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Why and how teachers transform their instruction

Barbara J. Light

Why and How Teachers Transform Their Instruction

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Barbara J. Light

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Dissertation Committee:

Ronald Williamson, EdD, Chair

David Anderson, EdD

Theresa Saunders, EdD

Virginia Harder, PhD

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Dedication

Without each of the following in my life, my dissertation would have never been started or finished:

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Abstract

In his 2011 book *The highly qualified teacher: What is teacher quality and how do we measure it?* Strong argues that as a profession, education has struggled to measure teacher quality and therefore cannot provide a proven system to consistently develop high-quality teachers. In order to move toward an operational definition of teacher quality, Kennedy, in her 2008 journal article entitled "Contributions of qualitative research to research on teacher qualifications" suggests that the causal mechanisms of the development of teachers who are identified as high-quality teachers must be researched, documented, and then used in teacher preparation and development. Instructional ability is a key component of teacher effectiveness. This case study examines instructional transformations made by four teachers to explore why and how teachers make transformations in their teaching. The overarching conclusion of the study is the importance of student-centeredness as a component of teacher effectiveness.

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Chapter 1:

Introduction and Background

Starting Point

Despite the focus on and importance of the concept of teacher quality, the field of education has struggled to define "teacher quality." In writing an editorial piece for *Education Week*, Fryshman (2014, para. 2) notes that "We are choking on data, but there are few if any properly validated experiments, and therefore no real knowledge" about what constitutes quality teaching. Seasoned educational leaders may know quality teaching when they see it and recognize poor teaching when they see it, but identifying it and operationally defining it are two different things (Strong, 2011). One barrier to establishing an operational definition of teacher quality and actual measurement of teacher quality is the complexity of teaching (Strong, 2011); however, instruction is the one skill that all high-quality teachers have (Brophy, 1986). This research study is an examination of the development of instructional ability in teachers through the lens of why and how the teachers make transformations in their instruction.

The National Center for Education Statistics estimates that in 2012 there were 3.7 million teachers, measured in full-time equivalents, in the United States (National Center for Educational Statistics, 2015b) and that in 2014 there were nearly 55 million students enrolled in kindergarten through twelfth grade in the United States (National Center for Educational Statistics, 2015a). The teaching and learning of teachers is an important component to the ongoing research work in teacher quality (National Research Council, 2000), which has become, or perhaps always has been, a political policy issue and research focus in education. During his first campaign for president, Barack Obama (2008) said,

> From the moment our children step into a classroom, the single most important factor determining their achievement is not the color of their skin or where they come from; it's not who their parents are or how much money they have. It's who their teacher is.

President Bush's educational reform efforts with the No Child Left Behind Act (2002) required teachers to be highly qualified.

Clearly, teacher quality is a topic worthy of such attention. In a summative report on teacher evaluation, Mead, Rotherham, and Brown (2012) state that "research shows that teachers affect student achievement more than any other within-school factor. Decades of inattention to teacher performance have been detrimental to students, teachers, and the credibility of the teaching profession" (p.3). However, Fenstermacher and Richardson (2000) note that teacher quality is a focus:

> Given the elusive and contested nature of quality, is there any sure way to tease out the characteristics and properties of quality teaching? A simple answer is that there must be, for so many of us appear to be deeply engaged in doing it. (p.2)

Fourteen states publically report teacher effectiveness information (Hull, 2013). Twenty-three states require at least 50% of teacher evaluation to be based upon one or more measures of student achievement (Hull, 2013). Hull (2013) describes two uses of student achievement data in teacher evaluation. Student growth percentile is a measure of how much growth a student has made in comparison to other students (Hull, 2013), but it does not isolate the impact a single teacher has on student growth (Baker, Oluwole, & Green, 2013). The value-added model does attempt to isolate the effect of the teacher from other variables, but it uses complex, and therefore potentially cost-prohibitive and poorly-understood, statistics that require multiple years of student achievement data (Hull, 2013).

Statement of the Problem

The quality of teaching has a significant impact on student learning (Brophy, 1986). Research studies have shown that the quality of teaching varies such that some individuals' teaching results in more student learning than that of other individuals (Brophy, 1986). As a profession, education has struggled to measure teacher quality and therefore cannot provide a proven system to consistently develop high-quality teachers (Strong, 2011). In order to move toward an operational definition of teacher quality, Kennedy (2008) suggests that the causal mechanisms of the development of teachers who are identified as high-quality teachers must be researched, documented, and then used in teacher preparation and development. Kennedy further notes that qualitative analysis into causal mechanisms is a gap in the existing body of teacher quality research.

The study is a qualitative, multiple case study (Yin, 2014) to examine the instructional component of teaching by delving into why and how teachers make significant changes in their instructional practices. Questioning teachers about their own perceptions of their instruction, why they might invest resources into learning new instructional strategies, and how they learn to transform their own instruction is the nucleus of this study. The data are descriptions of teacher learning, from their own perspectives and in their own voices, with specific attention to patterns that emerged across the multiple teachers in the study.

Purpose of the Study

The purpose of the study is to examine the development of instructional ability in teachers. The research is an exploration of the mechanisms behind teacher learning in the area of instruction and, as an exploration, was designed as a qualitative, multiple case study (Yin, 2014). While the study was not designed to provide an operational definition of teacher quality, the

work provides new postulations from the teacher viewpoint meriting future study, which could and should contribute to authentic progress toward an operational definition of teacher quality.

Research Questions

The following research questions were used to guide the study:

- Research Question 1: Why do teachers transform their instruction?
    - Subquestion 1a: Is there a pattern of events or experiences that typically lead to teachers transforming their instruction?
    - Subquestion 1b: How does student learning factor into the decision by teachers to transform their instruction?
    - Subquestion 1c: How do the reasons that these teachers transformed their instruction illustrate or fit with the conceptual framework of the study?
- Research Question 2: How do teachers transform their instruction?
    - Subquestion 2a: Is there a pattern of events or experiences that teachers use in learning new instructional techniques on the way to transforming their instruction?
    - Subquestion 2b: How do teachers describe their own instruction and the transformation of instruction?
    - Subquestion 2c: How does the transformation process illustrate or fit with the conceptual framework of this study?

The conceptual framework used as the lens for investigating the research questions is formed from the principles of brain-based learning theory (Leamnson, 2000), metacognition (Flavell, 1979), adult learning theory (Knowles, Holton, & Swanson, 2005), and self-efficacy theory (Bandura, 1977).

Research Design

The study employed a multiple case, qualitative methodology (Yin, 2014). The cases were four teachers who taught middle (Grades 6, 7, and/or 8) and/or high school (Grades 9, 10, 11, and/or 12) math and/or science. The data collection included two interviews with each teacher and at least one classroom observation of each interviewed teacher. The interviews focused on specific instructional transformations, chosen and previously implemented by the teacher. The focus of the first interview was why they transformed their instruction and the focus of the second interview was how they transformed their instruction. In some cases both interviews were completed in one session. Interview data was recorded in audio format and transcribed by the researcher. The classroom observation(s) of the teacher performing the transformed instruction took place after the interviews and generated data in the form of field notes. More than one observation was done if the first observation produced inadequate data. The teacher was asked some post-observation interview questions if necessary to clarify any confusion.

The data analysis involved descriptive coding procedures, as described by Miles, Huberman, and Saldaña (2014), applied to both interview transcripts and field notes. Additionally, jotting, analytic memoing, and writing assumptions/propositions were performed as described by Miles et al.

Setting and Subjects

The research setting is the various public schools, including charter schools, in the Eastern Upper Peninsula of Michigan. The Eastern Upper Peninsula Intermediate School District (EUPISD) is the regional educational service provider for the school districts. The area is rural, covering approximately 4,000 square miles with schools providing educational services to about

7,500 students (EUPISD, 2014). Most of the school districts are small and house kindergarten through twelfth grade in one building; however, one larger district has three elementary schools, one middle school, and two high schools, each in a separate building. There are fourteen public school districts, four charter schools, and two private schools in the region. Two of the charter schools, two of the public schools, and one private school do not provide services to high school students.

The research subjects were secondary math and science teachers who volunteered to participate in the study. The study focused on secondary math and science teachers due to the researcher's expertise in these areas. The research participants were required to be able to identify a manner in which they transformed their instruction at some time in their career, be willing to discuss the transformation process, and be willing to demonstrate the transformed instruction in class.

Limitations and Delimitations

Simon (2011) explains that limitations in research work are weaknesses that are essentially out of the control of the researcher. The limitations for this study include time, how the sample is obtained, the philosophical paradigm of the researcher, and the knowledge of the researcher related to the content of the study. The researcher lives in a specific area, is employed full time, and does not have time to travel extensively to collect data, so the research participants represent a convenience sample. The researcher asked the teachers to volunteer since she has no power or desire to require their participation. The teachers who volunteered may be more interested in or comfortable with their instructional abilities. The research participants also worked for a school administrator who gave permission for his teachers to be involved in the study. The researcher has a post-positivist worldview (Cresswell, 2009; Guba & Lincoln, 1994)

and designed the work from that perspective. As an instrument of data collection and analysis, the experiences and abilities of the researcher are limitations to the work. The teachers and the researcher all have busy schedules, so time for interviews and observations was a limiting factor. Each observation was a snapshot of an instructional transformation, which may have limited the researcher's ability to comprehensively capture the learning the teacher has done.

The decisions made by the researcher create delimitations on the research (Simon, 2011). Every decision made by the researcher defined the scope of the work and therefore established limits on, or delimited, the research. The researcher specifically attempted to set the demarcations and justify the decisions for the delimitations. Most of the boundaries were structured to strengthen the work by aligning the research questions, participant selection, data collection, and data analysis so that the study investigated what the researcher aspired to learn. These delimitations include using research participants who are all current secondary math or science teachers and allowing the research participants to choose the instructional transformation they wished to share with the researcher. The decision to perform a qualitative multiple case study is a delimitation, as are the choice of the research questions, the conceptual framework, the research protocols, and even the decision to investigate instructional transformation over other aspects of teacher quality.

Definitions

- The term "**quality**," whether used to describe the teaching or the teacher, refers to the level of excellence of the teaching or teacher.
- "**Instruction**" is defined as an interaction between someone who knows something (the teacher) and wishes to impart that knowledge to someone else (the learner). In education, it is often implicitly understood that in order for instruction to occur, the learner must

learn the new knowledge and that the degree to which the learner understands the new knowledge is a measure of instructional effectiveness.

- "**Instructional transformation**" is defined as any change intended to alter the learning experience for the student. Instructional transformations may be in the form of changing the way the student engages with content or in the way the learner engages with the teacher.
- "**Engagement**" is used with two meanings in this study. **Content engagement** is defined for this study as students actively working on learning the academic content intended by the teacher. The engagement is with the content itself. **Personal engagement** is defined as a student interacting in a positive manner with the teacher, or others, in the learning environment. The engagement is with the teacher as a person.

Summary

This chapter introduced the study of why teachers choose to change their instructional practices and the mechanisms of how teachers accomplish instructional transformations. The project developed out of an interest in the topic of teacher quality and the recognition of the lack of an operational definition for the term "teacher quality" (Strong, 2011). However, the study was designed to specifically focus only on the instructional component of teacher quality. The aspiration to understand the mechanism of instructional transformation dictated a qualitative approach to the study (Kennedy, 2008). Chapter 2 reviews the literature that supports the study, Chapter 3 describes the research methodology of the study, Chapter 4 presents the data captured by the research work, and Chapter 5 discusses the data and ramifications of the work.

Chapter 2:

Review of the Literature

Introduction

Miles et al. (2014) describe the conceptual framework as the "current version of the researcher's map of the territory being investigated" (p.20). They note that the conceptual framework explains the key factors in the study and the relationships between those key factors. The National Research Council (2000) begins their treatise *How People Learn: Brain, Mind, Experience, and School* with, "The essence of matter, the origins of the universe, the nature of the human mind—these are the profound questions that have engaged thinkers through the centuries." As one of the profound questions of humankind, how people learn has been extensively investigated over a long period of time and therefore the topic has spawned an abundance of learning theories. Since the conceptual framework can only be as complete as the researcher's current understanding and learning theories abound, a review of the literature was done to enhance both the researcher's understanding and the conceptual framework. The key factors that have been identified for this study are listed below with a brief explanation regarding their inclusion:

1. brain-based learning theory (Leamnson, 2000); the biological process of learning is foundational to any study of human learning.
2. metacognition (Flavell, 1979); the understanding teachers have of their own thought processes may address why teachers transform instruction.
3. adult learning theory (Knowles et al., 2005); the principles of how adults learn involve empowering people to take control of their own learning and may be at the center of the instructional transformations teachers accomplish.

4. self-efficacy theory (Bandura, 1977); the belief teachers have about their own abilities to change their instruction may be an important piece of the decision to change.

These constructs represent various elements of internal thought and each has been proclaimed as necessary for, or at least important to, learning. Bandura (1977) demonstrated the strength of self-efficacy as a predictor of behavior change. Flavell (1979) wrote that "Investigators have recently concluded that metacognition plays an important role in oral communication of information, oral persuasion, oral comprehension, reading comprehension, writing, language acquisition, attention, memory, problem solving, social cognition, and, various types of self-control and self-instruction" (p. 906) Brain-based learning theory (Leamnson, 2000) uses the current understanding of the biology of neuroscience to explain how learning occurs. Each of these theories expound thinking processes that are completely internal. Adult learning theory (Knowles et al., 2005) links the internal and external by connecting external stimuli with the internal thinking process.

Certainly, there are other powerful theories that could form the conceptual framework for this study. For example, Tough's (1977) self-directed learning theory, Mezirow's (1996) transformational learning theory, Schön's (1983) reflective practice theory, and Kolb's (1984) experiential learning theory are all important and relevant theories to this study. Including every relevant theory would create a cumbersome conceptual framework. Therefore, the researcher assembled the conceptual framework based on her own interests and knowledge of these theories. As noted by Miles et al. (2014), the conceptual framework in a qualitative study will be refined as the study itself progresses and changes the "researcher's map of the territory" (p. 20). Additionally, this chapter uses the established literature to explain the researcher's decisions

regarding the post-positivist philosophical viewpoint for the study, the selection of a qualitative approach, and the choice of a multiple case, causally-focused study.

Brain-Based Learning Theory

A theoretical understanding of how people learn is foundational to understanding how teachers transform their instructional abilities. Learning is an individual biological process and the act of learning involves brain chemicals and neural pathways (Leamnson, 2000). The brain is composed of neurons, and it functions when neurons send electrochemical messages, which are received by other neurons. Neurons in the brain of an infant reach out in all directions and do not appear to be genetically controlled to establish specific networks (Leamnson, 2000). Changeux, as quoted in Leamnson (2000), uses the term "exuberant" to describe the postnatal growth of neurons. A new experience establishes a neural pathway within the brain. During infancy, when practically every experience is novel, the brain is constantly forging new pathways. If the newly established pathway is not reinforced by repeating the experience, it will not stabilize and will simply disappear. For example, if the infant is picked up and cuddled each time s/he cries, the neural pathway that connects crying with attention will be reinforced and stabilized. For learning to occur, the nascent pathway must become stabilized through repeated use (Leamnson, 2000).

As a biological process, genetics can impact learning. Giedd et al. (1999) published a study about the plasticity and synaptic pruning of the human brain. They performed a longitudinal study of children in which the children had functional magnetic resonance imaging tests done on cross sections of their brains at four year intervals from ages 4 through 20. The pre-adolescent and post-adolescent images showed the most significant reorganization of gray and white matter in the brains of participants. Thus, the process of human development, which is

genetically controlled, can alter brain function. Konrad, Firk, and Uhlhaas (2013) used the work of Giedd et al. and others to suggest a brain-based explanation for the increase in risk-taking behaviors during adolescence. They conclude that the plasticity and synaptic pruning needed for extensive reorganization of the brain during adolescence, which is believed necessary for intellectual and emotional development, "permits environmental influences to exert particularly strong effects on cortical circuitry" (p. 425).

Environmental factors, including education, have been shown to impact learning in the brain. Educators essentially alter the brain chemistry and neural networks of others. Ostrosky-Solis, Garcia, and Perez (2004) performed electrophysiological brain scans on test subjects to show that the brains of literate adults activate differently than the brains of illiterate adults. They concluded that learning to read and write changes the functioning of the brain.

Metacognition Theory

The second critical construct in the conceptual framework the researcher must understand is how people understand their own learning process, which is metacognition theory. Metacognition is the knowledge and regulation of one's own thought processes (Helms-Lorenz & Jacobse, 2008). John Flavell was the first to use the term "metacognition" (Baker, 2009), but the concept is found in the work of educational theorists Jean Piaget and Lev Vygotsky (Baker, 2009). Cooper, Stewart, and Moulding (2007) note that most of the research into metacognition has been done with children and very few studies have examined the metacognition of adults. Metacognition has two aspects: knowledge about cognition and regulation of cognition (Helms-Lorenz & Jacobse, 2008). Knowledge about cognition, or how learning works, was described by Flavell (1979):

> Metacognitive knowledge is that segment of your (a child's, an adult's) stored world knowledge that has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences. An example would be a child's acquired belief that unlike many of her friends, she is better at arithmetic than at spelling. (p. 906)

Examples of potential metacognitive knowledge in this study may be related either to the teachers understanding of how they themselves learn or to the teachers' students, as in the teachers understanding how their students learn. An illustration of the teacher demonstrating metacognition about their own learning would be the teacher explaining that s/he had difficulty learning the rules of grammar, perhaps despite enjoying creative writing and liking English class, and even today has difficulty remembering a few specific grammar rules. The teacher might discuss how they always look up the rules they have trouble remembering or how they stick to the examples in the teacher's book for the lesson covering those specific rules. In any of these acts, the teacher is recognizing their own metacognitive knowledge.

Educators may extend their own metacognitive thinking and use it to help instruct students. Someone who had difficulty in learning the rules of grammar may have used some specific strategies or identified common pitfalls in their own learning process that will help students in learning the same material. The act of using learning strategies is the second aspect of metacognition, the regulation of cognition. It is important to note that the Helms-Lorenz and Jacobse (2008) definition specifically stated "one's own" thought processes. Therefore, the regulation of cognition must be done to one's own cognition. Teachers regulate their own thought processes when they recognize a lack of understanding and need to seek out more information, when they employ learning strategies like mnemonic devices in their own attempts to learn, when they connect their own current learning to their previous knowledge or

experience, and when they transfer knowledge to new situations (Dawson, 2008). Teachers can also teach metacognitive strategies to their students (Paris & Winograd, n.d.).

Metacognitive understanding of one's own learning beliefs could be an important aspect of why and how teachers make transformations. For example, Dweck (2008) introduced mindset theory with:

> In this book, you'll learn how a simple belief about yourself – a belief we discovered in our research – guides a large part of your life. In fact, it permeates every aspect of your life. Much of what you think of as your personality actually grows out of this "mindset" (p. ix).

Dweck then writes about a fixed mindset, which is characterized by a belief that abilities are set and cannot be changed and also by a strong tendency to compare one's own abilities with others as a way to validate the abilities, versus a growth mindset, which is characterized by a belief that abilities are developed through dedication and effort and that life is full of opportunities to grow and improve. Teachers with fixed mindsets might believe that they are great at explaining concepts to students because that is simply a talent they have and the reason that they know they are great is because they are better than all the other teachers at the school in explaining concepts to students. In contrast, teachers with growth mindsets would not value comparisons with other teachers' abilities, but would view themselves on a journey to become the best teacher they can be. The teachers with the growth mindsets would also see each lesson they taught as an opportunity to improve their own teaching with the understanding that effort can make them a more effective teacher. Understanding the impact of mindset on teacher development may be an important factor, and furthermore, understanding one's own mindset in terms of impact on learning may be a critical metacognitive piece for teacher development.

Adult Learning Theory

Learning theory, as a field of study, focuses on creating the best environment for learning to occur. The participants in this study will all be working adults. Therefore, adult learning theory, which is also known as andragogy, provides a structure for understanding how adults learn new information and skills. The structure can be used to design professional development and job training for adults or to better understand how adults learn from their experiences. Knowles, Holton, and Swanson (2005) attribute the strength of adult learning theory to its ability to "apply to all adult learning situations" (p. 2).

In 1973, Malcolm Knowles wrote *The Adult Learner*. The sixth edition is subtitled "The Definitive Classic in Adult Education and Human Resource Development." He advanced principles of andragogy that are collectively known as adult learning theory (Knowles et al., 2005). The six principles are the learner's need to know, self-concept of the learner, prior experience of the learner, readiness to learn, orientation to learning, and motivation to learn (Knowles et al., 2005). The following paragraphs about the six principles summarize Knowles et al. (2005) and provide an educational context that showcases each principle.

Learner need to know. Adult learners commonly question why they need to know something prior to learning about it. When adults see an opportunity to improve their quality of life by learning, they become willing, and even highly motivated, learners (Knowles et al., 2005). A common example in education is learning classroom management as a teacher. Many novice teachers have been given opportunities to learn about classroom management through assigned readings for university courses, discussions in university classes, and student teaching. Yet, until that novice teacher gets his own classroom, he may not see the necessity of establishing his authority as the teacher and learning to manage the classroom both in terms of student behaviors

and student learning. “Why do I need to know this?” is a valid and important question to adult learners (Knowles et al., 2005).

Learner self-concept. Self-concept often greatly impacts adults in learning. Adults are problem solvers in their daily lives, and they have control over much of their time and resources (Knowles et al., 2005). For example, parents constantly make decisions about how to raise their children, when their children need to go to the doctor, stay home from school, play outside, watch TV, go to bed, etc. They have often developed effective strategies for putting children to bed. Adults choose for themselves what they will eat, what type of car they will buy, and so on. Adults see themselves as self-directed decision makers in their daily lives. Therefore, adults resist efforts from others to get them to relinquish their self-directedness (Knowles et al., 2005). In education, outside consultants who come in to work with teachers may be unsuccessful in prompting change if they do not attend to the need of the teachers to be self-directed problem solvers. Grassroots efforts by teachers to change school climate or improve student learning are the products of the teachers’ self-concept as self-directed problem solvers and therefore can be more successful than administrator induced initiatives.

