials.

Finally, observations from teacher planning meetings, teachers, and possibly virtual videos are sources of information that described or documented the sharing of LISELL-B practices and materials.

Implications for Researchers

Using ANT in tracing the effects that practices and materials had in the classroom networks of teachers that were co-creators of a professional learning network has helped me understand how teachers are actually an effect of the networks that they work in (Fenwick and Edwards, 2010). What is implied by the various studies in the literature that focus on professional learning as teacher agency is (in ANTish perspective), rather an effect of associations within the network. Thus, it makes better sense then to focus education research on how networks produce effects in classrooms and schools that modify engagement and learning. By focusing solely on teachers, research has removed the teacher from their context and treated them as sole representatives of learning in the classroom. This would be like trying to describe the whole space shuttle by just looking at its carburetor which can account for the variability in the results of many published studies. Work with ANT begins to challenge these types of assumptions and helps illustrate the complexity that characterize networks in education that are made up of both humans and things. It also gives the researcher a new way to describe these effects which consider agency of all actors and actants.

Implications for Teachers

Teachers can use this study as a way to help them pay more attention to how their own practices and materials generate knowledge as the students interact with them within the classroom. This ANTish method can help teachers identify what different actors and actants do within their classroom network as in what are the mediators, intermediaries, obligatory points of passage and

immutable mobiles. Teachers can become network builders and create alternative ways to evaluate how learning and teaching evolve in a classroom by considering agency of things such as textbooks, computers and talk moves when interacting with students.

Implications for Policy Makers, Curriculum and Assessment Designers

Unfortunately, ANT does not give us an easy three step framework to follow in evaluating the effects and sustainability of professional learning. Rather, it will result in insight into the complex and contextualized nature of learning and teaching but, the ethnographic work will have to be done. By applying ANT to education issues**,** policy makers, curriculum and assessment designers have a new perspective to better understand the success or failure of reforms, curriculum and assessments to provide the wanted changes in the classroom that conventional research has not been able to provide. Considering how polices, curriculum and assessments can themselves cause effects within education networks, can account for unintended effects. Some of these unintended effects like teachers changing students test answers or parents opting students out of mandated testing are just a few examples of the agency of things in education. Thus, ANTish perspective opens up questions that ask what is taken for granted? How do policies, curriculum and assessments effect the people and things that they come into contact within different education networks? How can we develop alternative policies, curriculum and assessments that consider the different educational contexts in which they end up?

Some may question the utility of working with such an amorphous method/theory, but I beg to differ and offer the following account. In 2014 Flint, Michigan changed their source of drinking water for the city. This event wouldn't have been unusual if not for the highly acidic nature of the water (19 times more acidic than other local sources) and the high lead content of

the city's aging water pipes. The combination of the corrosive acidic water with the lead pipes resulted in a contamination of the city's water. This lead contaminated water unknowingly consumed by many of the city's residents became a medical disaster as high levels of lead were measured in the blood of children. In a news article (Ganim & Tran, 2016), pediatrician Hanna-Attisha said:

> It's a well-known, potent neurotoxin. There're tons of evidence on what lead does to a child, and it is one of the most damning things that you can do to a population. It drops your IQ, it affects your behavior, it's been linked to criminality, it has multigenerational impacts. There is no safe level of lead in a child.

It is now three years later and the lead water crisis which started in Flint has begun to spread to other cities throughout the U.S. as researchers began testing water for lead. In a report published on lead content of drinking water sampled in 12 states, 44 % of schools tested had one or more water samples with a lead concentration at or above the state's action level (Cradock, et al., 2019). So, this researcher wondered how many teachers, schools, research projects were affected by high levels of lead in school drinking water. How many intervention policies were implemented in response to student non-achievement, which was attributed to "bad" teaching, parenting, curriculum, non-rigorous standards, teacher quality? How many corroded pipes and lead-tainted drinking water sources have altered children's ability to learn? An ANT study could have followed those traces if used as it was intended.