Learner prior experience. The third principle of Knowles’ adult learning theory is using the prior experience of the learner. Adults bring a cognitive treasure trove of experiences to any learning situation (Knowles et al., 2005). Additionally, adults typically feel that their lifetime experiences define who they are as a person (Knowles et al., 2005). An effective instructional strategy for teaching adults is to encourage the learners to connect their current learning to their prior experiences. Given the variety of learning experiences among adults, the instructor should expect diverse variability in the manner the adult learners connect current learning to past experiences, but the array of connections themselves can provide for rich discussion and even

learning (Knowles et al., 2005). Professional development workshops for teachers that include opportunities for participants to share their ideas with small groups allow the adult learners to connect their own experiences to new information and allow them to establish who they are as a person and an educator by sharing their own experiences. Without the opportunity to connect new material to past experiences, adult learners can feel that the instructor devalues not only their experiences, but who they are as a person since their identity is steeped in those experiences (Knowles et al., 2005).

Learner readiness to learn. Readiness to learn is the fourth principle of adult learning theory. Adults are most ready to learn when they understand the learning is in preparation of an upcoming circumstance or current circumstance they face. Knowles et al. (2005) use the example of a woman who is only mildly interested in infant nutrition until she becomes pregnant, at which point, she is ready to learn about infant nutrition. Matching the timeliness of the learning to the life circumstances of the learner increases the readiness to learn. Teachers will invest time in their own learning when they know they will be changing curriculums. For example, a third grade teacher is somewhat interested in the second and fourth grade curriculums, but probably spends little time investigating the kindergarten or sixth grade curriculum standards. However, if that same teacher is reassigned to kindergarten, he is ready to learn about the kindergarten curriculum standards.

Learner orientation to learning. The next principle is orientation to learning. Most adults are application oriented and therefore benefit from assignments that require application of the new information. Knowles et al. (2005) describe a change in university extension courses in the 1950s. During the day, the course would be taught as “Composition I” to high school students. The same course was retitled “Writing Better Business Letters” for the adult learners in

the evening classes. The student outcomes were the same for both classes, but the class titles and methodologies were different. While the high school students learned grammar through instruction regarding the rules of grammar, the adult learners wrote business letters as assignments and learned grammar through analysis of their application of the grammar rules. Similarly, one method of changing the way teachers instruct is to offer a series of workshops interspaced with observations of the teachers, who are the learners in the workshops, in the context of their own classrooms applying the new instructional methods they are learning. On-going professional development with attention to learning from application may supplant the professional development model of a new topic and new presenter for each in-service day.

Learner motivation. The principles listed in this study as two through five were in the first edition of the adult learning theory proposed by Knowles. In 1984, Knowles added a sixth principle, motivation, to his adult learning theory and the first principle, which is need to know, was actually the last one added to the list in 1989 (Knowles et al., 2005). Motivation includes both external forces, such as salary and promotion, and internal forces, such as self-esteem and job satisfaction. While the typical adult is motivated to learn and grow, they experience barriers, such as lack of time, lack of resources, and self-doubt, which inhibit their ability to learn and grow (Knowles et al., 2005). An extremely talented teacher may be motivated to become a principal, but whether he can do so depends upon a sort of sum of the positive and negative forces. For example, he may really be motivated by the opportunity to make a bigger difference for the school and community and the bigger paycheck sounds great, but his commitment to raising his own children could impede progress toward the goal of becoming a principal.

Krupp's (1982) work in adult learning supports Knowles' work. Krupp identified thirty-four characteristics of adult learners and then affirmed the characteristics "by means of

interviews with over two hundred persons and through workshops with more than five hundred participants" (p. 1). Krupp provides no other research methodology information in her book, so the empirical nature of the work is subject to question. However, her characteristics align well with Knowles' ideas. For example, Krupp has four characteristics that relate to experience of the adult learner and one of Knowles' concepts is the role of prior experience in adult learning. Krupp's expanded list also includes six physical characteristics of adult learners, ten personality characteristics, six developmental characteristics, three environmental characteristics, and five learning characteristics. Krupp's conclusion from the work is that "concern for the adult learner means concern for the individual as a person in all aspects of his or her existence" (p. 3).

Criticism of Knowles' Adult Learning Theory

The six principles of adult learning theory described above have been criticized. Merriam (2001) writes,

> The central question of how adults learn has occupied the attention of scholars and practitioners since the founding of adult education as a professional field of practice in the 1920's. Some eighty years later, we have no single answer, no one theory or model of adult learning that explains all that we know about adult learners, the various contexts where learning takes place, and the process of learning itself. (p. 3)

Blondy (2007) notes the lack of empirical support for the principles of adult learning theory and therefore views each principle as an assumption. Merriam (2001) notes that Knowles himself came to view his own adult learning principles as assumptions later in life. Blondy then examines each assumption both in terms of research aimed to test the assumption and in terms of implications of each for online learning by adults. Blondy found that each of the six assumptions/principles has been challenged in the literature about adult learners. Several of the

challenges stand upon empirical studies to call specific tenets of adult learning theory into question, but Blondy debates the alignment of the challenges to Knowles' intent in the theory. For example, regarding the adult learning assumption/principal stating that adults prefer to be self-directed in their learning, Blondy first describes a study (Robinson, 1992, as cited by Blondy, 2007) from which the author concludes that, contradictory to Knowles' theory of andragogy, adult learners did not prefer to be self-directed. In her analysis of the challenge, Blondy then stated, "It is debatable whether this actually contradicts Knowles' assumption that adult learners are self-directed. The fact that learners preferred clear instruction regarding assignments does not equate to a lack of self-direction" (p. 120). Additionally, in the challenges presented to the tenets of adult learning theory, Blondy cites empirical studies that support the adult learning theory and contradict the empirical work used to challenge Knowles' principles. Blondy's overall conclusion is that the points in adult learning theory "represent an ideal starting point for educators to use in their instructional approach" (p. 116). Blondy also concluded that while Knowles' work was not founded on empirical research, the principles were "developed as a result of experience, observations, and theoretical influences" (p. 127) and that many of the criticisms stem from "a superficial reading of Knowles' work" (p. 127).

From Blondy (2007), it is apparent that well-designed and meticulously executed studies have provided empirical data that both support and contradict adult learning theory. Therefore, it must be asked whether a theory that is considered by some educators to be a set of challenged assumptions should serve as part of the conceptual framework for this study. Adult learning theory resonates strongly with the researcher in regard to this study because the theory is about empowering learners. Conlan, Grabowski, and Smith (2003) write that Knowles ultimately saw that his adult learning theory was actually learner centered and learner directed regardless of the

age of the learner. Conlan et al. (2003) reached the same belief as the researcher for this project, which is that the principles of andragogy are not specific to adults, but rather work to allow any learner to control his/her own learning. Milligan (1999) echoes a related belief of the researcher, which is that there is a connection between project-based learning and andragogy and Milligan even refers to project-based learning as "Knowles put into action" (p. 552). It seems logical that empowerment of the learner must occur in order for that learner to transform their actions. In this study of how and why teachers transform their instruction, the empowerment of the teachers as learners may be a critical step, and therefore, Knowles' adult learning theory should be a component of the conceptual framework for the study.

Related Theories

In their book, *Pathways of Adult Learning: Professional and Education Narratives*, Groen and Kawalilak (2014) entitle a chapter "The Big Four Adult Learning Theories." The four theories include the following: Knowles et al.'s, (2005) adult learning theory, Tough's (1977) self-directed learning theory, Mezirow's (1996) transformational learning theory, and Kolb's (1984) experiential learning theory. Merriam (2001) suggests two other theories may someday supplant Knowles' principles/assumptions as the theory of adult learning: self-directed learning and transformational learning. Groen and Kawalilak (2014) note that "andragogy was closer to a philosophy of learning and not an emerging theory on how adults learn" (p. 142) and then quote Knowles et al. (2005) as indicating that he "prefers to think of [andragogy] as a model of assumptions about learning or a conceptual framework that serves as a basis for an emergent theory" (p. 142). In this vein, these other theories of adult learning will be considered as work that stemmed from the work done by Knowles, rather than competing theories to his adult learning theory.

Groen and Kawalilak (2014) note that self-directed learning was described by Knowles, but then they give credit to Tough for establishing the concept as a learning theory. Tough (1977) found that adults in his data set spent an average of 500 hours per year on learning and that over 70% of that learning was self-directed. He used an iceberg analogy to explain some of his conclusions:

> For many years we paid attention only to the highly visible portion of the iceberg showing above the surface of the water. We focused our attention on professionally-guided learning. We provided courses/classes, workshops, and other learning groups, plus apprenticeship, tutorials, correspondence study, educational television, programmed instruction, and so on. Virtually everyone still agrees that all of this professionally-guided learning is an incredibly important phenomenon in the world today. At the same time, though, it turns out to be only 20% of the total picture, only the highly visible tip of the iceberg. The massive bulk of the iceberg that is less visible, hidden below the surface, turns out to be 80% of the adult's learning efforts. It consists largely of self- planned learning, though some is planned by other amateurs such as friends and peers. (Tough, 1977, p.9)

Tough was careful to note that self-directed did not mean learning by oneself. The learners in his data set emphasized the importance of social or community factors, but the learners made their own decisions about what and how to learn and they learned outside of formal educational settings. Brookfield (1994), a more recent researcher who has studied self-directed learning, writes that Knowles definition of adult learning theory is the prevailing definition and then Brookfield (1994) quotes Knowles:

> In its broadest meaning, self-directed learning describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (Knowles, 1975, as cited in Brookfield, 1994, p. 18).

Mezirow advanced the idea of transformational, or transformative, learning (Levine, 2014). Mezirow (1996) defined transformative learning as "the process of using a prior interpretation to construe a new or a revised interpretation of the meaning of one's experience in order to guide future action" (p. 162). Mezirow (1990) also wrote that "the most significant adult learning occurs in connection with life transitions" such as the marriage, the birth of a first child, or a new job.

Finally, Schön's (1983) ideas around reflection as a critical learning practice for educators may prove to be a key theory in understanding teacher development and teacher effectiveness. Any or all of these theories related to adult learning could have been used in the conceptual framework for this study but were not initially selected because the researcher was more interested in and more knowledgeable about adult learning theory.

Self-Efficacy Theory

In addition to the framework set by adult learning theory, Bandura's (1995) work on self-efficacy provides further insight into the construct of self-concept. While self-concept in adult learning theory refers to the beliefs adults have about who they are, self-efficacy refers to beliefs people have about what they can do. Bandura (1995) defined self-efficacy as "the belief in one's capabilities to organize and execute the courses of action required to manage prospective

situations" (p. 2). In examining why and how a teacher transforms their instruction, the teacher's perceived self-efficacy may be an important contributing factor.

Bandura (1977) attributed the development of self-efficacy to four sources: performance accomplishments, vicarious experience, verbal persuasion, and physiological states. Performance accomplishments are based on personal mastery, such that if a person had previously mastered a skill that s/he sees as similar, the person's self-efficacy is higher. A succession of positive mastery experiences will lead to higher self-efficacy. Likewise, repeated failures in learning similar skills will result in lower self-efficacy. Bandura concluded that performance accomplishments have a greater impact on self-efficacy than the other sources since personal performance both promotes personal success or failure and also either extinguishes or heightens fear. For example, a teacher who has tried to learn new technology tools in the past and failed, both has a record of failure and a fear of learning technology that has increased with each failure. The contrasting example of a successful technology learner also aligns with Bandura's conclusion. Additionally, Bandura wrote about learning from vicarious experience and notes that both live modeling, such as watching another educator use a new instructional strategy, and symbolic modeling, such as visualization of yourself using a new instructional strategy, are sources of self-efficacy. Verbal persuasion uses the power of suggestion or exhortation to cause a change in self-efficacy and physiological states employs methods such as biofeedback, relaxation techniques, and symbolic desensitization.

While Bandura (1977) was specifically addressing how to change the behavior of people with diagnosed phobias toward their feared construct, he also saw the concept of self-efficacy as a step toward a unifying theory of behavioral change and in fact titled his paper in that manner. Zimmerman (2000) notes that self-efficacy has been used as an effective predictor of learning

and that self-efficacy differs from self-concept in that self-efficacy is specific to individual performance tasks. For example, a teacher may generally consider him/herself to be athletic and in good physical shape, which is part of their self-concept, but may have a much higher self-efficacy about successfully participating in the teachers vs. students basketball game than about successfully contributing as a member of the teachers vs. students softball game. A teacher with a history of starting for their own high school basketball team a few years ago and never playing softball on a team would have differentiated self-efficacies toward these two athletic competitions.

The Conceptual Framework

The four theories about learning form the conceptual framework for the study. The researcher's understanding of the reciprocal relationships between brain-based, or biological, learning theory, metacognition, adult learning theory, and self-efficacy theory is graphically represented in Figure 1.

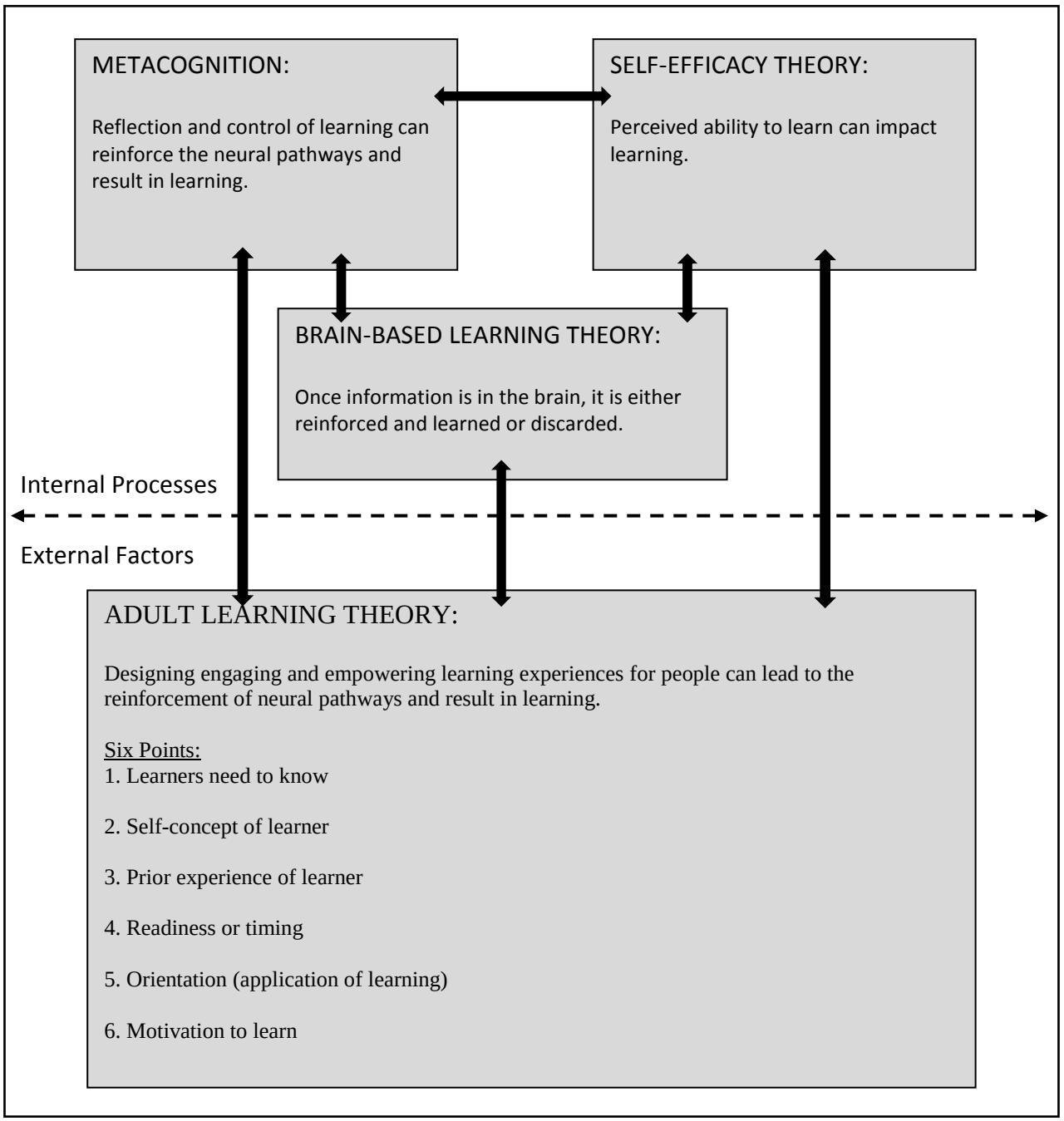

Figure 1: The four theories of the conceptual framework.

The study examined why and how teachers transform instruction through the lenses of metacognition, adult learning theory, and self-efficacy theory in prompting biological learning.

The metacognition and brain-based learning theory connection. A transformative act suggests a powerful and even empowering process of learning. In order for teachers to change their instruction, the neural pathways in their brains undergo change (Leamnson, 2000). Based on brain-based learning theory (Leamnson, 2000), the question of why teachers transform instruction is actually a question of what prompts the change in neural pathways. Two specific prompts are of special interest to the researcher. The first is the role that student learning has in initiating instructional change. Any self-reflection done by teachers about their own instruction is a metacognitive process. Further, identifying inadequacies in their own instruction requires metacognition, as does choosing methods to resolve the problems. The metacognitive thoughts themselves are obviously neural pathways in action and thus an example of brain-based learning; however, the use of metacognitive thoughts by teachers as stimuli to transform their instruction are a specific point of interest in this study.

The reciprocal relationship also exists. The learning done by the teacher may affect their metacognition. Helms-Lorenz and Jacobse (2008) stated that metacognition has two aspects: knowledge about cognition and regulation of cognition. Learning about their own learning could enhance teachers' use of metacognitive strategies.

The self-efficacy theory and brain-based learning theory connection. The role the self-efficacy of the teacher has in activating instructional transformation is the second prompt of specific interest to the researcher. Hayden (2014) summarizes Bandura's self-efficacy theory by stating "People will only try to do what they think they can do, and won't try what they think they can't do" (p. 13). Is this true of teachers regarding instructional learning and change? Does a lack of self-efficacy stop the learning process of teachers? Bandura (1977) proposed self-efficacy as a fundamental requirement for behavioral change.

In reciprocal manner, learning can impact self-efficacy. In explaining sources of self-efficacy, Bandura (1977) noted that performance-based treatments can be especially powerful in building or destroying self-efficacy. As teachers first attempt an instructional change, their experiences and learning during the attempt can impact their self-efficacy about transforming instruction and about their own instructional ability. One example of this relationship explored in this study is the role student feedback has in instructional transformations.

The adult learning theory and brain-based learning theory connection. In investigating the question of how teachers make instructional transformations, the impact of adult learning theory on learning is of interest to the researcher. For example, perhaps a teacher learns a new teaching method at a conference. The question of how this conference presentation was different from others that did not compel the teacher to make instructional changes is a question of interest to the researcher. How is teacher learning influenced by the tenets of how adults learn?

The reciprocal connection of how adult learning theory constructs are influenced by teacher learning seems more tenuous, unless the teacher applies the ideals of adult learning theory to their own instruction. If the teacher, like Knowles himself eventually, viewed adult learning theory as learner centered and learner directed regardless of the age of the learner (Conlan, Grabowski, & Smith, 2003), then the teacher's learning will impact the adult learning ideals through their own application of those ideals as instructive tools. For example, one of the tenets of adult learning theory is the readiness of the learner. When teachers seize teachable moments or plan lessons to include "just in time" instruction, such as when a classroom experience leads to questions the teacher anticipates, they have learned to use adult learning theory.

Connections among metacognition, self-efficacy theory, and adult learning theory. After examining how metacognition, self-efficacy, and adult learning theory each relate to biological learning as separate constructs, the connections between these constructs will be considered. For the conceptual framework, the researcher views self-efficacy as an extension or enhancement of the self-concept principle in adult learning theory. Self-efficacy is an aspect of one's self-concept. However, the researcher also notes a potential connection between self-efficacy and metacognition. If a teacher were to make an instructional transformation that was disliked by students, self-efficacy theory dictates that the teacher abandon the change effort since the attempt was unsuccessful, but metacognition could overrule the effect of the lack of performance success if the teacher's metacognition about the experience regulated his/her self-efficacy. The instructional transformation might simply take students some time to get used to and eventually lead to an improvement, but the teacher needs to realize that change takes time. The interplay between metacognition, self-efficacy, and adult learning theory is an exploration topic of this study.

Student Engagement

The theories of the conceptual framework provide a structural foundation for better understanding why and how teachers transform instruction. However, student engagement is also an integral concept in this study and therefore is presented as part of the literature review. Taylor and Parsons (2011) write about the importance of engagement:

> Student engagement is a rich research area. Educators must continue to seek to understand and apply specific, well-considered, if not agreed upon, strategies that support student engagement in learning both in and beyond the classroom. The consequences of not engaging students in learning are reportedly dire (Prensky, 2001; Tapscott, 1998;

> Gilbert, 2007; Willms, 2003, p. 56; Claxton, 2007). "Some educationists consider engaging disengaged pupils to be one of the biggest facing educators as between 25% (Willms, 2003) and over 66% (Cothran & Ennis, 2000) of students are considered to be disengaged" as cited in Harris (2008, p. 57) (p. 5-6).

Taylor and Parsons (2011) performed a literature review for the construct of student engagement in which they note "the literature we reviewed did not agree upon a definition of what student engagement might be. Several types of engagement were noted-academic, cognitive, intellectual, institutional, emotional, behavioral, social, and psychological to name a few" (p. 4). Silver and Perini (2010) also address the definition of engagement by consulting an etymological dictionary and thus find that

> the solution to the mystery of engagement takes full shape: "From Old French, engagier, to pledge." Engagement is something like a promise. It means commitment. Commitment: that's what we are looking for from our students, and you'll notice that both the teachers' list of "mores" and their rubric caught the signs of this commitment nicely: ownership, energy, concentrated thought, self-questioning, and an investment in quality. (p. 5)

Marzano (2007) devoted chapters of *The Art and Science of Teaching* to how teachers engage students in content (Chapter 5) and how teachers establish and maintain relationships with students (Chapter 8). Thus, Marzano identifies two distinct types of student engagement: engagement with academic content information and engagement with the teacher as a person.

The first type of student engagement used in this study is termed "content engagement" and is defined by the researcher as students actively working on learning the academic content intended by the teacher. Marzano (2007) performed a meta-analysis of studies about student

engagement in academic content as evidenced by "students attending to the instructional activities occurring in class" (p.99) and found that highly content-engaged students demonstrated a 27 to 31 percentile gain in academic achievement. The teachers in this study described transformations they made in their teaching that were designed to improve student engagement with the academic content.

The second type of student engagement is what the researcher refers to as "personal engagement." Taylor and Parsons (2011) specifically list common elements from the literature regarding engagement stating that "relationships and interaction-both virtual and personal-are shown to improve student engagement" (p. 8). Additionally, they cite survey work done by Willms, Friesen, and Milton (2009) which showed that "Students want stronger relationships with teachers, with each other, and with their communities-locally, provincially, nationally and globally. They want their teachers to know them as people" (as cited in Taylor and Parsons, 2011, p. 8). The interaction that Taylor and Parsons describe is the basis of what the researcher terms "personal engagement" in this study. For this study, personal engagement is defined as a student interacting in a positive manner with the teacher, or others, in the learning environment. The engagement is with the teacher as a person and in this study the teachers described personal engagement with students as part of their transformations.

Research Design Literature Review

To investigate why and how teachers transform their instruction, the research design employed is a qualitative, multiple case study designed from the post-positivist philosophical paradigm (Creswell, 2009). This section explains the researcher's decisions regarding the post-positivist philosophical viewpoint, the selection of a qualitative approach, and the choice of a multiple case, causally-focused study.

Philosophical paradigms. Creswell (2009) identifies three research traditions: quantitative, qualitative, and mixed methods. He also connects these traditions with at least one philosophical worldview, or paradigm, by noting that research design decisions should propagate from the researcher's own philosophical beliefs about truth and how the world works. He advises researchers to characterize their philosophical paradigm and recognize how personal philosophical beliefs impact research design decision making. Guba and Lincoln (1994) identify four philosophical paradigms: positivism, postpositivism, critical theory, and constructivism. Creswell also lists four paradigms, or worldviews, as he terms them, which are postpositivism, social constructivism, pragmatism, and participatory/advocacy. The list of paradigms from Creswell certainly overlaps with the Guba and Lincoln list and each paradigm will be examined.

Guba and Lincoln (1994) delineate a paradigm comparison structure that audits the ontological, epistemological, and methodological questions for each paradigm. The ontological question is "What is the form and nature of reality and, therefore, what is there that can be known about it?" (Guba & Lincoln, 1994, p. 108). A simplified version of this question could be "What is truth?" The epistemological question is "What is the nature of the relationship between the knower or would-be knower and what can be known?" (Guba & Lincoln, 1994, p. 108). This question explores the nature of objective versus subjective researchers. The methodological question is "How can the inquirer (would-be knower) go about finding out whatever he or she believes can be known?" (Guba & Lincoln, 1994, p. 108). The methodological question is not merely qualitative versus quantitative, but it exposes the underlying precepts in research schemata that stem from the ontological and epistemological beliefs.

Positivism. Positivism, or positive theory, is the philosophy associated with the mathematical and scientific progress during the Age of Enlightenment (Egan, 1997). The

ontology of positivism is realism, or naïve realism, which means that truth exists in the form of immutable natural laws and mechanisms and the truth can be determined (positively known) as well as reduced to some set of foundational concepts (Guba & Lincoln, 1994). The truth is also observable (Egan, 1997). The relationship between the knower and knowledge, or epistemology, in positivism is an objective relationship. The knower has no impact on the knowledge and therefore is an impartial observer (Guba & Lincoln, 1994). The research methodology spawned by positivism is the scientific method, a process of hypothesis testing through the manipulation of one independent variable at a time (Egan, 1997), and the primary research tradition in positivism is quantitative (Guba & Lincoln, 1994).

Postpositivism. Postpositivism challenges the idea that humans can know the absolute truth about phenomenon, which is the central tenet of its predecessor positivism (Phillips & Burbules, 2000). The ontology of postpositivism is very similar to positivism in that the truth is the immutable laws and mechanisms of nature (Guba & Lincoln, 1994). The difference is that the postpositivism paradigm recognizes limitations because human understanding of the truth is imperfect (Guba & Lincoln, 1994). In postpositivism, the truth is conjectural, empirically sought and established in probabilistic terms (Phillips & Burbules, 2000). The postpositivist paradigm stems from the theories of reductionism and determinism (Creswell, 2009). In terms of epistemology, the knower is an objective observer seeking to establish truth that fits with preexisting knowledge and will pass the test of critical peer reviewers (Guba & Lincoln, 1994). Replication is a key facet that increases the probability of determining truth, but one trial can always falsify a conjecture (Guba & Lincoln, 1994). The current quantitative research methodology with the use of null hypotheses is borne out of postpositivist thinking and the scientific method is often the investigative structure used by postpositivist researchers (Phillips

& Burbules, 2000; Creswell, 2009). However, Guba and Lincoln note the increased use of qualitative research techniques with a postpositivist paradigm, especially when contextual and situational data are important in the research work.

Critical theory; advocacy/participatory. The critical theory paradigm described by Guba and Lincoln (1994) and the advocacy/participatory worldview described by Creswell (2009) align. Creswell lists critical theory as one theoretical perspective that "may be integrated with the philosophical assumptions" (p. 9) of the advocacy and participatory worldview. In Guba and Lincoln's critical theory paradigm, reality is shaped by factors, such as politics, ethnicity, culture, gender, and economics, and then viewed as natural and immutable reality even though it was once, and still is, malleable. Guba and Lincoln classify the ontology of the critical theory paradigm as historical realism. In terms of epistemology, critical theorists see the knower and the knowledge as having a subjective relationship with the values of the knower influencing the understanding of the knowledge (Guba & Lincoln, 1994). Both Creswell (2009) and Guba and Lincoln (1994) describe the research methods as having a focus on dialogue between the researcher and the research subjects. The dialogue must be dialectical so that the researcher does not accept the historically crystallized view of the knowledge and can see the pliancy of the knowledge. Creswell takes the research methodology further by stating that the advocacy and participatory worldview is "research inquiry needs to be intertwined with politics and a political agenda" (p. 9). He further explains that at the heart of the research work is a desire for reform. The researcher acts as an advocate for the participants of the study who are often people marginalized by society. Creswell also notes that in advocacy and participatory research the participants become active collaborators in the work. Advocacy- and participatory-based research may be qualitative or quantitative in nature (Creswell, 2009).

Constructivism. The constructivism paradigm described by Guba and Lincoln (1994) and the social constructivist worldview described by Creswell (2009) represent the same philosophy. Constructivism states that individual people seek to understand the world in which they live and that truth is subjectively determined from one's life experiences (Creswell, 2009). The relationship between the knower and the knowledge is subjective and transactional, meaning that the "'findings' are *literally created* as the investigation proceeds" (Guba & Lincoln, 1994, p. 111, italics in original text). Research methodologies in the constructivism paradigm require interaction between the investigator and participants in such a way that the investigator understands the studied phenomenon through the eyes of the research participants and ideally obtains a consensus through dialectical dialogue with the research participants (Guba & Lincoln, 1994). Qualitative research methodologies, as used by social constructivists, often consist of open-ended questioning techniques to probe the understanding formed through social interactions (Creswell, 2009). Christmann, Balgar, and Mahlkow (2014) provide an illustration of social constructivism. They studied the perception of climate change in two geographically similar, but culturally different, German towns. They first established that the threats due to climate change were similar in both towns. They concluded that the perceptions of climate change were significantly different due to cultural and social aspects of interpretation. Social construction of meaning is a highly inductive process as is qualitative research (Creswell, 2009).

Pragmatism. Creswell (2009) includes a worldview that Guba and Lincoln (1994) do not address, perhaps because it does not easily fit the ontology, epistemology, methodology structure of the other paradigms or perhaps due to the evolution of philosophical paradigms in the years between the two resources. The pragmatic worldview centers upon problem solving; pragmatists value ideas or data based on their usefulness in solving a problem (Creswell, 2009). In the

Stanford Dictionary of Philosophy, Hookway (2013) traces the roots of pragmatism to the pragmatic maxim of Charles Sanders Peirce who wrote that in forming hypotheses one should consider what "effects, which might conceivably have practical bearings" (as cited in Hookway, 2013, the pragmatist maxim section, para. 2) in order to fully comprehend the truth of whatever concept is being tested. The roots of the philosophy suggest that pragmatists could view reality, as well as epistemology, as objective or subjective depending on the problem; or, perhaps the focus on the solution is dominant enough to obscure any thought of ontology or epistemology. Pragmatists are open to using various research strategies because they operate in a "whatever works" mentality. Therefore, they often attack the issue from all feasible sides and employ a mixed method approach in research (Creswell, 2009).

The philosophical paradigm of the researcher. The philosophical paradigm of the researcher impacts the research design decisions (Guba & Lincoln, 1994; Creswell, 2009). As a former science teacher and someone who earned a graduate degree in a scientific field, the researcher for this project is well versed in postpositivist thinking. She ascribes completely to the postpositivist paradigm. She believes truth exists in the natural world and in social structures and that truth can be established probabilistically or falsified through observation. She strives for objectivity in research and even views subjectivity as a weakness and lack of objectivity in most research. While she can identify specific concepts as social constructions, she still believes these can be distilled down into a set of foundational theories and often sees them based in experiences with the natural world. For example, she recognizes that gender-based expectations are socially constructed but notes the basis in biological, or genetic, differences. She is comfortable with either quantitative or qualitative methods aligned to the postpositivist paradigm. She values the peer review structure in research, and she will attend to concerns of research validity and

reliability in either quantitative or qualitative research work. Guba and Lincoln (1994) specifically note that the peer review structure used in most research disciplines and the attention to validity and reliability as measures of quality in research are postpositivism paradigm criteria.

Additionally, after years of teaching middle school, the researcher of this project has fairly well-developed pragmatist tendencies. She recognizes that the research work requires her to fight any urge to go into "fix it mode" and that she must stay open minded by setting aside any concern with applications or solutions related to this work. To focus on applications or solutions in this work could negate her ability to see an important pattern in the data. She needs to stay in the role of educational researcher despite having a role as problem solver in her daily job.

Her background and training in quantitative research will impact her thinking in this project. She does believe that there is a cause and effect relationship at work in this study, which is that teachers transform their instruction due to some event(s) and/or experience(s). Her goal is to try to identify and understand the role of those events and experiences on the development of teachers' instructional ability and how teachers learn from the event(s) and/or experience(s). Additionally, she would love to see teacher quality be reduced to a set of key concepts that can be measured; however, at this time she believes teaching is too complex of an interaction between teacher and student to be reduced to a simple theory or process. Despite these beliefs and training in postpositivism, she deliberately chose to base this research in a tradition other than quantitative research.

Qualitative versus quantitative research methodology literature review. The purpose of the study is holistic in nature. Whereas a quantitative approach would parse out specific elements, this study aims to conceptualize the overall development of the instructional ability of teachers by examining why and how they transform their instruction. Kennedy (2008) asserts

that qualitative methodologies are needed in the research field of teacher quality because, unlike quantitative, qualitative efforts can be instrumental in revealing the mechanisms undergirding the practices in education. A case study was chosen over a survey because the goal is in-depth examination and that will most likely involve follow-up questions to answers given by the research subjects to ensure that the salient points described by the subjects are fully elaborated upon and understood by the researcher. Yin (2014) indicates that qualitative research can investigate "how" and "why" questions in complex social settings. Maxwell (2004) addresses the use of qualitative studies as investigations of causation. He writes that quantitative researchers may "ignore or deny the possibility of identifying causality in particular cases, the importance of context as integral to causal processes, and the role of meaning and interpretive understanding in causal explanation—all issues for which qualitative research offers particular strengths" (Maxwell, 2004, p. 8). If the goal of this research was to examine how specific variables (such as pedagogy coursework, mindset, and use of indirect instructional strategies) related to some measure of effectiveness (such as student test scores), then quantitative methodologies would be indicated. However, there is an abundance of quantitative research designed in the fashion just described under the umbrella of research on teacher quality. Since the goal of this research is to better understand how and why teachers transform their instructional abilities, the requisite design is qualitative.

Creswell (2009) describes qualitative research as "a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem" (p. 4). Based on the attention teacher quality has been given, it could be considered a social problem, but more specifically, the question of how teachers develop their instructional ability can be classified as a human problem. Failure to develop an adequate level of instructional ability can,

and probably should, result in dismissal from a career in teaching, aside from the problem of poorly educated students. Creswell (2009) also designates the use of inductive processes and emerging questions as qualitative research design. The literature review for this project has not revealed any studies where teachers were asked about their development of instructional abilities. When a research topic has little or no previous work to build upon, the researcher should be encouraged to allow emerging questions or themes dictate direction of further data collection. With little well-established work in the field, it is difficult to test existing theories, and therefore, an inductive process of data analysis is appropriate. Miles et al. (2014) make several critical points about the nature of qualitative research including that the research is conducted through extended contact with the participants, the goal is gain holistic understanding of context, the researcher is the primary instrument of data collection, most analysis of data is done in words and is about identifying patterns or themes, and while many interpretations are possible, some are more compelling either for theoretical reasons or due to credibility that may be built with the data. Again, each of these points fits with the proposed project. The researcher plans multiple data collection sessions with participants, the data will be focused on rich textual descriptions, context will be examined and analyzed for its role, and finally, the researcher will be the data collection instrument and will look for patterns that may enhance the understanding of how teachers develop their instructional abilities and then share any compelling interpretations from the data.

Types of qualitative research methodologies. Within the realm of qualitative research design, there are several options. Creswell (2009) identifies five commonly used design options: narrative, phenomenology, ethnography, case study, and grounded theory (p. 176). Case study, phenomenology, and grounded theory were seriously considered in designing the study, and the

researcher concluded that any of these methods could be appropriate. She eliminated a phenomenological approach because Vagle (2014) describes the need for the researcher to immerse him/herself in the phenomenological experience or encounter, which takes time and study of the methodology itself as well as the phenomenon. The investment of time was one consideration in rejecting the method, but the whole approach, as described by Vagle, didn't resonate with the researcher for this project. The researcher debated intensely between doing a case study and a grounded theory study. Yin (2014) identifies the difference between grounded theory design and case study design in terms of when the theory development occurs. He notes that in grounded theory the theory is the end product, while in case study design the theory development is an aspect of the methodological design phase. Additionally, in comparing the description of grounded theory provided by Strauss and Corbin (1990) with the depiction of case study research provided by Yin, the researcher perceived more flexibility within the case study design. Therefore, a case study approach was chosen for its flexible design. Avoiding limitations due to methodology design seemed like the best way to ensure forward progress in understanding how teachers develop instructional ability.

Yin (2014) states that case study research can be exploratory, descriptive, or causal in nature. The intent of this research work is to probe the mechanism of learning to instruct, and therefore, the work is designed to be causally focused. The researcher begins this study with the belief that learning to instruct is a cause and effect process. She is interested in what types of events or experiences cause teachers to transform their instruction. These events or experiences would be the cause. She is additionally interested in describing the learning process for the teachers that results in the effect, which is improved instruction. Despite entering the project with a fairly linear cause and effect view of instructional skill development, the researcher recognizes

the inductiveness of qualitative case study work and is willing to reform her thinking based on the study results.

Yin (2014) defines case study methodology by describing the scope and features of the work. About scope, Yin writes, "A case study is an empirical inquiry that investigates a contemporary phenomenon (the 'case') in depth and with its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident" (p. 16). This case study will fulfill the scope portion. The examination of each teacher will be in depth through interviews and observations in the real-world context of actual secondary science classrooms. The study will be empirical as conclusions will be based on and supported by data and the work is certainly contemporary. Yin describes the features of the case study methodology as "A case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis" (p. 17). The research will also fulfill the features as described by Yin. Given the multitude of variables, triangulation of evidence and prior development of theoretical propositions will key aspects of the design work.

Yin (2014) describes appropriate reasons for choosing a single case study design over a multiple case study design. The reasons include that the case is highly unusual, critical for understanding a phenomenon, so common that it represents practically all other cases, or difficult to replicate because it is longitudinal. None of these rationales apply to the research presented here; therefore, a multiple case study is more appropriate, according to Yin.

Summary

The proposed study will employ tenets of brain-based, or biological, learning theory (Leamnson, 2000), metacognition (Flavell, 1979), adult learning theory (Knowles et al., 2005), and self-efficacy theory (Bandura, 1977) as the conceptual framework to explore why and how teachers transform their instruction. As a qualitative study, the emerging data may redirect the researcher to additional learning theories or other established work in the field of education. This chapter also explains the researcher's decisions regarding the post-positivist philosophical viewpoint, the selection of a qualitative approach, and the choice of a multiple case, causally-focused study. The following chapter will describe the specific methodology for the study.

Chapter 3:

Methodology

Introduction

This investigation of why and how teachers transform instruction stems from the lack of an operational definition of teacher quality. Instruction is a key component to teacher quality and needs to be better understood in order for the academic field of education to operationally define and measure teacher quality (Strong, 2011). This chapter defines the research methodology that was used to gather data regarding the questions of why and how teachers transform instruction.

The methodology is a qualitative case study. A quantitative approach was considered and rejected after some initial review of the literature regarding teacher quality. The existing literature in teacher quality has an abundance of quantitative studies, including some with very large samples and excellent statistical analysis techniques (for example, Darling-Hammond et al., 2005; Zuelke, 2008). Quantitative research, such as the numerous studies used in Marzano's (2007) book *The Art and Science of Teaching*, shows relationships between factors such as student tests scores and specific teacher actions. Marzano (2007) writes "The best research can do is tell us which strategies have a good chance (i.e. high probability) of working well with students" (p. 5). However, reviews of the quantitative body of work regarding teacher quality indicate conflicting conclusions among studies (Strong, 2011; Kennedy, 2008). Kennedy (2008) notes that despite an abundance of quantitative studies on teachers' qualifications, a lack of consensus regarding what variables correlate strongly with teacher quality persists at least in part due to confounding variables in nearly every quantitative study. Therefore, the primary impetus to embrace a qualitative approach is the overarching research questions for the study: How and why do teachers transform their instruction?

Research Questions

Research questions drive the design of the research. Lipowski (2008) concludes that "Developing a good research question is the most important part of the research process." (p. 1670). Miles et al. (2014) describe the roles research questions have in qualitative work as providing a focus to the study, narrowing the parameters in participant/sample selection, guiding instrumentation selection for data collection, and operationalizing the conceptual framework by making the researchers implicit ideas more explicit. Due to the inductive nature of qualitative work, the research questions do not lead to testable hypotheses but are needed to guide and focus the research work; additionally, qualitative research questions may be refined as needed due to the emerging data of the study (Miles et al., 2014). Cresswell (2009) suggests that one or two central questions and then no more than seven subquestions per central question be used in a qualitative project. The research questions used in this qualitative, multiple case study fulfill all the roles described by Miles et al. and follow the format suggested by Cresswell.

- Central Research Question 1: Why do teachers transform their instruction?
    - Subquestion 1a: Is there a pattern of events or experiences that typically lead to teachers transforming their instruction?
    - Subquestion 1b: How does student learning factor into the decision by teachers to transform their instruction?
    - Subquestion 1c: How do the reasons that these teachers transformed their instruction illustrate or fit with the conceptual framework of the study?
- Central Research Question 2: How do teachers transform their instruction?

- Subquestion 2a: Is there a pattern of events or experiences that teachers use in learning new instructional techniques on the way to transforming their instruction?
- Subquestion 2b: How do teachers describe their own instruction and the transformation of instruction?
- Subquestion 2c: How does the transformation process illustrate or fit with the conceptual framework of this study?

Research Subjects

Establishing parameters for the selection of research subjects is critical. In reviewing teacher quality research studies, Kennedy (2008) noted that "the most widespread weakness in the studies reviewed here was a general failure to articulate how teachers were selected" (p. 350). For this research investigation, participants are secondary (grades 6 to 12) science or math teachers. The selection of science and math is due to the areas of content expertise of the researcher. Each of the participating teachers was able to identify some specific aspect of their own instruction that they have transformed. In other words, they developed an instructional method for their own use that they did not use as a novice teacher. The actual instructional method was irrelevant in the selection of participants, but the teacher had be able to articulate what they changed, why they sought improvement, and how they learned to implement the transformation in their instruction. In selecting the research subjects the following criteria were not considered:

- age of the teacher
- years of teaching experience
- grade level taught in middle or high school

- gender
- school, other than it will be within the region the researcher lives in
- the researcher's knowledge of the teacher
- class size
- student factors such as socioeconomic status, ethnicity, special education status
- student academic achievement

To recruit participants, the researcher created an e-mail invitation that was sent to all secondary science and math teachers in the eastern Upper Peninsula region of Michigan. (See Appendix A for the e-mail text that was used with school administrators in asking permission to contact the teachers and the e-mail text for recruiting teachers.) The researcher then planned to create a list of all willing teachers and select the best cases for the case study. However, there were only four teachers who volunteered to participate in the study, and therefore, all four teachers were interviewed and observed.

Human subject research safeguards. In any research work involving human subjects, it is important to evaluate the risks to and rewards of the research for the participants. The risks associated with this study, for the teachers, included opening their thoughts about instruction and their own development as an educator. The interviews took one to three hours hour of each participant's time. The observations of classroom teaching also involved the risk of opening up their own classrooms to the researcher. The teachers may have been nervous about having another educator watch them teach and take notes about their teaching. The potential rewards associated with this study are very similar. The teachers may have appreciated the opportunity to spend time discussing their own instruction and receiving feedback from another educator about their own classroom teaching. The study was submitted to both the Lake Superior State

University Institutional Review Board and the Eastern Michigan University Institutional Review Board to evaluate the risks to the human research subjects (see appendix C for the approval letter from Eastern Michigan University). Research participants were required to sign the informed consent letter (see appendix D for the letter) prior to participating in the study.

The participants for this case study represent a convenience sample in that the teachers are all located in the researcher's geographic area. Due to the risks and rewards of the study, the participants may have represented a sample of teachers that was likely to be skewed toward teachers who are confident in their instruction, who seek improvement in their instruction, who are focused on instruction, and who have time to invest in this project.

Legal, ethical, and moral issues for this research study include protecting the identity of the research participants, keeping the data secure, and maintaining the integrity of the data by interpreting data in the way the research participant intended. The identity of the research participants were protected by the use of pseudonyms and by the avoidance of including specific details that would allow the school, school district, or research participants to be easily identified. When necessary, minor details that do not affect the interpretation of the data were deleted or changed such as references to specific students or other educators in quoted interview material. The actual data was housed in a locked file cabinet in a locked office. The research participants were provided with information of potential costs, such as time and the inconvenience of meeting or having someone observe class, and potential benefits, such as an opportunity to talk about their own learning and an opportunity to focus on their own instructional abilities. The research participants were provided with the opportunity to drop out of the study at any time prior to the submission of the dissertation. The researcher recognizes that interview data can be interpreted differently by the interviewer and the interviewee. Therefore,

she worked to capture the information provided by the research participants with the integrity of the ideas intact. Anytime she noted that multiple meanings were possible, she followed up with questions to check with the research participant to make sure she understood what was meant.