The highly fragmented nature of our education system, which has resulted in a multitude of contexts, dictates that we need to have many models of PL on our "education shelf" to address the many problems that such a system fosters. I borrowed this "educational shelf" analogy from a conversation that I had with a professor, after I began to question the efficacy of

researching the sustainability of PL when the likely outcome would be that an intervention would have no long-term effects. He noted that an education system is truly prepared for the future when it has a shelf full of models to choose from when the context is right; where a society with an empty "educational shelf" faces a bleak future. In consequence, this case study was undertaken not to solve a problem but rather to help fill the PL "educational shelf". But, there are still many questions to be asked. How will our LISELL-B practices fare if the After LISELL teachers leave the school? How can LISELL-B practices be further sustained in a world of increasing technology? What LISELL-B practices where still working in the other schools that were involved with the project? How did LISELL-B practices sustain themselves? Did they have to morph and adapt in other ways? What would PL look like if more of it chose to be informed by the non-traditional methods of the sociomaterial?

> *I woke up this morning thinking about how central computers are in the teaching work that Alex, Kelly and Charlie do-Computers are now central to:*
> *almost all of the communication in the school.*
> *all of the classroom planning.*
> *all of the students' records, test results and many of their classroom activities.*
> *all of the daily lessons begin with smartboards.*
> *the school's administration use classroom information and teacher planning notes to keep up with what teachers are doing.*
> *Many of the teachers' activities are centered around access to computers as well as state mandated testing. I can't even enter the school without going through a computer. I observed that every time Alex, Kelly and Charlie were planning or upgrading tests and classroom activities, they went straight to a web site— It's not just the ability to look up things but, to have access to science information, pictures and examples of how to do a science activity, much of which can be copied and added to a lesson in a few clicks. Teachers need instant access to information if they are going to use it.*

> *So herein lies the importance of a website for LISELL-B in order to maintain our LISELL-B network of information, practices and materials with our LISELLB teachers and possibly sustainability (not to mention recruitment of other teachers into the network).*

Future Recommendations for Professional Learning

This study has implications for the construction of PL and for the evaluation of PL sustainability. Data from the After LISELL study show that PL practices and materials do find their way into the classroom with varying amounts of fidelity. The end result of PL is that the practices that are modeled in the PL interact with teachers and students to result in learning. As Fenwick and Edwards (2010) point out, "ANT focuses not on what texts and other things mean, as in much qualitative research, but on what they do" (p. 8). Too much importance is placed on fidelity of implementation of practices learned in PL rather than what the practices do in the classroom/network. If PL focused on how practices and materials work in classrooms to help knowledge generation instead of focusing on increasing teachers' knowledge, PL outcomes may be more observable.

Providing High-Quality PL is just part of the equation. Each of the studies I reviewed in the literature took great pains in providing High-Quality PL for their teachers. The most in depth and elaborate PL occurred in a study by Clary et al. (2018). Still, the study outcomes were disappointing in that teachers did not retain information over time. Teachers were supposed to gain knowledge that could be passed to their students in a linear fashion. While ANT sees learning as not just human to human interaction but rather learning as something that happens within a network that includes an assemblage of things and actors (Fenwick & Edwards, 2010). But again, ANTish thinking would ask what makes PL High-Quality? Desimone (2011) offered a list of factors (content, active learning, coherence, adequate duration, and collective

participation) but they are human centered, mere tools, not things with agency that can be incorporated in networks to do something.

Assuming stability of networks is futile as is assuming stability of practices modeled in PL that are imbedded in them. Latour (2007) tells us that it takes work to keep networks together, therefore practices and methods that require exact implementation or are structured in a way to be non-flexible risk falling apart under the strains of different networks. The flexibility of the LISELL-B practices and materials allowed it to adapt to the networks that it was enrolled in. Also, in thinking about evaluation of PL, ethnographic methods like observation and interviews provide richer measures of enactment and sustainability of PL practices especially when networks change the PL practices in major ways.