Interview Data Collection

After the research participants were identified, the data collection and analysis, or coding, phase of the study was done. The inductive and emerging nature of qualitative research requires that data collection and analysis occur as simultaneous processes (Creswell, 2009; Miles et al., 2014). The general protocol that was planned for each case, which is each research participant, is outlined below:

1. Interview 1 generates raw data that is recorded in audio format
2. Interview 1 data is transcribed
3. Interview 1 data is coded; jottings and analytic memoing are done as data is coded
4. Interview 2 generates raw data that is recorded in audio format
5. Interview 2 data is transcribed
6. Interview 2 data is coded; jottings and analytic memoing are done as data is coded
7. Assertions and/or propositions are stated if possible
8. Observation 1 generates raw data in the form of field notes
9. Observation 1 data is coded; jottings and analytic memoing are done as data is coded
10. Assertions and/or propositions are stated if possible

In reality, three out of the four research participants gave shorter interviews and the two interviews were completed in one session. In every case the classroom observations were done on a different day than the interview and after the interview data had been transcribed and undergone initial analysis.

As described by Miles et al. (2014), the approach to this work was inductive such that the researcher allowed the data from interview one to impact or even craft phase two. Also, the study, while guided by the research questions, emerged as the patterns in the data emerged. An inductive approach may seem unfocused at times because the researcher refrains from making some research design decisions in advance of the data collection. However, for a research study where the researcher needs a holistic methodology and is focused on establishing theory rather than confirming or testing theory, an inductive methodology where the data dictates the direction and the theory emerges from the data can be useful (Creswell, 2009).

The interview protocol, as outlined by Creswell (2009) has the following format:

- a heading of date, time, place, teacher name stated as the recording begins
- an ice-breaker question
- four or five questions for the study
- concluding statement
- thank you to the teacher

The first phase of the interviews was about why the teacher transformed his/her instruction and the second set focused on how the teacher transformed his/her instruction. The sets of questions in Appendix B are examples of the types of questions that were used. Deviation from these questions did occur to follow the direction the interview headed; however, the researcher was careful to ensure that all key ideas were solicited from each teacher in the study.

Interview Data Analysis

All interviews were recorded in audio format, with the permission of each participant, and then transcribed into a spreadsheet. Miles et al. (2014) describe the use of jotting notes in the margins of the transcribed data as a method to capture the researcher's "fleeting and emergent

reflections and commentary on issues that emerge during fieldwork and especially data analysis" (p. 94). They also describe several methods of coding qualitative data, which may be used as stand-alone protocols but are often combined to meet the coding needs of the project. There is a hierarchy to the coding described by Miles et al. The coding work is broken into two cycles. In the first cycle, there are three elemental methods of coding that can be useful in setting up coding categories. Descriptive coding assigns labels, which are typically nouns, and the labels summarize each passage of the transcript. Two other coding methods, which could be used after the descriptive coding is done, were also logical and used for this work. Miles et al. describe provisional coding where the researcher begins with a list of codes based on what is expected in the data. The predetermined codes may be altered, deleted, or added to as the project progresses. Coding of this nature was done for this project and was based on the research subquestions. The other coding strategy used for the study is causation coding. Miles et al. depict causation coding as attempting to map a three part process in the research participant's journey. They state that "causation coding is appropriate for discerning motives, belief systems, worldviews, processes, recent histories, interrelationships, and the complexity of influences and effects on human actions and phenomena" (p. 79). The researcher used jotting, descriptive coding, provisional coding, and causation coding using the protocols in Miles et al.

The second cycle coding, as outlined by Miles et al. (2014) involves identifying patterns in the data. The following pattern codes, from Miles et al., are often interrelated: categories or themes, causes or explanations, relationships among people, and theoretical constructs. The researcher used the first cycle coded data to generate the pattern codes in the second cycle coding.

Miles et al. (2014) describe analytic memoing as "a brief or extended narrative that documents the researcher's reflections and thinking processes about the data" (p. 95). The focus of analytic memoing is the analysis and synthesis of ideas. Based on the information provided by Miles et al., analytic memoing has some similarity to jotting but is much more complete and in depth. Coding, jotting, and analytic memoing were done throughout the project as data was collected. Miles et al. suggest that alternating between the three tasks of coding, jotting, and memoing strengthens the research.

Miles et al. (2014) note the need for using assertions and/or propositions at some point in the study to further the concepts being constructed from the data. They describe an assertion as a summative statement stemming from the synthesis work in memoing. For example, in this study, a possible assertion could have been that teachers transform instruction when curriculum standards change. Assertions must have supporting evidence and must be revised when contrary data emerges. Assertions proved to be a valuable analysis tool for this study.

Classroom Observation Data Collection

The third phase of data collection was the classroom observation. The goal of the observation was to observe the transformed instruction performed by the teacher. As the lesson took place with students in the classroom, the researcher focused on how the teacher instructed and the students' response to the instruction. The researcher captured descriptive field notes, often with verbatim student-to-teacher interactions during the observation. Williams (2011) explains that descriptive field notes include detailed descriptions of what the observer sees, hears, and experiences. The language used should be concrete and the descriptions should be vivid. For this study, the researcher observed one or two class periods for each participating teacher. The descriptive field notes underwent coding in the same fashion as the interview data.

Researcher Bias

In qualitative research, the researcher is a biased filter and interpreter of the data (Miles et al., 2014). The educational philosophy of the researcher will impact how data is gathered, interpreted, coded, and analyzed. Her educational philosophy includes the following tenets:

- Everyone can learn, which means that teachers can learn to be high-quality instructors and all students can learn the curriculum with the exception of cognitively impaired students who can often learn at least some of the curriculum.
- Teachers want to be good at their job and therefore want to be good instructors.
- Teachers care about students and want them to succeed academically.
- Teachers, as the primary instructors of the curriculum and educators who spend the most time with the students, are the key to academic success of students.
- Educators have not taught the intended curriculum if students have not learned the intended curriculum.
- Items such as textbooks, pencils, computers, video clips, calculators, chalk, paper, lab equipment, etc., are all educational tools. Nearly anything can be used as an educational tool, but the effectiveness of the tool is in how the teacher uses it. The same tool, even a highly sophisticated simulation software program, can be used to maximize student learning by one teacher and minimize student learning by another teacher.
- High-quality education does not require any tools and can be done in any setting such as the middle of a forest, an underfunded classroom in any school in the world, etc.
- High-quality instruction is dependent on the teacher.
- Learning does not require a teacher, as in learning from experiences, and learning academic curriculum is not a formal process that must happen in a classroom.

Additionally, the researcher's experiences in working with teacher candidates at a teacher preparation institute may impact the study. The researcher has supervised student teachers in a teacher preparation program that employs a clinical approach to field work and the researcher has taught various methods courses for teacher candidates. During the observational phase of data collection, the researcher's experiences provided an important foundation of observational practice, but she was also able to focus the observations to capture specific data discussed in the interviews.

Validity

Validity is a measure of whether the test elicits the information that answers the research question(s). Miles et al. (2014) also use the word "credible" in describing validity, as in whether the results are credible in the study. They list various points to consider in qualitative research related to internal and external validity including: data that is context-rich and meaningful, exploration and explanation of uncertainty and rival interpretations, the use of negative evidence, the use of triangulation for replication, strong connection of the findings to existing theory, and application of research conclusions across settings. Kennedy (2008) also discusses validity in qualitative research and offers a specific procedure that should apply to this study. To increase study validity, Kennedy recommends direct observation rather than sole reliance on interview data.

This study will address validity by gathering data from both the interviews and observations that is context-rich, meaningful, and aligned to the study research questions. Rival explanations will be fully explored. The classroom observations provided additional information and addressed Kennedy's (2008) concern about relying solely on interviews. Two data sources, interviews and observations, were used for the study.

Reliability

Reliability is the idea that the same test will produce the same results in the same test situation. Miles et al. (2014) describe reliability as an issue of whether the study is "consistent, reasonably stable over time and across researchers and methods" (p. 312). Miles et al. also note that reliability begins with clarity in the research questions and thoughtful design of the study. They additionally mention meaningful parallelism across the data as a measure of reliability. This study was a multiple case study for that reason. While each research participant had their own journey in developing their instructional ability, the researcher examined patterns across the data for each participant and then patterns across the participants as a group.

Often, in case study research, the idea of triangulation is used to increase reliability (Creswell, 2009). Triangulation is obtaining data from three sources that show the same information. For example, in this study of how teachers develop instructional ability, the use of interview questions, and classroom observations would be two of the three data sources needed for triangulation if the same information was gleaned from each source. Another method of attending to reliability is asking the same question of a person either in different ways or at different times. Surveys often include positively and negatively worded questions that are essentially asking the same thing as a way to increase reliability. Neither triangulation nor positively and negatively worded questions were used in this study.

Creswell (2009) suggests that researchers monitor coding procedures for drift in meaning of the codes and double check interview transcriptions for accuracy to ensure reliability of data management. Miles et al. (2014) note the need for extra reliability checks when multiple researchers are involved in the work. This study was completed by one researcher, so intercoder agreement was a nonissue. The convergence of multiple observers was not available in this

research as a reliability measure. However, checks for researcher bias should be included, and the peer review done through the dissertation committee is a form of checking for reliability that was used (Miles et al., 2014).

Summary

In conclusion, to investigate why and how teachers transform their instruction, the research design was a qualitative, multiple case study designed from the post-positivist philosophical paradigm. The researcher's decisions regarding the post-positivist philosophical viewpoint, the selection of a qualitative approach, the choice of a multiple case, causally-focused study, and the decisions about research participants and research protocols were vetted in existing research design literature with the hope of learning something consequential about how teachers develop their instructional ability.

Chapter 4:

Results

Introduction

Teacher effectiveness is difficult to operationally define due to the complexity of the teacher role in a school (Strong, 2011). Yet teacher effectiveness is critical to student success (Brophy, 1986). Kennedy (2008) noted a need for investigations into the causal mechanisms of teacher development and suggested the use of qualitative research to meet this need. In this exploration into why and how teachers make instructional transformations, one of the goals of the research was to complete a study of instruction with a strong teacher voice. A total of four teachers participated in and constituted the cases in the multiple case study. To examine why and how teachers transform their instruction, two types of data were collected from the four teachers. The research methodology included both face-to-face interviews and classroom observations. One data set includes responses from each of the participating teachers during face-to-face interviews and the other data set is comprised of the researcher's field notes from classroom observations of the teachers. The interview responses are presented in textual format as quotes from the teachers' interviews. Some paraphrasing was done for clarity but always with meaning preserved and paraphrased material is never presented in quotation format so that it can be identified as paraphrased material. The classroom observation data set is also presented in textual format as descriptions of teaching actions and interactions with students performed during the time the researcher was observing the teacher. In both the raw interview and observations data sets, names of students, administrators, or colleagues were sometimes used by the teachers and researcher. In the reporting of results, the actual names have been removed and the people referred to as their role such as "principal" or "student."

To foster comparison of the cases and cross case analysis, the results have been organized into sections around key points such that the data from all four teachers were combined in each section. The first of these sections shares the relevant background for each research participant and the second is about the teachers as learners and instructors. Both of these sections were developed exclusively with interview data. The study results then include a section of information about the instructional transformations the teachers chose to discuss. The transformations form the core of the study. Following that segment are sections about why the transformations were made and how the transformations were made. The final section provides data about the success of the transformations. Much of the data throughout each of these transformation-based sections are from the interviews. The data set obtained from classroom observations is most integrated into the section about how the transformations were made but does factor into other sections about transformations. Data for each section are summarized in table format at the end of each section.

Relevant Background for the Research Participants

All names have been changed in this research study. Interview questions about the background of the teacher served as ice breakers for each of the two sets of interview questions. The data generated by the questions also served to establish an understanding of why the participants became teachers and the journey they experienced to get to where they are today in their careers. The background information is included because it is relevant to how and why the teachers made transformations in their instruction. A summary of the basic information about the teaching careers of the research participants is provided in Table 1 at the end of this section.

Kate. Kate is a middle school math and science teacher. She has been teaching middle school for about fifteen years and had significant teaching and parenting experience prior to

becoming a certified teacher. Her previous career involved teaching elementary aged children a health curriculum in school settings, and she had done substitute teaching, including long-term substitute teaching jobs. When asked about why she became a teacher she replied:

> Initially, I became a teacher because I was working for an agency as a health educator and they kept telling me at the agency that if I would get my teaching degree, it would move me up through the ranks at the agency and so I toyed with the idea for several years. Finally, I figured out how to go back to college with kids at home and kids in college and [with] working. I was student teaching and was one semester away from having my teaching certificate and got laid off from the agency. And so [I thought] "Well, now I'm going to finish and I going to go be a teacher because I just spent all this money doing that." So it was more of a career advancement to begin with, but now I'm happy that I did it and did get laid off because I can't see myself getting funneled into that job for a long term.

Kate was hired into a full time teaching position after graduation. She has a minor in math and is certified as an elementary teacher with a math endorsement. She currently teaches both math and science to middle school aged students.

Bree. Bree is currently a middle school science and art teacher. She has about twenty-five years of teaching experience in a variety of content areas and grades. Her background and original certification were in special education. She is the only teacher in this research study who has been a teacher for her entire career and did not start in another field. When asked about why she became a teacher, she responded with the following:

> Because I saw my mother who was very ill do far more than what she was able to. She lived 18 years and was only supposed to live 6 to 8. And I thought, "If she could do that, that would be so cool to be able to inspire kids to be able to do more."

Bree proudly showed some letters students had written to her including one that said, "Thank you for showing me gifts that I did not know I had."

Matt. Matt is a high school teacher who has taught primarily chemistry and physics during his career. He is highly qualified to teach several areas of science and all areas of math, and he has been teaching high school for more than ten years. Prior to becoming a certified teacher, he had significant teaching experience, including experience in a program that caters to low income high school students without family histories of college graduations and some work teaching university students. Matt actually began his career in industry as a chemist. When asked about why he became a teacher he said,

> I have a passion for helping other people and I discovered that I had a sort of a knack for understanding and communicating science. And I enjoyed sharing science with others. Well, in the course of doing that as I was growing up, and also as I was helping others, when I was in high school and college, there were various people that said, "You should become a teacher!" My mother was one of those and she was a teacher.

Jay. Jay has been teaching high school math and science for about fifteen years. He is certified to teach all math and science courses at the secondary level. Prior to finding a teaching position, he had significant experience in the business sector because

> At the time, there were no more jobs for teaching and I needed a job. I was married and making $800 a month, so I was offered a job to run a store. That's human resources and that's the other thing I wanted to say: teaching jobs at that time were hard to come by but

> I knew that teaching is human resources and involved the same strategies, so I knew I could market my teaching degree in different ways. That's another reason I chose it. I did end up running the business for four and a half years and I was at the top of it and made very good money. I still make less money now than I made 24 years ago.

When asked about why he became a teacher, Jay shared, "I love people and I love to help people. I believe education is the key to a happy and successful and fulfilling life."

Section summary. Three of the four teachers began in another career path before becoming a teacher. Each of the teachers clearly communicated that they are pleased with and/or fulfilled by their choice to become an educator. Three of the four specifically linked their reasons for becoming a teacher to helping people. All of these teachers are between 47 and 59 years old and are well into their teaching career as each of them has more than ten years of experience as a full-time certified middle or high school teacher. The information shared by the teachers indicates many similarities in their backgrounds. Table 1 summarizes the relevant background information for each teacher.

Table 1
Summary of Research Participant Background Information

Teacher	Became Teacher	Currently Teaching	Years of Teaching	Route to Teaching
Kate	career advancement	middle school math and science	about 15, all in current position	health educator, returned to university to enhance that career and ended up in a middle school teaching position
Bree	inspired by her mother to make a difference	middle school science and secondary art	about 25, in three different districts and several different grade levels	went to college to be a teacher (special educator); no previous career
Matt	to help people and discovered he has a knack for teaching science	high school math, chemistry, and physics	between 10 and 15, all in the same position for the same district	industrial chemist, then university instructor and tutor, then Upward Bound teacher, then returned to earn teaching degree and a high school teaching position
Jay	to help people and sees education as a key to a fulfilling life	high school math, middle and high school science	between 15 and 20, all in the same district and teaching secondary math and science	earned teaching degree, but there were few jobs, ended up managing a retail store for over four years before finding a teaching position

Teachers as Learners and Instructors

Each participant was asked to describe what type of learner they are. The interview questions of how the teachers perceived themselves as learners and instructors served to segue the focus from background information to instruction. Additionally, it also seemed important to hear what the teachers thought about themselves as learners and as instructors. The researcher

was specifically curious about whether each teacher had a fixed or a growth mindset (Dweck, 2006), the teachers' assessment of their own instructional effectiveness, and then whether either of these had any bearing on the instructional transformations. A summary of the basic information about the research participants as learners and instructors is provided in Table 2 at the end of the section.

Kate as learner. Kate has been a parent, been though a major career change, worked as an educator in various capacities, and experienced a wide variety of curriculum initiatives during her time as an educator. Additionally, she has served her school on a variety of committees during her time as a teacher. She has clearly been in a position to be a learner frequently as an adult. When asked about what type of learner she is, Kate responded with the following:

> I always want to know something new. It sounds corny to say you're a life-long learner and yet there's always something new out there to be learned or something new to be tried because you've just learned of it. So, I spend a lot of time trying to find new things to learn, new things to do; it's pretty eclectic.

When asked about how she goes about learning something new she responded:

> It varies on what it is. I taught myself how to use a MacIntosh computer by talking myself through it over and over and over again, which worked well when I had to help my children learn to use a computer. Most of the time it's just a simple, ok, I'm going to read about this and learn everything I can about it and then I'm going to do it. I don't put a lot of...as far as a verbal learner...I want it there in front of me and I do better, for the most part, by myself, not with a whole bunch of people trying to give me their ideas and stuff, too. I'm interested in their ideas, but I want to know after I know the basics. I want to know first and then get the information.

The researcher inferred from Kate's answers that she has a growth mindset.

Kate as instructor. During the interview each research participant was asked to rate their own instructional ability. Kate, who has been teaching for about 15 years, paused for a long time after being asked the question and then shared the following:

> Struggling, um, three years ago I probably would have told you that I thought things were going very well and that I would love to keep on teaching for a very long time. And, there's been some health things that have happened. For two different years I was out of the classroom for at least two months during the school year, which was very difficult for me. The first time I was there to start the school year, missed two months in the middle, and then went back. The second time I missed the first two complete months of school. So, this is actually my first year back in the classroom for a full year. I just don't feel that I'm totally on top of my game all the time. I get home from school and think, "oh, I should do this for tomorrow" and I just don't have the energy to do that for tomorrow, so we'll change the lesson plans a little bit or whatever. It doesn't help that this year seems to be a particularly rough group of students. So there's that on top of feeling like "wow, there's just too much" and a lot of it is the fact that [we have] the new math series and the science standards are changing for next year so that has to be looked at. There's just so many different aspects pulling me at one time right now that I just feel like I'm not the best teacher I could be.

Bree as learner. Bree is the educator in the study who has been a teacher the longest. She has been assigned to teach a wide variety of content areas in her twenty five years of teaching. She shared in an interview that she used to be extremely capable as a learner and that learning new information or skills was easy for her. To the same question about describing

herself as a learner, Bree answered, “I used to be more of a reader learner, an easy student.” However, Bree has had two bouts of cancer and feels that has changed her in many ways, including as a learner. Her last battle with cancer was fairly recently and she said,

> The ADD [attention deficit disorder] was a complication 17 years ago [the first time she had cancer] and this last time is was really bad, so I am having to learn to accommodate for attention deficit. They [speaking of her students] just can't focus, so, I've learned that and I know it's how I work, too. And I am much more difficult to teach than I used to be. I have to want to do it [to learn new information]. Really, really bad I have to want it.

Bree had difficulty with the question about mindset and twice gave answers that were nonresponsive to the question asked. She reiterated that she would have to see value in putting in the effort,

> I am the one that I can do it [learn new things], but I have to want to do it. I don't have the energy or the desire anymore to learn something. If it's something that is of value to me, I'm all for it and I'm invested in it. I still can't sit still for a great length of time. You know when [at meetings] I push myself and then I get up and look and it's still only [been] 45 minutes. So I still have to deal with that, but if I can use it and I can relate it to my students, then I will continue [to learn] it. But if it's something that I deem....stupid then I don't. You know if it's not relevant then I don't waste my time or energy on it.

Bree as instructor. Bree responded to the question about her instructional ability with, “I'm on the upper end because I can get with most students, so as a general ed[ucation] teacher, being able to do that I can usually guide them in and move them on.” She believes she is a better art teacher than science teacher:

> As an art teacher, I am a great art teacher because I see the kids work and I want to grow up and be like them. I may not be able to do it myself [the artwork], but somehow I am able to get them to want to try and to play around with it and just see good in what they do. I do some of the same things in science.

Matt as learner. Matt has an impressive background of accomplishments that attest to his ability to learn information. His interview answers clearly indicated that he understands science processes at a depth appropriate to teaching science at a post-secondary level, which he has done and continues to do through advanced placement and concurrent enrollment courses. He started the discussion of himself as a learner with the following:

> I tend to be kind of a detail-oriented person and I tell stories, too, so please pardon me, but here's a story from my past when I was a freshman in college and I think that that might help illustrate. I am good in math, but I felt that when I was in high school, after having had math analysis, that I may not be ready for calculus and I knew how important calculus would be to help me with science. So, I took a pre-calculus course and I'm glad that I did. It was a wise decision. But, as I took it, there were some things that I was strong at and others that I was rather weak and I didn't know it. I had never had the unit circle that I recall and we didn't have trig when I was in high school and that's very important. Well, what happened was, I did very well on some tests and from my point of view I didn't do so well on others. [In fact] I did rather poorly on some others and so I think that it all averaged out to a B, possibly even a low B because I had gotten a low C or a high D or something like that on a test late in the course over some trig functions and some other things. I thought, "Wow, how can I study and do well on the final exam?" So, I made a review sheet. I wrote down all of the formulas that we had gone over during the

> course, all of the major theorems and corollaries that went with them. I am not a good memorizer, so the act of preparing the review sheet helped me to organize my thoughts, write down all the most important things that I needed to know by heart, so that I had, not exactly a cheat sheet, but something that I could look at to get all that information back up into my head just before I went into the exam. It worked!

At this point Matt laughed before continuing with,

> I am usually a slow exam taker because I am so thorough. I'm often the last one finished. When I finished that exam, I looked around. Not a single person had left the room and I thought, "Oh, my! I must be doing something wrong!" so I went back and I checked my answers and it seemed ok and I did the best that I thought that I could do, so I turned the paper in. I learned later that I was the only person that finished the test and that I had gotten a 100%.

When presented with the question designed to evaluate the teacher's mindset, the researcher said:

> There's this idea coming out of psychology about learning that it's kind of a spectrum, but people tend to be one of two types. They either tend to have this kind of fixed mindset where when they are challenged with something new, they either think they already know it or ...

Matt jumped in at that point in the question with recognizing Carol Dweck's (2008) work on mindset. To the question, he answered:

> I think when I was growing up that I started out having more of a fixed mindset, but with the goals that I set for myself and the way that I pushed myself, I think that it helped me develop a growth mindset which has increased over time. So, I think that one's mindset can change.

Matt indicated that he has thought about the psychology of mindset and how it connects with the learners in his classroom with the next part of his answer; however he did not specifically delve into how he uses what he knows about mindset in his own teaching. He said:

> What's really interesting to me is, now that I'm a teacher and looking back working with my students, I see some of them that exhibit characteristics of the fixed mindset. I've heard some people who classify themselves as being stupid because they did poorly on a test and that really frustrates me. That really frustrates me because in my opinion all students can learn. It's just a matter of finding the key like I had to find the key, the way that I studied best to score well on exams and retain information.

Matt as instructor. Matt, when asked about his instructional ability, thought about the teachers he has had and worked with and then said the following about his instructional ability compared to those other teachers he has known:

> I put myself in the middle. In comparison to some teachers I have had in the past or if I can say it very quietly some I have worked with. I think that I am a lot better than that. However, I have had some superb teachers in both high school and especially college because I was in college for so long. And I don't think that I measure up to those standards. It's not that I don't want to. It's more time and what I'm able to accomplish during my day, so I have not "arrived." And to be honest with you I think that teachers who think that have arrived may have a problem. I think that just like people are life-long learners, teachers also should be life-long learners. There are always new ways to think about how to reach students.

Matt spoke of two instructional areas that he is actively working on as a teacher. The first is differentiation and the second is technology integration. Matt said, "Differentiated instruction is

a challenging goal in my opinion. It's very important, but I think that teachers develop certain expertise in working with the particular classes of students and it's very difficult to reach all learners." Matt also expressed frustration over the lack of time he can carve out of his schedule to think through and learn new technologies:

> I am very comfortable using technology for some things. But, I feel like I am in a world right now where we've gone to the web 2.0 that I am a little out of my element keeping up with all the things that are happening so quickly around me in the workplace. You can see with all the stuff I have I my plate, that I'm doing right now, with the emphasis on labs and experiences and stuff like that, that to keep abreast of all the tech advances for education in addition to keeping all of my labs going and my leadership role here at the high school, at some point I have to eat and sleep.

Jay as learner. Jay is an avid reader with a wide variety of interests and experiences. Without formal training he has built houses and fixed mechanical issues in a multitude of machines typical in rural areas, such as snowmobiles and dirt bikes. Jay also enjoys sports with technical aspects such as weight lifting, sailing, and fishing. He has learned many of these interests and abilities as an adult. Like Matt, Jay indicated a growth mindset with his description of himself as a learner:

> Tenacious. School did not come easy to me. My home life was quite complicated. No study habits and no supervision. So for me to learn, I did not know how to learn as a child. My brain fires well and I didn't know that as a child, but now I do. I understand what that means today. You know it's a matter of the wiring. So as a learner now what I am is I read, I do, I practice, and I study and I don't quit until I'm done. I don't really need a lot of fluff. I don't need a pat on the back. I'm very self-motivated. I am not afraid to ask

for help. As a child I was. But really the type of learner, I'm a very atypical learner. I just don't quit until I'm done. And if that's fifteen hours, I don't really care. I don't quit until I'm done and I've been like that my whole life. And I realized it more as I went to university. Before I went to university I got cancer and the medications damaged my brain and the first year of university I could see it...they call it chemo brain and I couldn't retain anything I read. And I got a high B in an engineering calculus course that everybody was failing because I didn't have to read that much. I'm tenacious so I'd just do the problems until I had it figured out, but I couldn't pass the general psychology class because anything I read, I couldn't retain it and follow the words. I lost that ability in my short term memory so I think that's when I learned to stick to it because I didn't quit. I wanted to quit and I didn't. I just kept at it. At this point in time, I don't have any issues. My brain functions really well. I can read a book, retain it, repeat it, organize it, but I would say I got a little disruption in that. To tell you truthfully how I learned, it's had a few blips along the way. Now, I don't know, I just learn it. I ask questions. I read until I do it. To give you an example, I had a priest from my Catholic church, he came to me. He's from Ghana so he couldn't figure out an essay written by Pope John Paul II and it's a PhD level essay on theology and philosophy and I don't read theology or philosophy. He couldn't read it and he asked me for help and this is the kind of person I am, I read it for seven hours and I googled every word. Each word has great depth, right? It's like temperature. Temperature isn't hot and cold. It has great depth in a paper like that and I didn't quit until I was done. And that's the kind of learner I am. I guess I just don't quit because I'm curious. I want to know.

Jay as instructor. Like Matt, Jay's evaluation of his own instructional ability also included some frustration over what can be accomplished in the time available. He talked in the interview about having six different content classes to teach each day. This type of schedule, which is common in small, rural schools, presents teachers with additional challenges to being instructionally proficient. When asked about his own instructional ability, Jay said:

> To me humility is an important word. I'm not the best teacher. I have weak areas, but I believe my saving point is [that] I'm always learning, I'm honest and not afraid to admit fault, and always growing. I believe I have a unique way of engaging and interacting with students and that is really what is best about my teaching ability. They trust me as an individual [and know] that I care about them and look out for them. Therefore, they do most of the work [for my class]. Every year I teach, I improve. That's what I love about the job. I'm better now than I have ever been in my life. I have six [different classes to prepare for] and I teach seven hours with no prep hour and therefore I can never get a real true handle on my content. It's changed every three years since I have worked here. If I was left alone...So, how I accommodate that is that I choose certain subjects each year to take it up a notch. I take failure on my students' part seriously and I always try to find new ways to teach content.

Jay also discussed novice teachers and drew on his own experience when he began teaching:

> I mentor a lot of new teachers and what I tell them is "you will suck for three years and you will realize it after three years." A smart boss knows that an intelligent person will make lots of mistakes if they are learning to discipline properly and deal with classroom management. Every year they try to get better-that's a good employee. No matter how good you think you are, you should always be trying to find new methods or ways to

improve. I'm not an administrator, but if I was, I would accept nothing less than that from any employee or they would not be able to work for me.

Section summary. Based on the data, each of the teachers has assessed their own learning ability and preferences. Each of them has had confidence in their own ability to learn at some point in their life, but two of them experienced chemotherapy as cancer treatment and noted the changes in their ability to learn due to the chemotherapy. Three of the teachers clearly indicated a growth mindset in their reflections on themselves as learners. Bree's answers did not allow for a determination of her mindset. Kate, Matt, and Jay all talked about specific things they had learned as adults and recently, which is further evidence of their growth mindset. Some of the learning was in areas outside of education, but each of the three also talked at some point in the interviews about learning they have done in the past year or two that specifically relates to instruction. More of this information will come out further into this chapter in the teachers' responses to questions about their transformation.

In asking the teachers to evaluate their own instructional abilities, the researcher was a little concerned that they would choose to be more modest than truthful in their assessment of their own ability. However, each of the teachers gave significant thought to the question and relayed answers that seemed a sincere self-appraisal. None of them believed that they were an instructional "superstar" but all of them placed themselves somewhere in the middle. Kate and Matt recognized specific areas they wish to work on to improve their instruction. In the interviews some barriers to making the improvements were identified. Table 2 below summarizes the learner and instructor data.

Table 2
Summary of Research Participants as Learners and Instructors

Teacher	As Learner	Mindset	As Instructor
Kate	life-long learner; learns best on her own until she has the basics; interested in learning new things in many different areas	growth	struggling due to health issues and energy; believes she falls short in spending enough time planning
Bree	short attention span due to recent cancer treatments; must see value in learning the information otherwise she won't put the effort into it	unknown due to nonresponsive answers	places herself on the upper end because she can relate to students and provide enough to move them along
Matt	detail oriented	growth, specifically understands mindset concept and believes mindsets can change	believes he is somewhere in the middle and is working to improve in the areas of differentiation and technology integration
Jay	tenacious-works until he learns it; brain fires well	growth	believes he is not the best, but much better than he used to be; spoke about continuous improvement as a focus for teachers and their instructional skills; chooses one content area each year to focus on for improvement

The Instructional Transformations

Each teacher was asked to describe a transformation in their instruction. They were told that the transformation could have occurred anytime during their teaching career. Matt and Bree each chose two transformations to discuss, while Kate and Jay each selected one transformation. Therefore, the data for this study includes six transformations. Three of the transformations are

instructional strategies related to teaching math or science content and are referred to as content-centered transformations. The other three transformations involve strategies for working successfully with people and are not tied to teaching any specific age of student or any specific content area and therefore are referred to student-centered transformations throughout the study. Both content-centered and student-centered transformations are considered instructional transformations because the definition of "instructional transformation" used for the study is any change intended to alter the learning experience for the student. Instructional transformations may be in the form of changing the way the student engages with content or in the way the learner engages with the teacher. A summary of the transformation information is provided in Table 3 at the end of the section.

Content-centered transformations. The transformations specifically related to the teaching of science and math include Kate's inquiry-based teaching of math, a focus on teaching vocabulary in science done by Bree, and Matt's use of probes in labs to help students obtain accurate data.

Kate's inquiry math transformation. Kate, who has been teaching at least one class of middle school math each year for the past fifteen years, transformed her math teaching a couple years ago by eliminating the prominence of teaching standard algorithms for problems solving in favor of an inquiry-based, student-discovery focused math curriculum. She still teaches the standard algorithms, such as the equations for area of shapes or the process of long division, but now her students work to arrive at those after working to establish conceptual understanding first. In explaining the change, Kate said:

> All of the things that I took for granted with math made me start questioning why I do math that way [and] why I am asking the kids in my class to do math that way. And, so I

> really started, at that point then, when I got back into the classroom, really started looking at, all right, if I'm going to teach them how to do this, [then] before I teach them how to do it, I'm going to teach them why to do it. I'm going to do the history behind it and we're going to practice some of these procedures that we do before we ever get to the standard algorithm.

Bree's vocabulary transformation. Bree explained her transformation choice with brevity. In teaching middle school science, Bree made an intentional shift in her teaching to focus on vocabulary, stating, "If they [the students] can learn the vocabulary, then they can figure out most of anything else so, I stress vocabulary and I'm using more ways of memory techniques for the kids."

Matt's lab probe transformation. Matt teaches several upper level high school science courses, including advanced placement and concurrent enrollment courses. He considers lab work to be a critical component of student learning both in terms of science content and for lab skills. In Matt's curriculum, some labs are prescribed step by step for students because they are designed to illuminate material taught by direct instruction rather than support student inquiry. Speaking about the more prescribed labs, Matt noted:

> [As a teacher], I experienced some of the same things that I experienced as a student in high school and college as we were doing the labs. Some of the labs, the results were quite variable. It was frustrating to the students and also to me as a teacher to have students work so hard following instructions, trying to do the right thing but we didn't find what they were doing wrong easily at times until towards the end of the period when the data was worked up and they actually handed the report in. Well, that's no good. You want to be able to make corrections on the fly. You'd also like to be able to collect good

> data within a reasonable amount of time and if people tend to be visual learners, it's nice to be able to see the data in more than just a number form, to be able to generate graphs on a laptop computer to be able to see relationships more easily.

His solution to these lab-based frustrations was to purchase and use lab probes, specifically Vernier LabPros and the accompanying software. Vernier is a company that manufactures and sells lab equipment: "Vernier pioneers award-winning interfaces, sensors, software, and curriculum to transform how educators teach science and how students collect, analyze, and interpret scientific data" (Vernier, 2016). The LabPro line of equipment has sensors in tools that are designed to provide accurate measurements of properties such as pH, dissolved oxygen, and temperature. The accompanying software, which Vernier also provides, allows the measurement data to be displayed on a computing device in various formats such as graphs over time or tables of repeated measurements.

Student-centered transformations. Bree, Matt, and Jay all chose to discuss a transformation about how they relate to students. In their own ways and for their own reasons, they each talked about learning to see their teaching more from the student perspective and about becoming much more learner-focused in their approach to teaching.

Bree's transformation: More relaxed teacher. Bree noted this about science teaching: "It [science] has to be an academic [class], a needed discipline, but I've got some kids with some real emotional issues, so you kind of have to give them space." and she also talked about becoming "more relaxed and less rigid" in her approach to teaching.

Matt's transformation: Learners have different and significant needs. Matt had two experiences in a short time that prompted him to really examine his teaching through the eyes of his students. One of those experiences was working with students in Upward Bound, which is a

program designed to help high school students with college potential who have barriers to college admission such as poverty, low grades, or no family history of college attendance. Matt shared:

> In working with students from the Upward Bound program, [I learned that] there are many things that go on in students' lives that teachers don't think about. If you're concerned about where you're going to sleep that night or whether there's going to be enough food, you can't concentrate on school. If you have some sort of strife going on at home between Mom and Dad and they're about to divorce or if you have friends that are talking you up on Facebook and posting inappropriate pictures or there's lies about you that are circulating at school that people are propagating, how can you focus on tough college prep science courses?

Jay's transformation: Students do not all learn the same way. Jay captured his transformation succinctly in saying, "For me the transformation would probably be tailoring the education to the individual and realizing that none of them learn the same."

Section summary. The transformations that teachers chose to discuss were classified into two categories. The researcher anticipated that the teachers would choose transformations related to their content teaching, such as the math inquiry instructional change that Kate implemented, the vocabulary teaching Bree selected, and the lab probes Matt discussed. However, three of the teachers chose to talk about a transformation in the way they worked with and related to students. The researcher did not expect such a strong focus on student relationship building in the study. Yet, due to a variety of personal experiences Bree, Matt, and Jay all chose a student-centered transformation. The instructional transformation selection results are summarized in Table 3.

Table 3
Summary of Transformation Selection Data

Teacher	Category	Transformation
Kate	Content-centered	Inquiry-based math instruction
Bree	Content-centered	Focus on vocabulary teaching
Matt	Content-centered	Probes to get accurate lab data
Bree	Student-centered	Being more relaxed with students
Matt	Student-centered	Meeting student needs
Jay	Student-centered	Differentiation both in academics and in working with students

Why the Transformations Were Made

Teachers can make changes in instruction for a variety of reasons. A significant part of the interviews was devoted to exploring the reasons for the transformations. The teachers clearly articulated one or more reasons they made the transformations. Again, this section is organized by the type of transformation with the content-centered transformations first, followed by the student-centered transformations. A summary of the basic information about why each transformation was made is provided in Table 4 at the end of the section.

Content-centered transformations. As professional educators, the participants in this study have had many opportunities for professional development. Professional development may come in the form of a workshop to learn new instructional strategies, which is what prompted Kate to change her math instruction, or in the form of sharing ideas with colleagues, which is what caused Bree to change her instruction, or in the form of seeing something new at a conference, or as in Matt's case by working on a grant funded project. The fundamental reason to change instruction, for each of these teachers, is to improve learning for students.

Kate's inquiry math transformation. Kate changed her math instruction after attending an Intel Math workshop series. Kate described the training and her reasons for going to the professional development workshop:

> Three or four years ago I was asked to go to a math program at the Intermediate School District and it was a math program put together by Intel. I had done some work with Intel before and knew that they only did quality work. So, three of us from our school were asked to go do the Intel training and come back to the school and try to put it in with our curriculum. It was extremely intensive-one week in the summer for two different summers plus eight or ten days out of the classroom and going to the ISD during that school year. What we did was really take math back to the basics and so you might have the standard algorithm for multiplying two digits numbers together, but the whole purpose of Intel Math was to take you back to the basics of what are you doing when you do that algorithm and why does it work.

Bree's vocabulary transformation. Similarly, Bree, who transformed her instruction to focus on the teaching of vocabulary, said, "That's where kids fall down is the vocabulary." She teaches one semester of eighth grade science and another teacher has the students for the opposite semester. She said, "the decision [the other teacher] and I made together is to focus on the vocabulary. If they can learn the vocabulary, then they can figure out most of anything else so, I stress vocabulary."

Matt's lab probe transformation. As a chemistry and physics teacher, Matt uses labs in his teaching. Prior to incorporating the Vernier probes in lab he noted that, "there was a tendency of students to get frustrated [and] to say, 'Aw, man, this physics stuff doesn't work! How can I understand? How can I believe it?'" Thus, his reason for the transformation,

> If you have good data, you can show the relationship that the lab was intended to show and the students learn and there's a satisfaction that they have. They got the take-home point because they understood it and the data supported the take-home point. They believed it and could apply it.

Student-centered transformations

Bree's transformation: More relaxed teacher. Bree, who has been teaching in excess of twenty years in a variety of settings, explained the reason for her transformation, when she was asked "Can you think of a transformation that you made? And it could have been anytime in your career." She said:

> Oh, absolutely. Several [transformations], throughout the career, but the two most significant were both times I had cancer. And just the approach to it [teaching]. I'm a lot calmer now than I was before, so it's a personality change and for example, in art, I was much, more strict before or rigid in many ways and now I'm not. The kids still have their expectations, their rubrics, but I also try to create more of an atmosphere where they can come in and relax and enjoy the process of art.

Matt's transformation: Learners have different and significant needs. Matt shared, "Ok, the [transformation] is an early change and I'm going to be very honest and tell you something that's painful, but that benefited me greatly." After he had been teaching at the college level for a few years, he invited someone who was both a trusted friend and his superior to evaluate his teaching. Matt said:

> I asked him to come and evaluate me because I wanted to have some sort of record of how I was doing. I received the worst evaluation that I have ever received. I thought I was doing a wonderful job and I wasn't. The points that he made were excellent. At the

> time it was very painful, although I did not...I did not react well to it inside, although I took it in stride in reacting to him and with others. But see, [the person who evaluated him] is a wonderful teacher. He was trained as an actual high school teacher. He has a master's in science teaching. He knows how it's supposed to be done. I had never gone through any of those experiences at that point. I had taken the university route because I was interested in becoming possibly a professor and I would have focused on research, although I love teaching. I made slides with words that were too small. I went too quickly at times through the information I was presenting. I did not put myself in the students shoes at times when I was using jargon in explaining jargon that is common to science and I was making assumptions about the students that I should not have-that they had some of this material in high school or in their prior background, and so, they're at college, they're at the university level, they should know. Well, that's not true. As a side note, in addition to discovering this about myself and about my teaching, I also discovered something very important about students.

Matt had one of those perfect storm situations happen to him at this time in his career. Not only did he receive an evaluation of his teaching that indicated he was not the teacher he thought he was, but he also started working with students in Upward Bound, a program to help high students overcome obstacles, such as financial need and no family history of post-secondary education, to get into college (US Department of Education, 2016). During the summer, the students take supplemental courses on a university campus, which provides both academic support and the opportunity to see a university. Matt said that, at around the same time, he received the painfully poor evaluation:

> Through the Upward Bound program, I discovered what it means that all students can learn. There's a mindset that many teachers have, and I think it's true of teachers at the college level, too, and it's "some students can't learn this stuff" for the particular subject that they teach. I don't think that that's true. In working with students from the Upward Bound program, there are many things that go on in students' lives that teachers don't think about. If you're concerned about where you're going to sleep that night or whether there's going to be enough food, you can't concentrate on school. If you have some sort of strife going on at home between Mom and Dad and they're about to divorce or if you have friends that are talking you up on Facebook and posting inappropriate pictures or there's lies about you that are circulating at school that people are propagating, how can you focus on tough college prep science courses? If you are in the university arena, if you are worried about losing your financial aid or there's boyfriend/girlfriend/significant other problems, those are all distractions, too. We all have challenges at one time or another in life that we work through. In addition, people make opinions about themselves and their own progress which are incorrect at times.

Jay's transformation: Students do not all learn the same way. Jay has a pragmatic, common sense approach to education. Perhaps some of his pragmatism has been reinforced through his years of teaching low level high school math students or perhaps his pragmatism makes him a great fit for working with such students. When asked about why he made his transformation, he stated:

> I could just tell they didn't understand what I was talking about. I knew they weren't learning the content. Formative assessment is second nature to me. I didn't even know like that word is part of the jargon right now. It's pretty simple: You teach, you check to

> see if they learned it by walking around, asking questions, looking at their work, and you're doing that naturally as a teacher. And when they're not learning, I don't blame kids. I ask why. I'm not one to say it's their fault. I truly believe...you know if you truthfully want to know the transformation, I'm a firm believer that if you have to do something you do it. I'm paid to teach all kids. Not just the ones that come here well rested. Not just the ones that didn't have a big fight the night before. I have to find a way to engage every kid, no matter what I receive. That is my job, whether I like them or dislike them. Quite honestly I can't dislike anybody. I'm incapable of it, but I did that today with a young lady. I know she has been off her game and come to find out she's been off her medications for several conditions. I sat with her and we worked together for an hour. So, again, I have more successes than failures. Any time I have a failure, I say, "Well, why?" And, you know, that's the beauty of teaching. Every year you get to reinvent and find new methods of reaching them and you do that by interacting with them, not talking at them. To teach, you have to interact back and forth. There has to be a banter back and forth. That's the only way they will actually learn. They can write notes down, but it doesn't mean they know what they are doing.

Section summary. Every transformation in this study was done to try to improve student learning. The teachers may have recognized a need that students have and sought a professional development opportunity to educate them on how to better meet the need. Or, the teachers may have simply seen something somewhere that they recognized as a way to improve student learning and then figured out how to use that in their own teaching. In each of the cases of that in this study, the teachers each had intense personal experiences that led them to make the changes. Table 4 summarizes why the teachers made the transformations.