Sustainability of PL networks depends on their ability to morph/change/adapt if they are going to be sustainable over time, especially as they move in and out of the various networks that make up our fragmented education field, the networks formed by reform and the networks of teachers, communities and material objects without which they would fall apart (Fenwick & Edwards, 2010). These data also illustrate the varied negotiations that LISELL-B practices and materials have to overcome to remain sustainable within a network and the importance of recognizing that changes are a healthy indication of practices at work. Evaluating the success of PL needs a richer set of qualitative methods rather than narrow pre-post test data to illuminate the sustainability of PL. Fiona King (2014) offered a framework that also gave a richer picture of evaluation of PL that included "system factors," which is a start in the ANTish direction.

Lastly, as stated earlier, networks are unstable and what endures is the associations (Latour, 2007). The metaphor that comes to mind is one that Rebecca Solnit (2016) offers. Is one of mushrooms that appear after a rain "as if from nowhere". This is due to a vast array of

fungal rhizomes that lay beneath the soil. “uprisings and revolutions are often considered to be spontaneous, but less visible long-term organizing and groundwork—or underground work—often laid the foundation” (p. xv). I see the LISELL-B actors that made up the now dispersed LISELL-B network as rhizomes imbedded in new networks that can re appear like mushrooms after a “good rain”.

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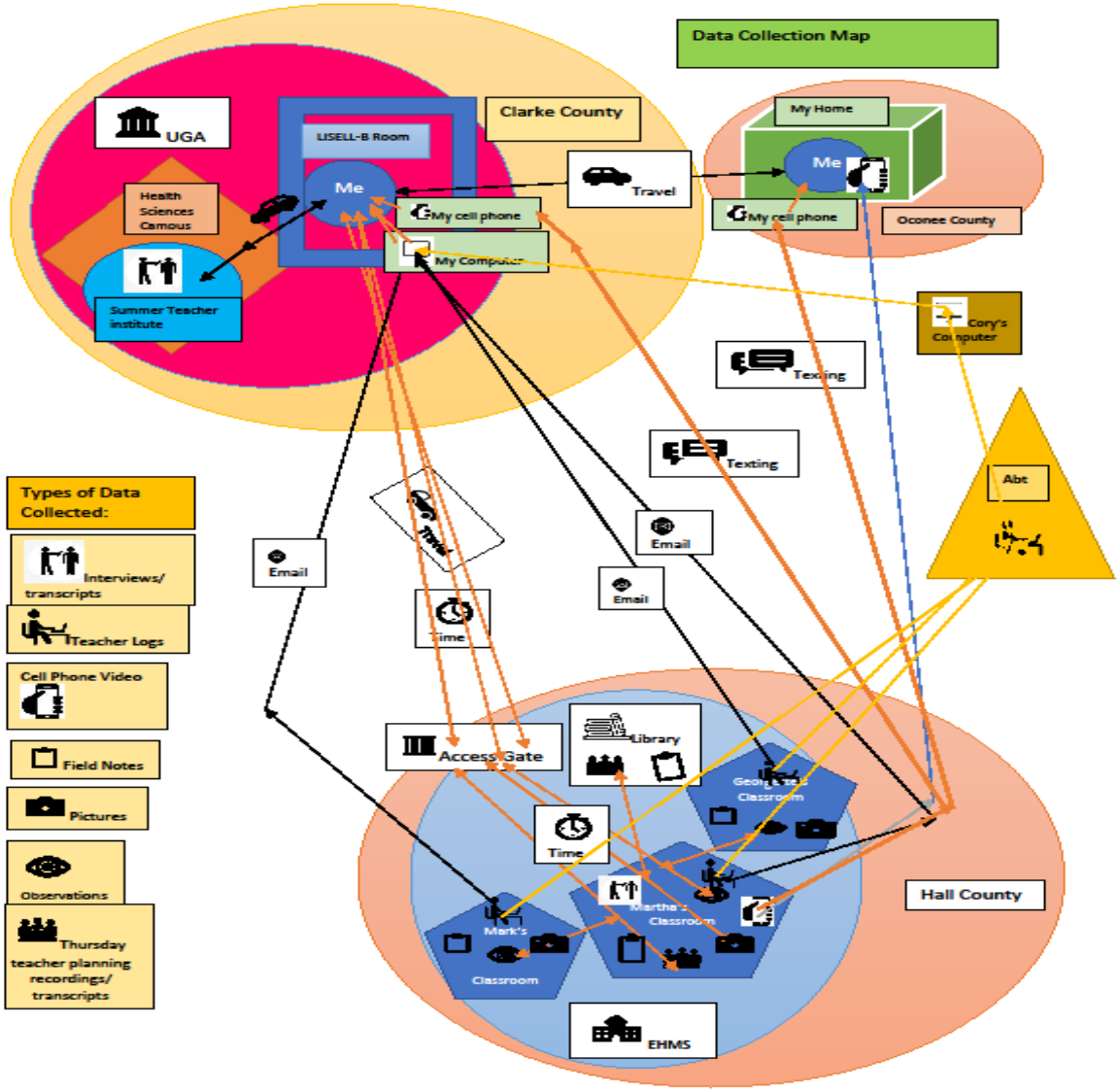
APPENDICES