Table 4
Summary of Why Transformations Were Made

Teacher	Why Transformation was Made:	Transformation:
Kate	Intel Math workshop Series	Inquiry-based math instruction
Bree	To improve student learning	Focus on vocabulary teaching
Matt	Frustration with lab data	Probes to get accurate lab data
Bree	Cancer	Being more relaxed with students
Matt	Poor evaluation of his teaching	Meeting student needs
Jay	Noted lack of student understanding	Differentiation both in academics and in working with students

How Transformations Were Made

The reasons teachers have for transforming instruction are very important and that information is potentially valuable to educational leaders, but probing into how instructional transformations are made could be an even more important topic for educational leaders. For example, a building principal can only go so far in convincing a teacher to do something different, but once the teacher decides to make a transformation, knowing what is needed to make that happen is very useful to an educational administrator or leader.

In this section, the three content-centered transformations and the three student-centered transformations are examined again, but this time for detailed data about how the teachers made the changes. After the interviews, the researcher spend time observing each teacher in action with students in their classroom. The researcher was specifically looking for evidence of the transformation(s) in each participant's instruction and interactions with students. The classroom observations provided much rich data for the study and are primarily shared in this section of how teachers made the transformations. A summary of the basic information about how the teachers made the transformations is provided in Table 5 at the end of the section.

Content-centered transformations. Unfortunately, the researcher was not able to see Matt teach a lab with the Vernier equipment, but the researcher has used them for labs herself and is therefore familiar with what they can do. Therefore, Matt's content related transformation data are all from his interview. The researcher was able to view lessons in Bree's classroom and Kate's classroom of the content-centered transformed instruction, so both interview data and observational data are provided in this section.

Kate's inquiry math transformation. After interacting with numbers differently herself in an Intel Math workshop, Kate decided to try to change the way her students experienced math. When asked about how she made the change, she began by talking about her own experiences in the workshop:

> We did a lot of hands on math. They made us get out of our comfort groups. You know, when you go to a training, you kind of sit with the people you know. They would break us up so you sit with other people. It was cross grade so sometimes you'd be sitting at a table with a kindergarten teacher, a third grade teacher, a sixth grade teacher, and a ninth grade teacher. You'd be working on the same activity and you'd hear the kindergarten teacher say things like "this is stupid because this is so far above what I need to be doing to teach it to my children that this is really of no value to me" and the ninth grade teacher could say the same when we were doing some of the simpler things and yet, what really kept getting brought up to us was you need to know where the kids are coming from and you need to know where they're going when you're done with them. That was a really hard concept for some people to understand, I think because they felt like they were there to learn how to teach, but that was not really the intent of the training. The intent of the

> training was to give you that massive background of numbers and how they work together.

Later in the interview she went back to the idea of how abstruse the workshop goals seemed to the attending teachers when she said:

> It was a very hard thing to wrap your head around: that you're going to go spend all this time there and all you're going to do is learn to love math. Truly! And then you have take that love and you have to figure out how to put it in your classroom.

When questioned about how she incorporated the ideas into her own classroom, she said:

> I think the biggest challenge was letting go and letting the kids explore on their own because, as the teacher, you're supposed to know what you want them to do, how you want them to do it, what you want your outcome to be. That whole process of stepping back to say "All right, today we're going to work on dividing fractions and I want you to see what you can come up with from this." and just giving them something and letting them do everything they can to it and then saying, "I see you got it this way. Can you figure out another way to do it? Can you find another way to make the same thing happen? Do you get the same answer if you do it this way? How about if you use a manipulative for this?" And, that is extremely hard to do because suddenly you're feeling like you're not in any kind of control any longer. Yet, you know that there has to be outcomes that happen even if you're letting them do their exploring on their own. So, it's just a real difficult thing to do, to let go and let them do what needs to be done on their own.

Kate's classroom observation data. During the classroom observation of Kate's math class, which included both days of a two-day lesson, she facilitated learning by asking key

questions as she walked around to check on student progress and learning. The students were in groups. Kate said in her interview that she usually groups a high, a middle, and a low math student together in each group. The lesson was on finding the equation for area of a triangle. The lesson information provided to students first directed their attention to the equation for finding the area of a parallelogram, which they had learned at some point earlier. Then they each cut out a parallelogram from graph paper and subsequently made a diagonal cut to create two triangles from their parallelogram. From that point on the lesson challenged the students to discuss and explore how to find an equation for the area of the triangles. Kate spent the beginning part of the group work time checking in with each group to make sure they were following directions to get the triangles from the parallelograms, but then she began to ask questions as she visited each group of students. In one interaction Kate asked, "What would the formula be?" and a student said, "I think it's length times width divided by three." Kate responded with, "Why would it be divided by three?" The student said, "Because 'tri' means three." At this point a student in another group suggested that the formula might be length times width divided by two. When Kate asked why he thought it should be divided by two, he said, "because we cut the parallelogram into two triangles." Kate then directed students to try out both proposed equations and compare the answers with the area they could find by counting the squares of the graph paper in each triangle. The result of this was that the students became convinced the correct equation was the length times width divided by two.

One of the things students struggled with in this lesson was the idea of length and width versus base and height. They knew that area of a rectangle or parallelogram was length times width, but then Kate asked if base was the same as length. Base is commonly used in measuring triangles and was a term brought into the discussion by students. As Kate tried to help students

make the connection between the areas of the two shapes, she tried to guide them to the realization that base and length were synonymous terms in what they were doing, but the students weren't sure. The students seemed to be able to identify base and height on triangles and length and width on parallelograms but were not convinced that the terms base and length were interchangeable. Kate had to end the lesson for the first day at that point due to time constraints.

The next day students were asked to get into groups again and work on two problems. The first problem asked them to find the area of a parallelogram that had a square cut out of it. The challenge of the problem was that they had mixed units. The parallelogram measurements were in feet and the square measurements were in inches. Most groups figured out to convert the units after a few minutes, subsequently found the area of the parallelogram, and then subtracted the area of the square. However, one group was working on subtracting out the square first and then finding the area of the modified parallelogram. They were struggling to use mixed units in their calculations. While the problem is solvable in this manner, it is much more difficult. Kate encouraged their thought processes because they were correct and the path they were on could lead to a correct solution, but she pointed out that the mixed measurements, such as 3 feet 2 inches for the width of the parallelogram, made the calculations more difficult. She asked them to explain why the mixed units would make the problem more difficult, which they could correctly verbalize for her. The group then seemed to get stuck with some group dynamic issues in arguing about how to try a different way to solve it, and they never did get to a solution. Even though the worksheet given to each group had two problems on it, many groups only did the first problem and at least the one group who argued did not even get the first problem done.

During the two days classroom observations of Kate's math teaching, most of the time was used in the group work already described; however, students also had the opportunity to

solve math problems individually during the warm up for each lesson and as homework given at the end of the first lesson of the observations. Kate facilitated discussion of each problem as they checked answers in a whole class setting. Kate asked a student about how they solved a problem and the student responded with, "I used the distributive property first and then found the common factor." For another problem a student had an incorrect answer and when asked about why he missed the problem, he said, "I did it out of order." Kate responded, "Ahh, order of operations!" and then had the student explain how he had done the work out of order and what should have been done first. For another problem, Kate asked, "What does the s squared tell you about an area?" The students answered that the shape must be a square. When students were grading their homework, Kate challenged them to find their mistakes and students identified math errors they made such as not carrying a number in a two digit multiplication problem or forgetting to divide by two when finding the area of a triangle. At the end of the second lesson, in the whole class wrap up, a student asked, "Feet to inches is multiplication, right?" Kate answered with yes and a brief explanation that when you go from a bigger unit to a smaller one you would multiply to get a bigger number. Immediately, a different student piped in with, "Except for fractions, right?" meaning that when you multiply by a fraction, you actually get a smaller number. Kate again answered with yes and asked the student why that was true. The student replied that it was because a multiplying by a fraction was actually like dividing.

Bree's vocabulary transformation. Bree has been teaching middle school for many years, but middle school science for only about five years. Bree changed her science instruction to focus on vocabulary because she saw students struggle with the vocabulary and perceived science terminology as a barrier to success for the students in her science classes. When asked about how she made the change, she said:

> I stress vocabulary and I'm using more ways of memory techniques for the kids. I do flash cards with the kids. It's one way of doing it. You know, exposure, exposure, exposure. Telling them, showing them, practicing with them, whenever you do the vocabulary, this is how you can remember it, this is how you can do that. Even using bribery. I know you're not supposed to.

She laughed at this point in the interview before continuing with the following:

> We have pop quizzes and pop quizzes mean that if you get a seven out of ten with an extra credit, so seven out of eleven, they get their choice of a tootsie pop, a blow pop, a pop tart, popcorn or pop.

Bree's science students have a pop quiz every week. Bree's definition of a pop quiz is a short quiz that is not announced prior to the day of the quiz. The students know they have one each week, but they do not know on which day it will occur. On a day when a pop quiz is given, Bree will often have students review just before taking the quiz.

Bree's classroom observation data. During the classroom observation for this research study, the students had a pop quiz over the scientific method. Prior to the quiz, Bree asked students to review on their own or with a partner. She assisted one group of students by providing an analogy to help them remember what a constant is in a scientific study. Then Bree reviewed the terms with the whole class, and as they discussed each term, she asked for two students to share about how they remember the definition of the vocabulary term. Bree said that due to the importance of the information about the scientific method, the students were having three pop quizzes, one per week for three weeks, and they must pass two of them with a certain score. When asked about what if a student didn't pass two of these pop quizzes, she responded that they would retake it at lunch time until they had passed two of them. Most of the material for

this course is assessed once with a pop quiz and then assessed in other ways. Once a student finished his quiz he brought the quiz to Bree at the front of the room. Bree immediately graded it and talked quietly with them about it as needed. If the student earned a high enough score they chose a treat. On the day she was observed, she offered students pop tarts, blow pops, and tootsie pops.

Although Bree did not mention it during her interviews, when the researcher visited her classroom for the observation, she talked about teaching students a specific note-taking strategy by using Cornell notes. During the classroom observation, after the pop quiz was over, the students used paper Bree provided for their Cornell notes. The paper was already divided into three sections. The left margin was separated for key points, the bottom quarter of the paper was sectioned off for a summary and/or further questions, and the rest of the paper formed the largest section for note taking during lecture. Bree used a PowerPoint presentation to teach the organelles of the cell. Students took notes using the Cornell note sheets provided. During Bree's lecture the names of the organelles were highlighted as vocabulary words. The PowerPoint slide presenting the nucleus spawned a discussion when students realized that the nucleus of an atom, which they knew from an earlier unit, and the nucleus of a cell had similar meaning. Bree did not point out the similarity-in fact she didn't have the opportunity to do so. A student immediately made the connection between the two uses of "nucleus" and noted his thoughts aloud and then a few other students responded with more information and ideas. In this case students understood that the same word was being used for two different structures in science because the meaning of nucleus fit both situations, and Bree confirmed that it was the same word used for two different structures, one in chemistry and one in biology. However, when Bree verbally asked why the nucleus of the cell has a double membrane as part of classroom discussion during her lecture, she

did not recognize a probable student misconception due to the vocabulary. One of the students who answered her question seemed to think that one of the membranes was for the nucleus of the cell and the other was for the nucleus of the atom. Bree did not respond to the student answer as if it were a misconception. The student did not express her ideas with tremendous clarity, but at least the strong potential for a misunderstanding was present in the answer she provided, and Bree accepted and affirmed the answer as it was given.

Matt's lab probe transformation. Vernier lab probes are fairly expensive, and Matt did not have experience with them when he was a student, so his interview delved into both how he discovered their value as an educational tool and how he funded the purchase of enough to outfit his lab. Matt worked as the principal investigator on an education grant funded by the Environmental Protection Agency prior to becoming a certified teacher. The author of the grant worked for the Department of Health and hired Matt to be the educator on the project. Later, Matt collaborated again with her and a local chemistry professor on a water quality education grant funded by the Environmental Protection Agency. Matt said:

> And that was the project where we first used lab probes. Actually, [the author of the grant] brought one. I had never seen one before. It was just written into the grant. I guess she had purchased a handful of them. So she showed me how to use it. I thought, "Wow, this is great! It's so easy!" We were there with students and she instructed a student or two and they went off and did their thing and got great data and brought it back and they had fun. I thought if this is what technology is like and the students are having this much fun with it, we ought to think more about this. We measured temperature, conductivity, and then we purchased a dedicated device to get dissolved oxygen. So, it all was very

interesting to me. And then I went through my teacher ed[ucation] courses and I took students on one of these field trips for water quality analysis, a continuation of the grant.

The principal of the high school went along as a chaperone on that trip. Matt shared:

> He liked the project, the way it was run, and I wanted to write a couple of grants to get lab probes that were here at the high school so I wouldn't have to borrow them from the ISD or [local university]. I could have my own set of probes and I thought that perhaps in the future I could write more grants and the collection would grow. Well, that's history now. It worked. I got over $7,500 in grants and when something is working, other people are willing to contribute toward it, too. So, the Upward Bound program offered to purchase some equipment to help with what I was doing over here. [The principal] was willing, more willing to contribute because he could see what I was doing with it and how it was affecting the science instruction.

Once Matt had lab probes, he designed labs integrating the use of the probes for both chemistry and physics. He discussed a specific lab that he uses to help students develop concrete understanding of the motion concepts of distance, time, and acceleration. He noted that the students often had incomplete understanding or even misconceptions, especially about acceleration versus time graphs, until he began using the lab probes to investigate motion. He offered this information about how he worked to implement the probes into various labs:

> I would troubleshoot the labs in the evening to make sure that they were working well and that I understood the procedure. And then I'd have a short pre-lab. After the first lab or two the students enjoyed working with computers because they could see that's in their future. When they got to college that's something they would need to know. Some of them, some of the students were a little intimidated by it because it was a brand new way

> of thinking and doing things for them. But others of them just ate it up. They absolutely loved it. As I went around helping the groups I could help them if they were having equipment troubles. At times there would be trouble with the sensor. Replace it-done! Sometimes they didn't calibrate correctly. I could calibrate for them. Done! If they were having trouble collecting data, I could see from what they had on their screen what the problem was and fix it so that nearly every group by the end of the lab had good data.

Student-centered transformations. In explaining how they transformed their teaching to be more student-centered, Bree, Matt, and Jay each talked about at least one specific student from their own experiences who had tremendous challenges due to issues beyond the classroom such as home environment or immense social awkwardness or diagnosed emotional disabilities. As a result of the efforts by Matt, Jay, and Bree to meet the needs of each specific learner, the students facing severe challenges had been successful. In each case, the teacher implied or discussed the high likelihood that those students would not have graduated without their efforts to help the students.

Bree's transformation: More relaxed teacher. The personal experience that changed Bree's teaching was her own two battles to survive cancer. Both times that Bree had cancer the situation was very serious and required her to take months off work to have treatments. Bree noted that her cancer treatments took a toll on her energy level and her ability to concentrate. She shared:

> Language is an issue. Chemo brain comes in. The biggest challenge is dealing with the fatigue and the language aspect. I point to things and say "You know that thing you write with" and the student is like "pen". That's the biggest challenge - dealing with the fatigue and the lack of finding words.

She said that her family and friends have told her that she is a lot calmer than she used to be and these changes have been at the root of the transformation in her teaching to be more relaxed and student-centered. Bree believes that

> Even if I hadn't had cancer or hadn't had it again, you still have to adapt because the kids today are wired differently due to the technology they use. If you want to stay old school, that's fine, but you're going to lose most of them.

Bree's classroom observation data. During the classroom observation, Bree allowed students to leave the classroom to get drinks from the drinking fountain, which is right outside her classroom door. She also allowed students to use the restroom, which is near her classroom, without any type of hall pass. She had one student sitting right next to her desk and away from other students. She had several interactions with him during the observation. After quietly directing him to do the opening bell ringer question a couple of times, she said, "[Student name], will you please work?!" and he finally did comply. When the students were studying for the quiz, another student moved up to study with the student by Bree's desk. After a brief period, Bree said to the two boys, "Sounds to me like we've gotten off track," and then Bree helped them both study by asking questions and offering an analogy to help them remember a vocabulary term. At one point during the studying time three of Bree's middle school students were messing around and one of them grabbed another's shirt. Bree said, "Guys! Let go, stop, and behave!" and they did as she asked. When it was time for the quiz, Bree had the student who sits right next to her desk hand out the papers. After the quiz, Bree commended the class for doing well on the quiz. Bree wanted the observation to carry over into her next class, which is high school art, since some of the interview was about her teaching in art class and this transformation has significantly impacted her art teaching as well as her science teaching. During art class she

seemed even more relaxed and as she walked around helping students as they worked on a montage project. She said “Oh, cool!” to one student, asked another student about the lunch menu for that day, asked another student, “Have you thought about trying it this way?” She also granted requests to use the restroom and provided help both in terms of how to do the project and in terms of artistic information. In general, she had relaxed conversations with students, asked questions to prompt student thinking about their own art work, and engaged personally with each student in the class.

Matt’s transformation: Learners have different and significant needs. Once Matt realized, due to the poor evaluation of his teaching, that he was not the high-quality teacher he thought he was and wanted to be, he and his evaluator identified specific components that were ineffective. Matt shared:

> I made slides with words that were too small. I went too quickly at times through the information I was presenting. I did not put myself in the students shoes at times when I was using jargon in explaining jargon that is common to science and I was making assumptions about the students that I should not have-that they had some of this material in high school or in their prior background, and so, they're at college, they're at the university level, they should know. Well, that's not true.

Matt also shared about how he addressed each of these issues.

> Here are the changes: First I made the words on my slides a whole lot bigger. I tried to bring demonstrations to class, used more diagrams because people are visual learners. I am a visual learner, too and I wasn't being visual enough in the way I was communicating with my students. I slowed down and I asked more questions. My favorite question is “does this make sense?” Even when they don't want to answer, I can tell when I ask that

question because if they do understand they'll shake [nod] their heads and respond. If they don't understand when I use that question, they'll just sit there. And with the types of questions they bring up after that, I can help see what they're thinking and where I need to go back and go over information again. I did more homework problems in class. When you're a college professor, there's a tendency for people in math and science to just sort of have their own little show and to keep on going and to give all these notes and they think they're communicating and doing a wonderful job. Their students are getting all this great info. If the students don't understand the material and they can't apply it, they're not going to remember it and they're not going to build on top of it. So, what I did is, I would stop every once in a while as I was teaching, before I ever came to the high school arena, and I would ask them what questions they had from homework. And we worked on them. And the day before a test, rather than me telling them "review on your own" I actually made a review sheet. There are times when I used old tests and I would go through what I considered the most important information and [then] they had a chance to ask me anything they wanted. I got wonderful feedback from them because of that. And, frankly I got compared with some of the other faculty members that were there and did not do that. I got a lot of very private feedback from not only students, but also other faculty members that had my students after I had had them. Also faculty members that had students who were family members, like sons and daughters who were in the courses that I taught. It was pretty much unanimous that they really appreciated the fact that I treated the students with respect...that I understood that some of them struggled and needed help, and that I was willing to reinforce concepts, and do my best to communicate with them. And also, laugh when I made a mistake and be a human being. So, those were big

changes for me coming exclusively from the college environment at first as I began as a teacher.

Matt's classroom observation data. During the observation of Matt's teaching with his high school class, many student-centered teaching strategies were noted. On the white board at the front of his classroom for each class he teaches, he had written "I can" statements so students know their learning objectives as well as information about homework assignments for the entire next week and the answers to the homework due today. The homework answers were written in black dry erase marker, but next to two of them for the physics class used for the observation, Matt had written "(ask me ☺)" in red. Those were physics problems that Matt wanted to go through in class with students. As class began, Matt took attendance and said, about a student who must frequently miss class and was gone this day, "Nice to see her yesterday. Tell her we missed her." He was speaking to the class in general, perhaps hoping one of her friends might mention it to her. Matt then provided a quick agenda for what would take place in class today and asked for some helpers to pass back homework papers. He sincerely thanked each student who volunteered to help. His interactions with students were very relaxed and friendly. He granted one student some extra time to complete some work because she had missed some school due to illness. He began the lesson with, "Ok, I'd like your attention." and then thanked them for quieting down. The lesson was going over chapter review questions in preparation for an upcoming test. Matt asked students which homework problems they would like him to show and then, as they requested, he did several torque problems on the board. Each time, he reviewed the steps of the problem as he went, beginning with "let's create a fabulous diagram" before starting in with the math. He even used a meter stick and took the time needed to draw a stick figure diagram that represented the situation posed in each problem. Matt's instruction about

problem solving was very clear because he labeled his diagrams completely, wrote all formulas down as they were used, color-coded different parts of the problem to show students what was happening, and frequently asked students questions to point out commonly missed or misunderstood pieces. He asked, “What step is next?” and pointed out “This is where many students get stuck on the test.” Matt responded to various students as they answered his questions with “Yeah, good job.” “Nice work!” “It’s good to hear your voice. You could speak up more often,” and “Very nice!” At the end of each problem he paused and asked, “Does my answer make sense?” and then encouraged the students to do the same on the upcoming test when they finish a problem. At one point, in setting up a problem, Matt realized he had written grams as the unit on the drawing when it should have been kilograms. He said, “Whoops! Sorry!” as he fixed his mistake, and then he noted why he realized it had to be kilograms (so the final answer could be in Newtons, which are kilograms times meters per second squared), remarking that students might learn to catch their own mistakes in the same way. In general students answered questions correctly during this lesson, but when one student was incorrect, Matt stated that he was “on the right track” and then guided him to the correct answer. Near the end of this class, Matt asked if anyone had any other questions.

Matt’s next class was a chemistry class and was also observed as part of this research. Matt began in much the same way as the previous class, with taking attendance as students checked their own homework answers against his on the board. He started class by asking, “How are you doing today?” and then after students responded, he asked, “How did the balancing go last night?” Their homework was balancing several chemical equations. Matt asked the students if there were any equations they wanted to see him work out on the board and one of the students asked him to do number fifteen. Matt responded to the request by saying, “Good!” and then he

worked through the problem on the board step by step. He explained why he started with certain elements and asked students questions as he worked through it. After doing that problem, the students did not have any more questions, so Matt drew their attention to one of the chemical equations on the homework that was a combustion equation. He asked if they knew what combustion was, built the lesson around their ideas, and taught the concept using the equation from the homework. He then did a demonstration of combustion in which the combustion of the ethyl alcohol was powerful enough to shoot a 35 mm film canister across the front of the room and make a very loud pop as it launched! The students expressed their amazement at how loud it was and how fast the film canister rocketed across the room and off the side wall.

Jay's transformation: Students do not all learn the same way. Jay talked in this interview about his first few years of teaching. He knows that most of his focus in his first few years was on classroom management and that only when he had firmly established his classroom management style and skills was he able to attend fully to student learning. When Jay was asked about how he transformed his teaching to be more student-centered, he discussed how he uses what he knows about how students in his classes learn in order to differentiate his instructional approaches:

> Well, the most basic differentiation I'll use is, first, I know that if I'm lucky about 30% of my class can learn from two examples on the board. So I cover it. I have taught long enough to know which questions…I've taught eighth grade to twelfth grade and I've tutored all the classes to college algebra. I did that for five years so I know what they need to know at each level. I know the same mistakes are made whether you're in seventh grade or in the first or second year of college. They are making the same mistakes. I choose my examples. They have to be part of the core content. I know my curriculum and

> I choose relevant examples that will teach the curriculum. At the same time I pick my questions either on a test or in class that will have them look or use the areas that I know will cause them the most trouble. So I can point them out. I then model that, those questions. I have them take notes usually, then I assign an assignment. I've arranged the class in a way that they're sitting with people they like and I usually have somebody who learns it on the board and somebody who learns quickly from somebody close. So then I am usually left with a tier of three to five kids in any classroom that can only learn it when I sit next to them. So then I move around the room and I sit right beside them. They are not going to learn it off the board. And then I try to address their specific issues. Then, once they get going, they can usually work with the people beside them. At the end of it, in my assessment, I pick questions very specific to the skills that I want them to learn in math and they are allowed to retake their tests. I reteach the content. They can retake the test. I will change the questions so they have multiple opportunities to have access to that knowledge if they didn't get it the first time. We have an after school tutoring program which I lobbied pretty hard to have implemented and we have that four days a week so I have them stay after school for that.

Jay noted that he regularly stays after school to work with students in that tutoring program.

Jay's classroom observation data. The observation of Jay's teaching showcased his aforementioned methods well. The observation occurred in a pre-algebra class of about a dozen students. This class is co-taught by Jay and the special education teacher, but she had to attend an individualized education program (IEP) meeting the day of the observation. There is also a paraprofessional assigned to this class every day. After class, Jay noted that six of the students in the class had an IEP and two of the other students had chaotic home lives that interfered with

school attendance and academic achievement. The class was designed for high school students who were a year or more behind in math. Pre-algebra is typically an eighth grade course and these students were in ninth, tenth, and even eleventh grade. Jay began class by saying, “Get a pencil, get your worksheet out, I’ll take attendance, and we’ll get started.” Jay took attendance and then made a quick trip around the room to check and see where each student was with their work. He then said, “Please put your pencils down,” and he showed a math problem on the board at the front of the classroom. As he began the problem he asked the students, “What do I see that jumps out at me?” A student identified the negative sign in front of the first number. Jay queried, “How many times can I use it?” Another student answered, “Once.” Jay continued to question and answer his way through the problem. At the conclusion he told his students, “My eyes don’t see this stuff the way yours do. Math is not hard, you just have to see it correctly.” Jay used a clapping monkey toy he had in his desk at one point during the problem to applaud a student for answering correctly and to another student he quickly apologized when he mistakenly thought the student suggested cancelling out the wrong thing in the problem. Jay deliberately taught specific pieces of math equations. Part of his lesson was about the division bar in a problem and what it means you can and cannot do with the numbers. Jay spent fifteen minutes in direct instruction, mostly with the first problem, but he also introduced a counter example to the division bar point he made to students. During this direct instruction, Jay also pointed out common mistakes that he saw students doing yesterday while they were working on problems. Then the students had work time for the rest of the class period. The paraprofessional spent most of the work time with three students in the back of the room who were working ahead of the other students. She had the answer key and checked their answers as they worked. She also answered questions students had about the work. The students and paraprofessional seemed to

have a very collaborative working relationship and the students were diligent in their work. That left eight or nine students who were working individually on their problems. Sometimes the students helped each other out. Jay moved around the room with a stack of blank notebook paper, checking on students, helping students by working out problems with them on his notebook paper, and redirecting off task behaviors. Jay's tone was authoritative, but friendly. He called one student by name and then motioned for him to turn around and get back to work. He called another student by name and said, "You need to settle down." To another student he said, "Put a slash through the ones you get wrong. Don't erase, so I can see your mistakes. You probably got them all right, though." To another student he said, "[Student's name], you're day dreaming!" Jay paused for a moment, then asked the student, "Are you back? I don't know where you go. It must be a happy place." He smiled at the student with the last sentence. To another student, "Sit up [student name]! You'll think better." When students complied with his requests, which they always did during the observation, he thanked them. At times, two or three students had their hands up to solicit help at the same time. Jay tried to get to each of them in the order he saw them and said things like, "Let me help [student name] and then I will head over to help you."

To this outside observer, Jay seemed like a firm but benevolent task master in math class. At the end of his interview, Jay shared some treasured notes he has received from students over the years. During his teaching career, Jay has always been assigned to teach the lower level high school math students and therefore has always spent at least part of his day with the most "at risk" students in the school. One student wrote,

> Since the teachers have challenged us to write a letter to a teacher as a sign of appreciation for the work they do, I thought I would take some time to write a quick one.

> I chose to write to you for a couple of reasons. The first being how much work you put into to your job. Don't get me wrong, all of the teachers here put in a huge amount of work, but it is almost inspiring to show so much passion for what most people consider a dull job. The second reason is how much you care about your students. Every single student that comes into your door you treat with an equal amount of respect and as somebody who typically gets judged based on bias very frequently, I find that one characteristic very respectable. I can already say that just being in your classroom every day for the past quarter has changed me. Not drastically, but the way I think is different. I am still a very confused teenager so it is hard for me to express what I mean through words but my outlook on life is a bit different in a positive fashion thanks to you. I feel like you change a lot of people for the better and you don't even realize the amount of influence that you spread, but us kids are always listening and changing. That's the thing about us, we don't like to talk much about what is going on in our heads, but the slightest little thing someone says can change us entirely. I am comfortable with voicing what is going on in my head nowadays since I am a bit older and slightly more mature. But, I can tell you confidently that there are a lot of kids who get influenced by you. So I would just like to say thank you for all of this.

Another student who had moved on to college wrote to Jay and shared this with him:

> I'm writing a paper about you. Here's a few paragraphs that I have been working on: The whole class roared with laughter. His class was exciting and it certainly was not because of the quadratic formula or love of numbers. He was honest and real and we knew that. We knew that he would answer any question that we had or talk about anything we wanted whether it was about school, life, love, poverty, depression, hope,

> goals, or our future. It didn't matter. Yes, he cared that we learned math and how to compute numbers and all of the other abstract academic bullshit. But more so, he cared that we were happy and that we knew we were loved. He knew if one of his students was feeling down or needed someone to talk to. To this day, I am not sure how he pulled that off. How did he know? Did our eyes beg for his kind and wise words? Were we that obvious? Time and time again he knew that I needed someone to tell me that everything would be ok and that soon enough I will be an adult and in complete control of my own life, whatever that means.

Section summary. How the teachers transformed instruction was highly personalized to their own learning preferences, what they teach, what the transformation was, and the needs of their students. However, in each case the transformation required an investment of time and thought as well as changes in the classroom structure or culture. Transformations rarely occur rapidly, so each teacher experienced a learning curve as they refined what worked well and what needed to be rethought. In some cases the transformations were relatively easy to make because the transformation made life easier for everyone in the classroom, such as Bree's more relaxed teacher transformation. In other cases the transformation was very difficult for the teacher to make. Kate had to relearn how she did math herself, do a paradigm level shift in what she thought math teaching was, and then work to find all the manipulatives and hands-on activities. She needed to transform her math to be inquiry based and conceptually focused. Table 5 presents a summary of the data in this section.

Table 5
Summary of How Transformations Were Made

Teacher	How Transformation Was Made	Transformation
Kate	Kate began teaching math using an inductive rather than deductive approach. Her instructional strategies changed dramatically.	Inquiry-based math instruction
Bree	Bree began having students use flashcards and mnemonic devices to better learn vocabulary terms, and she started giving vocabulary pop quizzes every week.	Focus on vocabulary teaching
Matt	Matt first learned to use probes when working on an EPA education grant that had high school students using probes to get water quality data; Matt funded his own set through grant writing.	Probes to get accurate lab data
Bree	Talks with students as people and allows them to have their needs met (high energy students can move around during class, can get drinks of water, etc.)	Being more relaxed with students
Matt	Matt changed the way his PowerPoint slides looked, did more problem examples and homework problems in class, started using demonstrations and diagrams in his teaching, appeared more human to students, asked questions to check for understanding, provided reviews for tests, and respected his students and their struggles much more.	Meeting student needs
Jay	Jay arranged student seating so students could help teach each other, started working individually with students who needed that to learn, learned his curriculum and what pieces of it are typical problem areas for students, and now he chooses example problems and assessment questions that highlight common student misconceptions or difficulties. Jay also decided to give students multiple opportunities for retesting coupled with reteaching.	Differentiation both in academics and in working with students

Transformation Success

The research participants chose the transformations that were the focus of the study. It is logical to think that any change that was not successful would not have been chosen as the transformation for discussion. The teachers chose to discuss transformations that were an improvement in their teaching. How teachers recognize and measure success for an instructional

change is important to examine. As part of the interview, they were asked about how they knew the transformation was a success and if they shared the ideas with other educators.

Content-centered transformations. The researcher expected that the evaluation of success of the content-centered transformations would be based on academic achievement data such as improved test scores. The teachers responded to this line of questioning with some references to improved academic achievement data but used a lot of other types of student response data to measure the success of their content related transformations.

Kate's inquiry math transformation. Kate dramatically changed her math instruction to be inquiry based and in her interview she talked about the tremendous amount of time it takes to do inquiry-based math instruction. When asked about what specific things made her realize that the math teaching transformation was successful, Kate responded with

> I have kids that come up and say, "You know what? I never understood math before. I didn't understand what they were trying to tell me, what they were trying to get me to do, but if I do it this way, like you showed us that we could or we found that we could, if I do it that way, it makes sense to me and I can keep on doing that." I can watch the successes here being built upon as they move along. Sometimes within the same school year. Sometimes it's later-it's a couple years later where I see that because I helped them here, it helped them here. That's what I am there for...I am there for the kids and it just makes sense to me that you do whatever you can to help move them all along.

Since Kate did not mention any academic achievement data, she was asked a follow up question about whether she had any assessment data to support her above response. Kate's first verbal reaction was the following:

> Funny you should ask that! Because we have done GLAD [Grade Level Assessment Device] testing as our assessment data through the ISD for the last several years. I was having pretty good data with that, but last year they changed the math test. [Also,] the MEAP [Michigan Educational Assessment Program] last year changed to the M-STEP [Michigan Student Test of Education Progress] so you can't compare that data either.

Then Kate shared:

> I watched from the beginning of the year [where they scored] from about 15 to 20% tops [in terms of] what they knew. We tested two weeks ago and I still have some kids down here in the 20 to 30% range, but more than half of them are in the 45 to 55% range, which it [the score] should be since we are halfway through the school year. I have some in the 65 to 75% range. So there are gains being made. I'm hoping, with the new math recovery that we're doing, that some of the kids who are still down in the 20s and 30s, we'll be able to start pulling them up so that they're gaining with their classmates, but I don't have hard data on that yet.

Kate is currently attending a series of workshops to learn math remediation strategies and is working to bring the strategies into her teaching. When asked about whether she had shared information about her transformation with others, she said:

> I talked with other teachers about it. I've had a couple of teachers say that they are really jealous of the way I do things in my classroom, but they don't make the change. I have a special ed[ucation] teacher that comes into one math class every day and she and I work together for modifying the curriculum for the kids that need it. She has said how much she appreciates being in the classroom and watching what happens with the kids. The at-risk coordinator is in my classroom, usually for parts of both math classes and she has

> made comparisons between my math class and other math classes and said things like, "I go to [another] classroom and watch them just drill, drill, drill on the standard algorithms and the kids are so confused. Then I come to your class and watch them work on just the numbers behind the algorithm and what's happening and how they can move forward and alternative ways to do things and she said that "I watch them grow more in your classroom than what I am watching in other classes."

Of the three teachers from her school that attended the Intel Math workshop series, Kate noted that she is the one who has most embraced the methodology and made the largest change in instruction.

Bree's vocabulary transformation. Bree and the other middle school science teacher in her school changed their instruction to focus on vocabulary. When Bree was asked about how she knew her transformations were successful, she talked about a change in students' understanding of learning expectations:

> They know what they have to focus on. They know what they have to study. There is no doubt this is what's expected of you, and then for those that get it and move on, they can apply it much more broadly. And the ones that have…they're very concrete, the regular vocabulary practice and testing stuff like that is concrete. But, then there's the aspect for the other ones to be able to branch off.

Bree later added the following information about signs she sees as evidence of increased student interest and learning in science:

> I think they [the students] do a lot better. The kids are more interested in stuff. The science fair projects that the kids chose to do this year were very interesting. They were different and I think that is part of what we [did] when we went through ideas. [I asked

> the students,] “What do you think about?" So many of [the projects] really did pertain to [the individual students] this year.

Bree has discussed the transformations in her teaching with close friends who are also teachers, including the teacher she exchanges classes with at semester time. When asked about whether she had talked with the ninth grade science teacher, Bree said, “there's not been an opportunity to sit down and discuss it and I also know that [the other eighth grade science teacher], since he does the next step, he does talk with [the ninth grade science teacher].”

Matt’s lab probe transformation. Matt indicated that he immediately saw the potential the lab probes had to improve labs for students and he knew the transformation to lab probes worked as soon as he began using them:

> When I first came to [this school] I had no lab pros. I experienced some of the same things that I experienced as a student in high school and college as we were doing the labs. Some of the labs, the results were quite variable. It was frustrating to the students and also to me as a teacher to have students work so hard following instructions, trying to do the right thing but we didn't find what they were doing wrong easily at times until towards the end of the period when the data was worked up and they actually handed the report in. Well, that's no good. You want to be able to make corrections on the fly. You'd also like to be able to collect good data within a reasonable amount of time and if people tend to be visual learners, it's nice to be able to see the data in more than just a number form, to be able to generate graphs on a laptop computer to be able to see relationships more easily. And through the relationships you can also pick up student error or equipment error and fix them more easily. All those things came about.

Matt also added:

> Misconceptions are a real challenge to work with in science and you certainly don't want to propagate misconceptions by mistake but it can happen if you're not careful, so one of the ways that I try and minimize student misconceptions is by using the lab pros and it's worked wonderfully. Um, and here's one of the nicest things that I have discovered: I had students that went away to college and they'd come back after their first semester and say, "[Mr. Matt], you just can't believe it! They're using the same equipment at the University of Michigan that we used in our lab and some of the very same experiments. I was training my college lab partners because I knew how to do it." Can you imagine what kind of satisfaction I had in getting feedback like that? And I had people going to [other universities] and after a while they'd tell me that they felt like they were doing better because they had had exposure to those kinds of things in their background. So, it's all been worth it.

Matt has presented on the use of lab probes for high school science classes locally to other teachers, at a statewide technology conference, and at an international chemistry education conference. In his efforts to write grants to fund the lab probe acquisitions, Matt discussed his vision with others and said the following about it:

> Yes, I did talk to other people as part of the grants that I wrote. I always put in that I would share with my colleagues. There were others that had been to the trainings at the ISD. [Two other science teachers] had actually been given a Lab Pro, but they were sitting in a closet. They never used them. So, I bought six through my grant and [those other two science teachers] gave me theirs. And then I had eight, so that was very nice. Although people liked them when I gave presentations at the fall conference, there were very few other who used them. [A math teacher] would use them for a graph matching

> lab in math. I can't think of a single other teacher [in the school district] that has used them since I have been here.

Matt did note that he had helped a few science teachers at other schools who had used them.

Student-centered transformations. The researcher expected the teachers to discuss student reactions and interactions with them as the primary method to measure the success of student-centered transformations. While this was one major means the teachers used to gauge the success of the transformation, they also discussed the role colleagues can have in validating the changes they made.

Bree's transformation: More relaxed teacher. For Bree, success of this transformation is measured first by her own stress level and then in terms of the transformation's impact on her students. Bree communicated that as she relaxed and became less strict and more student focused as a teacher, her students also relaxed. She said in her interview, "I'm not taking responsibility for them [the students] all the time. I'm giving it back to them and that helps immensely. So, yup, they find their own answers now." She said that her family and friends have told her that she is much calmer and more relaxed than she used to be as a person, "A lot calmer is what I've been told," and when asked directly, Bree acknowledged that her cancer-modified personality has allowed her to enjoy interacting with her students more.

Matt's transformation: Learners have different and significant needs. Matt, in reflecting on the student-centered transformation in his teaching, embedded the reasons he knew it was working into answers to questions about why and how he made the transformation. Additionally, when asked if the person who had given him the evaluation that launched this transformation in his teaching had ever seen him teach after the changes, Matt responded enthusiastically,

> Yes! About two years later I was teaching a large lecture class and I had him come and evaluate me. Instead of doing the same dry old stuff that I had done in the past, this happened to be molecular geometry day and I brought in a whole bunch of balloons. I gave one to each student and I had each student blow them up, and then they were instructed to find somebody else with the same colored balloon and tie them together. I went around the room and I got their different balloons and made all the different structures: linear, trigonal, planar, and so forth all the way up to octahedral. Well, that's different. People don't usually do that kind of thing in a college lecture class. It's quite visual and it helps students understand the electron pair geometry pretty well, better than if I had just pulled out a whole bunch of models. But after we had made the balloons, then I could bring out the models and they understood better where the models came from and what they were representing. There's a point of confusion that many students have. Textbooks will ask for what the molecular geometry is and then they will ask for hybridization, bond angles, and stuff like that. Students think that it's all connected together, but actually, there's electron pair geometry which the balloons explain very well and they there's molecular geometry which focuses on the position of the atoms, which the ball and stick models explain very well. So I was able to relate those two different levels to tables to help students to be able to predict the geometry and all the other things people ask questions about: bond angles and hybridizations, stuff like that. And it helped the students a lot.

Matt also shared a detailed recounting of his efforts to interact with a significantly challenged student. He asked that the details of this part of the conversation not be shared in order to maintain very strict student privacy, but Matt explained his efforts to connect with the student

and the tremendous success, both in school and beyond, the student had due to those efforts. Matt spoke of how much he learned about student relationship building through that experience and how it made him feel that the transformation was successful at a time when he was refining his understanding of how to more effectively interact with students. When asked if he had shared his ideas about student-centered teaching with others, Matt noted that he discussed the transformation with a specific university colleague. Matt implied that he was careful about whom he shared his thoughts with at that time due to the political climate of the school and his position at the school.

Jay's transformation: Students do not all learn the same way. Jay often referenced his own improvement as a teacher during his interviews. In his pragmatic, student-focused fashion, he knew that the changes he made in his teaching were working because he observed when his students reacted positively to the changes. He said, "Every year I've taught, I've seen my success rate increase. I've seen more kids that would've never graduate, graduate. I've seen more kids have access to success." As Jay talked with the researcher at the end of his classroom observation, he mentioned that he analyzes both academic achievement data and behavior data continuously to inform his decision making about his own teaching. Jay has discussed his transformation and ideas about continuous improvement with colleagues both at the administrative level and at the classroom teacher level. Jay has even talked with his students about why he does many of the things he does to help them learn.

Section summary. Teachers gauged student responses to the transformations they made in their instruction and used that as the primary measure of success in assessing the transformation. Academic achievement data also had a role for some teachers in determining the success of the transformation. In exploring this topic, the researcher also asked about whether the

teachers shared about the transformation with colleagues. For some of the transformations, fellow educators were very important in validating the success of the transformation. The results for the theme are shown in Table 6.

Table 6
Summary of Transformation Success

Teacher	Success Measurement	Transformation
Kate	Student feedback and demonstration of math understanding convinced Kate that her transformation was working. Comments from colleagues also supported her conclusion.	Math basics
Bree	Bree observed better student learning and that students were making more personal connections to the material.	Focus on vocabulary teaching
Matt	The reaction of the students and the quality of the lab data and experience convinced Matt immediately that this transformation was successful.	Probes to get accurate lab data
Bree	Bree noted that students were more relaxed in her classes and that she was enjoying interacting with students more.	Being more relaxed with students
Matt	Student feedback and academic achievements showed Matt that his efforts were working. Feedback from respected colleagues also reinforced the student feedback.	Student-centered teaching
Jay	Jay keenly and constantly observed his students' reactions to changes in his instruction based his decision making about his own instruction and what was working well on those observations.	Differentiation both in academics and in working with students

Summary

In conclusion, each of the teachers chose to discuss one or more transformations in their teaching that they successfully implemented. Each teacher is convinced that the transformation they described is an improvement in their teaching, and they base that conclusion primarily on evidence provided by their students and secondarily on feedback from other educators whose appraisal they value and trust. The transformations themselves fall into two categories, content-

centered and student-centered, and they provide excellent insight into why and how teachers transform their instruction. The final chapter of this study will further analyze the data from this chapter and discuss applications related to this research.

Chapter 5:

Discussion

Introduction

The starting point for this investigation was an interest in teacher quality. Strong (2011) identified a need in the field of education for an operational definition of teacher quality and stated that the effectiveness of teachers cannot be truly measured without such a definition. In this qualitative investigation, instruction was parsed out as a critical component in the study of teacher effectiveness. Brophy (1986) noted that instruction is a requisite skill for highly effective teachers. Kennedy (2008) stated a need for the study of the causal mechanisms that result in high levels of teacher effectiveness.

This research study is an exploration of the mechanisms behind teacher learning in the area of instruction. Since the researcher is not able to directly scrutinize the neural pathways of teachers to gauge learning, an observable result of learning was identified. The observable result, or aperture into the teachers' brains, is transformations teachers have made in their instruction.

The data for this multiple case study of why and how teachers transform instruction include detailed descriptions in the teachers own words and actions. Four secondary math and science teachers were interviewed about transformations they made in their instruction. Then the teachers were observed during their classroom teaching of students for evidence of and further data about each transformation. The transcriptions of the interviews and the field notes taken by the researcher formed the data for the investigation, which are presented in Chapter 4.

The following research questions were used to guide the study and will be used to structure the discussion of the study:

- Research Question 1: Why do teachers transform their instruction?