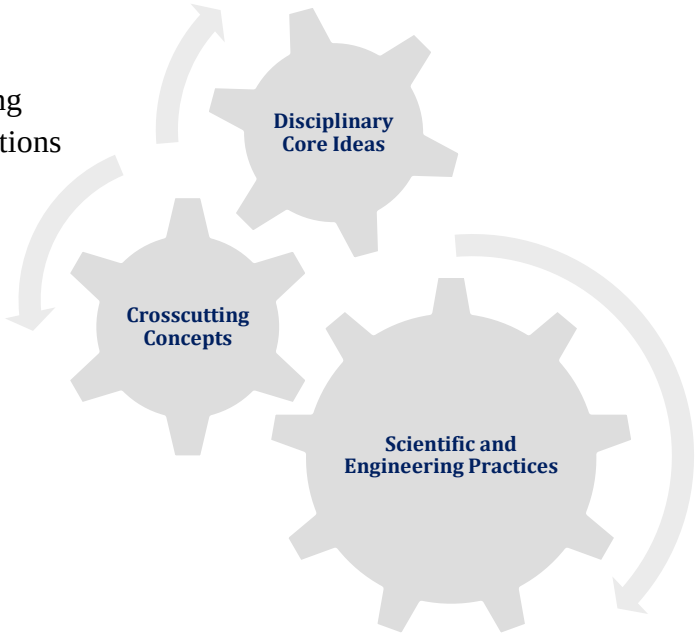
A. Data Collection Network



B. Three Dimensions of Science Learning

Scientific and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in arguments from evidence
8. Obtaining, evaluating, and communicating information



Crosscutting Concepts

- Patterns
- Cause and effect
- Scale proportion and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change

Disciplinary Core Ideas

- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Engineering, Technology, and the Applications of Science

SOURCE: National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

C. Articles that Mention Sustainability

Article	Date	PD	Outcomes	Theoretical Framework	Grade	Study
Laura M. Desimone, Andrew C. Porter, Michaeal S. Garet, Kwang Suk Yoon, & Beatrice F. Birman, *Effects of professional devlopment on teachers' instruction: Results from a three-year longitudinal study.*	2002	No measurement on student achievement but authors concluded that practice **should lead to long term student achievement.** Teachers that took PD that focused on teacher practice = increase in classroom use/practice. Evaluated the data from the Eisenhower Professional Development Program-looked at effective teaching practices.	Found great variation in PD & teaching practice-authors concluded due to within teacher variation. Schools do not have a coherent approach to PD	None was reported	Elementary and high school Mathematics and science teachers.	1 year after, 3 year-long study that looked at effects of PD in year 2 on instructional practices in year 3. Year 1 was used for baseline data. Collected survey data. 207 teachers in 30 schools.
Carla C. Johnson, Jane Butler Kahle, & Jamison D. Fargo, *A study of the effect of sustained , whole- school professional devlopment on student achievment.*	2007	Discovery Model School Initiative. Whole-school PD-sustained collaborative PD-2-week summer academy, monthly PD based on implementing science	There was a significant increase in student achievement in year 2 & 3. "Change in instructional practice requires time for it to be transferred effectively into practice" (p.10).	None was reported.	Middle school teachers	1 year after was year 4-Looked at year 2, 3 and 4. 11 teachers 100 hours of PD. Posttest-only, quasi-experimental, control group, interrupted-time series design. 282 students-Student achievement was assessed using the Discovery Inquiry Test (DIT).

		instruction for 3 years.	teacher collaborations sustained in year 4 even after all funding and project ended. "teachers were committed to collaborate extensively on their own time" (p.11). No measure of student achievement in year 4.			
Joseph P. Allen, Robert C. Pianta, Anne Gregory, Amori Yee Mikami, & Janetta Lun, *An interction-based approach to enhancing secondary school instruction and student achievment*	2011	My Teacher Partner-Secondary (MTP-S) is a web-mediated approach focused on improving teacher-student interactions in the classroom. 20 hours of in-service training spread across 13 months. Workshop, annotated video library and a year of professional coaching followed by a brief booster workshop. Teachers send in videos of their class sessions.	Substantial gains in student achievement= to moving the average student from the 50th to 59th percentile. But were only significant in the post intervention year. Teachers were still using the techniques after the study even though there weren't any gains in the first year. Hence teachers need time for change.	Teaching Through Interactions framework - emphasizes the extent to which student-teacher interactions influence student academic motivation, effort and achievement.	Secondary school teachers	Looked at during study and year after and after study. 78 teachers. Randomized control study. Used the Classroom Assessment Scoring System-Secondary (CLASS-S). Student state assessments were used as achievement markers.

Beatrice Avalos, *Teacher professional deevlopment in teaching and teacher education over ten years. (Chili)*	2011	Review of publications in Teaching and teacher education 2000-2010.	Complexities of teacher professional learning. Found nothing about sustainability. Teachers were still the "center of the process, teachers continue to be both the subjects and objects of learning and development" (p.17) Contexts were important.	None reported	Not applicable	Review
Barbara K. Sullivan-Watts, Barbara L. Nowicki, Minsuk K. Shim, & Betty J. Young, *Sustaining reform-based science teaching of preservice and inservice elementary school teachers*	2012	2 year-long PD program Guiding Education in Math and Science Network (GEMS-Net) based on commercial science curriculum and kits. Begun in 1998-funded by NSF Local Systemic Change program. Pre-service education students were assigned to inquiry-based classrooms.	There was a significant positive effect of multi-year access to the kit-based program on mentor teaching practice. Findings-most of mentor teachers reported no PD in science. In-service teachers were supported by PD for 10 years after NSF funding ran out. The kits fostered will to teach science in both pre-service and mentor teachers. Positive "kit effect" outside of teacher	None was reported	Elementary school teachers (K-6), none majored in science.	1 year after. 27 pre-service teachers and their mentors. Used rubric to score videotaped lessons along with an analysis software-StudioCode. Measures of content knowledge and interviews.

			mentor relationship. Generally, kits do not support discourse which leads to a lack of evidence and argument ability.			
Panayiotis Antoniou & Leonidas Kyriakides, *Adynamic integrated approach to teacher professional development: Impact and sustainabillity of the effects on improving teacher behaviour and student outcomes (Cyprus)*	2013	Dynamic Integrated Approach (DIA), 1 year of PD. Critical reflective approach and focus on teaching skills. Compared to Holistic approach-teachers reflected on whole spectrum of their practice-develop action plans without a specific focus.	Studied student achievement which increased with teacher PD. 1 year later, there were no differences-no loss and no gain with teacher skills. Did not measure student achievement in 2nd year. Teachers reported that they needed more time to prepare classes, leadership needed to support.	Educational Effectiveness research	Primary school math teachers	1 year after PD. Pre- and post- tests. Compared to holistic approach. 130 teachers split between two PD. 123 participated in follow-up.
Benjamin C. Herman & Michael P. Clough, *Teachers' longitudinal NOS understanding after having completed a science teacher education program.*	2014	One of a few science education programs that require pre-service science teachers to complete a course of study focused on NOS and NOS pedagogy (p.2)	Long lasting positive effects on NOS (Nature of Science). They did find that teachers did not do well with inventive character of science knowledge.	None was reported	Secondary school science teachers	2-5 years after PD, 13 teachers. Measured NOS views via pre- and post-test-coding of VOSTS responses.

Stefan Zehetmeler, *Sustaining and scaling up the impact of professional development programmes. (Austria)*	2015	Started in 1982, Austrian PFL profgramme-3 x 1-week seminars over 2 years. Workshops, input discussion, group work. Focused on networks, shared vision, mutual accountability. Focuses on fields of content, didactics & pedagogy.	Context was a large contributor – needed supportive leadership, shared vision. Provided different kinds of evidence, from different perspectives. One teacher bloomed the other did not.	Impact research & innovation research	Secondary math teachers	13 years after PD. A case study of 2 teachers. Document analysis, interviews, Used the impact of PD model and looked at Teachers, facilitators, program & context.
Birgitte Lund Nielsen, *QUEST for sustainable CPD: Scaffolding science teachers' individual and collaborative inquiries. (Denmark)*	2015	QUEST-a long-term collaborative PD with two phases: Implementation & Institutionalization. No sustainability data. Factors potentially supporting sustainability: Continually scaffolding teacher's collaborative inquiries, Research to practice-concrete tools & supporting	Large amount of variability between schools studied.	Bandura-personal and social change are complimentary.	Not reported	Mixed Methods, 42 schools, Science teacher surveys & observations.

		teacher's enactment.				
Judith Haymore Sandholtz & Cathy Ringstaff, *The influence of contextual factors on the sustainability of professional development outcomes.*	2016	Three-year science professional development.	Reported that Context was a key factor across the cases- principal support, ongoing support, resources, collegial support, personal commitment, external factors	Operational Theory- PD influences teacher's instructional practices	Elementary-K-2	2-3 years after PD, 5 x Case studies; Interviews were coded.
Martin Dodman, *Researching the sustainability of teacher professional development (Italy)*	2016	Explored a possible theoretical framework for researching the sustainability of teacher PD. Resilience & transformability	N/A	The capacity for a system to reproduce itself - Autopoiesis, Maturana & Varela	N/A	Theoretical paper Used force-field analysis: Human potential + wellbeing=person environment
Dina Drits-Esser, Julie Gess-Newsome, & Louisa A. Stark, *Examining the sustainability of teacher learning following a year-long science professional devlopment programme for inservice primary school teachers.*	2017	1 Year PD Physical Science Inquiry Academy- implemented inquiry-based science PD. 3-day summer academy taught the 5 E instructional model. Goal was to assesses the impact of PD on teacher adoption of reforms and the sustainability of these changes.	Looked at Inquiry practice, Inquiry belief, physical science content and physical science knowledge. All teachers changed with significant increase in 1st year. 2nd year, only knowledge changed, and adoption of practices was partial. Teachers learn on the job. School level and teacher level	The inquiry approach	Primary school teachers	1 year after 2-yearlong study-15 teachers, 88 hours-medium length PD=mixed methods study.

			factors were examined. Teachers readiness to change beliefs was #1 factor followed by Supportive peers, mentor and principal's priority on science and easy access to training in use of materials.1 year not enough to =comprehensive change in teachers practices and belief.			
Lisa Gaikhorst, Jos J.J. Beishuizen, Bonne J.H. Zijlstra, & Monique L.L. Volman, *The sustainability of a teacher professional development progrmme for beginning urban teachers. (Netherlands)*	2017	1-year PD. Investigated the long-term effects of PD and which characteristics and activities in school organizations contributed to sustainability. Professional Learning Community (PLC)- the Mastery program-to increase quality and retention of teachers. Focused on 4 modules: cultural	A significant long-term effect was found on teachers' competences and professional orientation. Open school culture was important factor for sustainability. The PD increased teacher's long-term knowledge & professional orientation but not short-term effects.	Not reported	N/A	1 year after study. A quasi-experimental design study with a control group. Quasi-experimental design. Interviewed teachers and principals (19). Used a knowledge test and questionnaires.

		diversity, language differences, cooperating within the school environment and ensuring safety. Group meetings, classroom application & lectures. Met once every two weeks for 4 hours over 12 months.				

D. After LISELL-B Log

Part A. Science Activities.

A-1-Thinking about this last week, did students in your classroom have opportunities to Coordinate hypothesis, observations and evidence by.... (check all that apply).

1. Stating their expectations based on prior experiences and knowledge (hypothesis)?
2. Using their senses and tools to make targeted observations and collect data?
3. Selecting appropriate observations to serve as evidence to evaluate their hypothesis?

A-2-Did any of your students have opportunities to learn about controlling variables by.... (check all that apply).

4. Identifying variables in science (anything that can change during an observation or experiment)?
5. Distinguishing between independent variables, dependent variables, and controlled variables (constants) when designing an investigation or discussing the investigations of others?

A-3 Did any of the students in your classroom have opportunities to explain cause and effect relationships by... (check all that apply).

6. Identifying cause and effect relationships (where one event, the cause, brings about another event, the effect, through some mechanisms or process)?
7. Describing key mechanisms or processes that relate to the cause and effect relationship?

A-4 Did any of the students in your classroom have opportunities to use models to construct scientific explanations and test engineering designs by... (check all that apply).

8. Using one or more types of models (e.g., physical, drawn, simulation, mathematical) to explain scientific concepts?
9. Using one or more types of models to test and improve designs?

A-5 Did any of the students in your class have opportunities to develop general academic vocabulary in context by... (check all that apply)

10. Using general academic vocabulary (non-science) orally to support meaningful explanation of science concepts or practice?
11. Using general academic vocabulary in writing to support meaningful explanation of science concepts or practices?

A-6 Lastly, did any of your students have opportunities to own the academic language of science by... (check all that apply).

12. Translating scientific language into everyday language or vice versa?
13. Breaking down the technical nature of scientific vocabulary through roots, prefixes and suffixes?
14. Translating dense, abstract, or depersonalized science text into more active personalized text, or vice versa?

Part B. Resources used during the science activities.

B-1 Please answer the following questions that pertain to activities that you recorded in Part A. above.

Graphic organizers (e.g., Venn diagrams, thinking maps, KWL charts)
Lab forms or format for doing investigations (e.g., specific lab investigation format, lab notes templates)
Reading for developing science understandings (e.g., magazines, language boosters, online resources)
Vocabulary instructional materials (e.g., physical or virtual flashcards, word cards, glossaries)
Physical models and manipulatives (e.g., "hands-on" physical materials, investigation kits, lab equipment)
None of the above

Part C. Technology

C-1 Did students use any of the following types of technology while doing science activities in your classroom? (check all that apply).

- *Computer animation or online video* (e.g., Brainpop)
- *Digital physical lab equipment* (e.g., probeware, data collection devices)
- *Online reading or information gathering* (e.g., webquest, virtual text)
- *Online writing/reporting* (e.g., virtual notebook, EdMoto, Google docs)
- *Online or digital games/learning aids* (e.g., Quizlet, Gizmos, Kahoot)
- *Data visualization software* (e.g., online graphing, excel)
- *Online assessment softwar*e (e.g., USATestPrep)
- *None of the above*

Answers
Never
A Little (1-10% of time)
Some (11-50% of time)
A lot (51-100% of time)

Part D. Talking about, reading about & writing about the science activities.

Rate the amount of time that your students talked about, read about & wrote about science activities.

- How often did students have the chance to talk about science activities throughout the week?
- *Students engaged in paired student-student talk?*

- *Students engaged in group (3-7 students) talk?*
- *How often did students have the chance to read about science activities throughout the week?*
- *Students read silently in class?*
- *Students took turns reading aloud for whole class?*
- *Students read & discussed with each other?*
- *How often did students have the chance to write about science activities?*
- *Students took notes from a teacher presentation or lecture?*
- *Students wrote about activities individually?*
- *Students wrote about activities in pairs or groups?*

Answers
Never
A Little (1-10% of time)
Some (11-50% of time)
A lot (51-100% of time)

Part E. Did you use any labs?

What lab/s did you do with your class this week and were any of them LISELL-B labs? If you used a LISELL-B kit, did you modify it in any way to meet your needs?

Part F. Teacher collaboration

Please describe any collaborative work that you did with the other teachers this week. Where you part of any professional development this week? If yes, please describe.

E. After LISELL Associations Map