  - Subquestion 1a: Is there a pattern of events or experiences that typically lead to teachers transforming their instruction?
  - Subquestion 1b: How does student learning factor into the decision by teachers to transform their instruction?
  - Subquestion 1c: How do the reasons that these teachers transformed their instruction illustrate or fit with the conceptual framework of the study?
- Research Question 2: How do teachers transform their instruction?
  - Subquestion 2a: Is there a pattern of events or experiences that teachers use in learning new instructional techniques on the way to transforming their instruction?
  - Subquestion 2b: How do teachers describe their own instruction and the transformation of instruction?
  - Subquestion 2c: How does the transformation process illustrate or fit with the conceptual framework of this study?

The conceptual framework, described in Chapter 2, used as the lens for investigating the research questions is formed from the principles of brain-based learning theory (Leamnson, 2000), metacognition (Flavell, 1979), adult learning theory (Knowles, Holton, & Swanson, 2005), and self-efficacy theory (Bandura, 1977). This chapter examines the data as responses to the research questions and evaluates the information that emerged from the study in light of current educational practices with special attention to potential applications for school leaders as well as for possible directions for future research work.

Why Teachers Transform Instruction

The teachers studied chose to transform their instruction to improve student learning in some manner due to a variety of prompts or circumstances. Within the data there are both some patterns and some notable points for discussion. One pattern is the intense personal learning that occurred prior to the transformations. Another pattern is that the six transformations discussed fall into two classifications: content-centered instructional changes and student-centered instructional changes. The notable points related to why teachers transform instruction include the role professional evaluation or feedback can have in prompting teachers to change their instruction and some insights from the teachers regarding professional development.

Events or experiences related to transforming instruction. Research Subquestion 1a asked about patterns of events or experiences that lead to teachers transforming their instruction. The interview data for the study showed that each of the teachers had an intense personal learning experience that prompted them to make changes in their instruction. Another pattern that emerged in the data is related to the types of transformations made by the teacher.

Personal learning for the teacher. At the center of the conceptual framework, described in Chapter 2, is brain-based learning theory. The fact that the teachers in the study discussed transformations in their teaching as precipitating out of their own learning experiences is logical and perhaps even expected. However, the strength of the learning experiences is noteworthy and illustrates brain-based learning theory. Leamnson (2000) described the neural pathways formed in the brain as learning occurs. A new idea forms a new pathway or connection between neurons and then, through repeated use, the pathway becomes stabilized. The teachers in the study described their learning experiences as intense, which would ensure a strong, stable neural pathway in the brain.

All of the teachers in the study had a personal and powerful learning experience. For Bree, having cancer changed the way she experienced living. She had to adapt to the changes in the way her brain worked due to the chemotherapy and adapt to a decrease in stamina and energy. Her experience in accepting herself with these changes led to better understanding of her students and some of their struggles. Cancer forced Bree to relax her former standards for herself and for her students. In describing this change she said that she was previously "much more strict before or rigid in many ways" than she is now. She expressed in her interviews that she believes stress triggered both of her bouts with cancer and so she had to intentionally focus on being more relaxed:

> It [cancer] almost killed me twice. It's stress. I'm not climbing any career. I don't have to make it anywhere. I can retire. Well, I can't collect, but I can retire. I don't need to prove myself anymore. I don't have time to suck up anymore. I don't have to agree with others. It's fine with me [if we disagree]. I can still get along. And it's the same thing with the kids. I'm not taking responsibility for them all the time. I'm giving the responsibility back to them and that helps immensely, so it's kind of been a combination of things and then the cancer of course, you just stop and [think] what are you doing.

The lifestyle changes have included altering her teaching, but the changes began with powerful and personal learning.

Kate discussed the powerful learning experience she had in the Intel Math workshops, describing the workshop as "extremely intensive-one week in the summer for two different summers plus eight or ten days out of the classroom" and noting that the goal of the workshop was to have the participants experience math differently:

> What we did was really take math back to the basics and so you might have the standard algorithm for multiplying two digits numbers together, but the whole purpose of Intel Math was to take you back to the basics of what are you doing when you do that algorithm and why does it work.

Kate embraced the opportunity to learn and then wanted her students to have the same sort of experience with math, so she transformed her teaching.

Matt and Jay both had profound experiences with students who had personal or family struggles and those experiences prompted them to learn new teaching approaches. Matt also had a personal experience in trying out lab probes and seeing students use them, which opened up his thinking and impelled him to learn more. Matt said that at the time, he thought to himself, "if this is what technology is like and the students are having this much fun with it, we ought to think more about this." The only transformation that doesn't fit this pattern, based on the study data, is Bree's change to focus more on vocabulary. She did not mention seeing another teacher try this with great success or any personal experience with vocabulary teaching that compelled her to learn and change.

Therefore, this study found that one reason teachers transform their instruction is that they have intense personal learning experiences themselves, thus forming strong neural pathways in their own brains, and they want to use what they have learned in improving education for students. A key question to extend understanding is what factors caused or influenced the neural pathways in the teachers' brains to strengthen so that learning occurred?

Personal learning impacted by a change in self-efficacy. Another pattern in the data around the personal learning of the teachers is that teachers transform their instruction after a decrease in self-efficacy about their teaching. Kate's learning experience in Intel Math training

and Matt's experience in receiving an unexpectedly poor evaluation of this teaching have a similarity in terms of impacting self-efficacy. Kate, with a minor in math and years of math teaching, thought she knew math content. She said,

> I think what really struck me was the idea that I had used math throughout my whole entire life without really understanding why math worked the way it did. And I like math. I like teaching math. It was all of a sudden to have that light bulb for me to say this is why it works [and] this is what happens. It became important to me to make sure that the kids were walking out of the classroom with that same kind of knowledge.

Matt thought he was, in his words, a "wonderful" teacher. Both Kate and Matt experienced a learning process that dramatically changed their perception of their own abilities, or their self-efficacies. Bandura (1995) defined self-efficacy as "the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (p. 2). The process of first deconstructing and then rebuilding the self-efficacy of the teacher is what Kate and Matt experienced and then they made comprehensive transformations to make their instruction more effective. Zimmerman (2000) notes that self-efficacy has been used as an effective predictor of learning in studies with children. Children with higher self-efficacies persisted longer at problem solving and in writing revisions. The data in this investigation suggests that a notable decrease in self-efficacy in adults might be correlated with learning. Therefore, one reason teachers may transform instruction is because an experience decreases their self-efficacy about instruction and the transformation is an attempt to re-establish a desired level of self-efficacy. These ideas need much more research support, but the study data indicates a potential relationship between teacher learning and a decrease in self-efficacy.

Professional learning potential barrier. It is conceivable that teachers who want to learn and want to make changes in their teaching experience barriers to doing so. Kate's case illuminates a facet of adult learning theory (Knowles et al., 2005) related to a potential barrier for teachers who want to make instructional transformations. The Intel Math workshop series she attended was spread over two summers and the school year between the summers. This extended time frame allowed Kate to use what she learned in the training with her students. The opportunity to apply learning to everyday life or work strengthens the learning of the adult and is a tenet of adult learning theory. Vega (2015), in her review of teacher development research, concurs:

> When teachers receive well-designed professional development, an average of 49 hours spread over six to 12 months, they can increase student achievement by as much as 21 percentile points (Yoon, Duncan, Lee, Scarloss, and Shapley, 2007). On the other hand, one-shot, "drive-by," or fragmented, "spray-and-pray" workshops lasting 14 hours or less show no statistically significant effect on student learning (Darling-Hammond, Wei, Andree, Richardson, and Orphanos, 2009). Above all, it is most important to remember that effective professional-development programs are job-embedded… (Darling-Hammond et al., 2009, para 6)

The application of learning also strengthens the neural pathways in the brain related to the learning, thus also connecting Kate's transformation to brain-based learning theory. Therefore, to ensure that teachers can apply their personal learning and transform their instruction, they must be given the time needed to make the change and the opportunity needed for application of the change.

Categorization of transformations into content-centered and student-centered. Flavell (1979) said, "Metacognitive knowledge is that segment of your (a child's, an adult's) stored world knowledge that has to do with people as cognitive creatures and with their diverse cognitive tasks, goals, actions, and experiences" (p. 906). The changes that Bree, Matt, and Jay made in becoming more attuned to the needs of their learners indicate metacognition in action. Matt and Jay specifically discussed in their interviews that they changed when they began to view learning and teaching from the perspective of their own students. The shift in thinking is a metacognitive process. It is logical for teachers to focus on their own role and performance in the classroom. Beginning teachers have much to think about in terms of presenting content and following lesson plans. Metacognition enters when teachers recognize, at some point, that what they do is inconsequential unless learning occurs. From there, they then realize that their own understanding of education needs to change to be student-centered and a metacognitive modification occurs because they are aware of a change in their own thinking.

Engagement. The study data have a pattern, which exhibits the aforementioned metacognitive shift, in the types of transformations the teachers made. To the researcher's surprise, half of the transformations selected by the teachers related to working with students. However, it should not have been a surprise. Taylor and Parsons (2011) specifically list interaction as a common element from the literature regarding engagement and they express that "Respectful relationships and interaction-both virtual and personal-are shown to improve student engagement" (p. 8). Additionally, they cited survey work done by Willms, Friesen, and Milton (2009) which showed that "Students want stronger relationships with teachers, with each other, and with their communities – locally, provincially, nationally and globally. They want their teachers to know them as people" (as cited in Taylor & Parsons, 2011, p. 8). The data in this

study identified two types of student engagement and both are critical to widespread student success. The first type of engagement is engaging students with academic content. The second type of engagement is the engagement of the student with the teacher as a person. One of the core beliefs of the researcher is that students learn best from people they like and respect. Teachers who excel at personally engaging students, treat students well and seem to enjoy their job because they appear to enjoy spending time with the students. The researcher defines "instructional method" as any strategy designed to teach and therefore she includes strategies to engage students on a personal level as well as strategies to engage students in academic content. Therefore, it should not have been such a surprise that the teachers chose to make and talk about transformations that changed the way they engage with students on a personal level.

The researcher recently expanded her understanding of engagement in classroom education to include a third type that is student-to-student engagement for educational purposes. Michaels and O'Connor (2012) describe the learning power of productive talk moves which relies on student to student academic discussion and illustrates the student to student engagement for educational purposes. Kate seemed to consider her transformation as a content-centered transformation. She said, "…the whole purpose of Intel Math was to take you back to the basics of what are you doing when you do that algorithm and why does it work." Therefore, her transformation is classified as content-centered in the study. However, Kate's transformation could also be considered a third form of engagement in education, which is engaging students with each other in productive academic discourse. Kate talked about how difficult it was for the teachers in the Intel Math workshop series to grapple with math themselves as learners in an inquiry-based, discourse-focused system. Kate also expressed that the other teachers from her school district who attended the workshop did not make the transformation to using inquiry-

based, discourse-focused lessons. Throughout the history of education, many students may have participated in academic discourse with their peers, but, based on Kate's experiences, employing an instructional strategy to capitalize on collective knowledge building through student discourse is a major transformation in classroom teaching. One reason that this third form of engagement may be the most challenging for teachers is that it requires the teachers to use both their social skills and content knowledge in a very deep, comprehensive manner to set up the students for discovery and productive academic discussion. It is much easier to control lessons, students, and even the other two types of engagement by being the focal point of the lesson as the teacher. Setting the students up to carry the cognitive load of learning and having them focus on each other's ideas is a transformative shift in instruction and could be a investigated further using the basic methodology of this study. However, since Kate viewed her transformation as a content-centered change, it will be considered that for this study.

Significations of categorization. The divide between content-centered and student-centered transformations in the data in this study suggests that the both types of instructional strategies are important to teachers. It is a stretch to say they are equally important to teachers, but the split in this study happened to be even with three content-centered and three student-centered transformations. What may not be equal is the amount of attention typically given to content-centered instructional methods and student-centered instructional methods. Additional research may be needed to examine the following ideas prompted by this study: Do teacher preparation methods courses give equal attention to both areas or focus specifically on content teaching? One argument for a focus on content teaching in educator preparation is that you can't teach people to get along with others. However, the results of this research suggest otherwise. Three of the four teachers in this study learned to be more student-focused and to relate better to

their students. Each of them presented information to show that the students recognized their efforts and appreciated the teachers for their ability to connect with students. Jay and Bree shared notes from students. One of the student-written notes to Jay said:

> The second reason is how much you care about your students. Every single student that comes into your door you treat with an equal amount of respect and as somebody who typically gets judged based on bias very frequently, I find that one characteristic very respectable.

Matt discussed the student responses to the changes he made to be more student-centered:

> I got a lot of very private feedback from not only students, but also other faculty members that had my students after I had had them. Also faculty members that had students who were family members, like sons and daughters who were in the courses that I taught. It was pretty much unanimous that they really appreciated the fact that I treated the students with respect...that I understood that some of them struggled and needed help, and that I was willing to reinforce concepts, and do my best to communicate with them.

Another potential argument for a focus on content teaching is that by the time people get to a university teacher preparation program they already know how to work with others. Again, this study speaks against that type of thinking. Matt and Jay both had years of work outside the educational field before entering the classroom. Jay was a store manager for a few years before he found a teaching job and he said the following in discussing his background: “I knew that teaching is human resources and involved the same strategies [as business management], so I knew I could market my teaching degree in different ways.” Yet, despite years of working with people in other settings, both Matt and Jay chose to discuss transformations about learning to

work differently with students. Bree, who has been a teacher her whole career, also transformed her instruction to be more relaxed and student-focused after years of teaching.

Strong (2011) stated that, as a profession, education does not have an operational definition of teacher quality and therefore cannot measure teacher effectiveness. The categorization of instructional transformations in content-centered and student-centered may be the most important contribution of this work toward an operational definition of teacher quality. Educational leaders who work to operationally define teacher quality should consider how to include student-centeredness in the definition and educational leaders who design measurement tools for teacher effectiveness need to include measurement of how teachers engage with students on a personal level.

Additional implications. Educational leaders who work in teacher development should attend to the information. Must teachers learn to relate to students as part of their on the job training during first few years of teaching or is this a skill that can be taught in a preparation program? There is merit to the idea that teacher candidates cannot practice working with students in a real teacher to student scenario until they are actually teaching. Even student teaching can fall short of supporting teacher candidate learning about relationship building because the cooperating teacher can act as a buffer and may have already built solid connections with students. However, to maximize and accelerate the development of beginning teachers, teacher preparation programs can and, based on this study, should work to set up teacher candidates for that learning about building student relationships in their first years of teaching. It would be interesting to study the definition beginning teachers have of instructional methodologies. Would the novice teachers, like the more experienced teachers in this study, include strategies for personally engaging students in their definitions? As an extension of this thinking, questions

such as the following could be investigated: Do teacher candidates have conversations in methods courses about how to discipline students for misbehavior without damaging their personal connection with the student? Do teacher candidates ever reflect upon what to do when students do not do homework because when they go home after school people at their house are constantly yelling and crying or because they feel unsafe or because their family is homeless? The teachers in this study personally interacted with students who have chaotic home lives and those interactions illuminated for them the considerable impact home and personal issues can have on students and their learning.

The teachers in the study, as is perhaps typical with most teachers, went into education to help people and make a difference. Bree said that she thought that it "would be so cool to be able to inspire kids to be able to do more." Matt described his reason: "I have a passion for helping other people and I discovered that I had a sort of a knack for understanding and communicating science. And I enjoy sharing science with others." Teachers are people who have chosen a career of serving others, and in general, they care deeply about others. It is logical that children who hated school rarely have interest in becoming teachers, so it is equally logical to presume that many teachers were students who liked school and were good at school. While this is an obvious generalization, for many teachers, a chaotic home life or significantly struggling to behave or learn in school is a perspective far from their own experience. Matt noted this sentiment when he described his own learning about students through his work with Upward Bound:

> In working with students from the Upward Bound program, there are many things that go on in students' lives that teachers don't think about. If you're concerned about where you're going to sleep that night or whether there's going to be enough food, you can't concentrate on school. If you have some sort of strife going on at home between Mom

> and Dad and they're about to divorce or if you have friends that are talking you up on Facebook and posting inappropriate pictures or there's lies about you that are circulating at school that people are propagating, how can you focus on tough college prep science courses? If you are in the university arena, if you are worried about losing your financial aid or there's boyfriend/girlfriend/significant other problems, those are all distractions, too.

In this, Matt implied that his own experiences as a student and teenager were far different from what the students he has worked with face.

How can teacher preparation faculty prepare candidates to step into classrooms ready to teach students with experiences that are so different than their own? The sensible first step is to raise awareness. A novice teacher has many, many things to think about and could easily miss clues to important situations unfamiliar to them. The teachers in the study interacted with students and those interactions prompted them to recognize needs that they were not meeting and then they transformed their teaching in response to that information. Perhaps if teacher candidates interacted with students in such a way that the candidates could learn about drastically different perspectives that students can bring into the classroom, the candidates would be better poised to meet the learning needs of their students in their first teaching job. However, insuring candidates have that type of transformative experience is difficult. Could a similar level of candidate awareness be raised through case studies or discussion or some other form of information presentation? Future research could be devoted to how teachers make the metacognitive shift to student-centeredness and how teacher candidate development in this area can be addressed.

Jay identified his need to engage with students differently early in his teaching career, without an administrator pointing out the need for a change. Jay voiced in his interviews that he experienced a level of chaos in his own home as a child and teen. Therefore, Jay's prior experiences with growing up may have provided an orientation to seeing a need to relate differently to students. Knowles et al. (2005) describe a change in university extension courses in the 1950s. During the day, the course would be taught to high school students, and the same course was taught to adults in the evening. The student outcomes were the same for both classes, but the class titles and methodologies were different because the orientation to learning was different for the adults and the high school students. Jay's childhood experiences may have orientated him to identify the impact personal difficulties have on student learning. Both the connection to prior experiences and having an orientation by seeing an application of the knowledge gained from his prior experience with a turbulent home life indicate the use of adult learning theory.

In contrast, Matt made the same type of transformation in his teaching, but because he did not have personal experience with extended turmoil at home, he didn't see the need to change until someone else exposed the need for the transformation in his teaching. The idea that Jay was more attuned than Matt to the needs of students living in chaos aligns with brain-based learning. As someone with experience in the area, Jay probably had some existing neural pathways established from his own thoughts and experiences about living in turmoil as a child. Without any such background, it's logical to think that Matt had no pre-existing neural pathways and therefore had to experience a more significant exposure to the issues to establish the pathways in his brain.

Student learning as cause for transformation. Research Subquestion 1b posed "How does student learning factor into the decision by teachers to transform their instruction?" The study data sets were analyzed for information about the teachers' use of quantitative academic achievement data and qualitative information as impetus for instructional transformations. Two of the teachers in the study had contrasting perceptions of themselves as instructors early in their careers and discussed transformations related to the perceptions they had, which provided insight into the role feedback has in informing teachers of their own instructional effectiveness.

Academic achievement data. In posing this research question, the researcher was wondering whether teachers would link their instructional transformations to the academic data of their students. The current school improvement model in Michigan dictates that professional development be linked to data. In the Michigan School Improvement Framework (Michigan Department of Education, 2014), strand three is about professional learning, standard eight specifically addresses the professional learning system, school indicator U addresses purposeful planning, and includes the following:

- Student and instructional staff outcome, demographic, process and perception data are used to identify and align professional learning priorities.
- Professional learning outcomes are developed specifically to address school improvement strategy areas.
- Professional learning is designed to be continuous, job-embedded, and aligned with adult learning theory.
- Professional learning is differentiated to meet the individual needs of instructional staff.
- Professional learning is designed to include a process to monitor and evaluate implementation and impact.

While school improvement has been a mandated process since 1990, the requirement of linking student academic data to professional development and to the school improvement plan is more recent (Michigan Department of Education, 2005).

Many of the transformations discussed by the teachers in this study were done prior to the requirement to use student data as a determinant of professional learning for teachers; however, it is interesting to note that none of the teachers described a use of quantitative academic achievement data in why they transformed their instruction. Jay, Matt, and Bree all mentioned student learning in a qualitative manner when discussing why they changed their instruction. Jay said, "I could just tell they didn't understand what I was talking about. I knew they weren't learning the content." Matt described, "… a tendency of students to get frustrated [and] to say, 'Aw, man, this physics stuff doesn't work! How can I understand? How can I believe it?'" Bree simply noted that her students struggled with vocabulary. In Kate's interviews she indicated that her principal asked her to attend the Intel Math training. She didn't say that her students' math scores were low or that math instruction across the school was targeted for improvement due to low test scores or anything along that line, but academic achievement data may have been one reason for her administrator to encourage her to go. In every transformation in this study, the teacher felt that the change he or she made was an improvement because it helped students learn better. The teachers stated or implied that they made the transformations in order to help students learn better, but the data of the study does not indicate that any of the transformations stemmed from an analysis of academic test score data. This case study does not show that the teachers did not employ data in their decision making, but it does indicate that the academic achievement data use at the core of their transformations was more qualitative than quantitative.

To capture the results succinctly, the pattern of why the teachers made these transformations, related to academic data, is that they saw a need without analyzing a lot of data or they had a learning opportunity they were interested in that could help students. One potential interpretation of this information is that the teachers were transforming instruction due to formative assessment rather than summative assessment. Marzano (2007) notes that "Teachers administer formative assessments while students are learning new information or new skills. In contrast, teachers administer summative assessments at the end of learning experiences" (p. 12-13). If the teachers in this study were making decisions to transform instruction in an attempt to improve student learning due to data they gathered during the formative assessment stage, as opposed to waiting until the summative assessment stage, that would present an interesting follow up study opportunity.

Knowles et al. (2005) noted that when adults see an opportunity to improve their quality of life by learning, they become willing, and even highly motivated, learners. Knowles et al. also discussed that the adult orientation to learning is application based. The teachers in this study illustrated these facets of adult learning theory. Once they saw a need or opportunity to improve, they invested effort into learning and then applied their learning to change their teaching.

Teacher self-efficacy and feedback about student learning. Matt transformed his teaching due, in part, to evaluative feedback he received about how his teaching was impacting student learning. The scenario of this feedback is important to note. Matt asked for the evaluation because he wanted a record of how he was doing. It was not required at that time for the teaching position he had. The evaluator was not only his superior, but also someone he considered a friend and respected as an educator. Matt respected the background that the evaluator had in educational training and as a teacher. In Matt's words, "But see, [the person who evaluated him]

is a wonderful teacher. He was trained as an actual high school teacher. He has a master's in science teaching. He knows how it's supposed to be done." Despite all of this, Matt talked in his interviews about how difficult it was to hear that his teaching fell short: "I thought I was doing a wonderful job and I wasn't. The points that he made were excellent. At the time it was very painful…" Matt truly believed that his teaching was good until his supervisor/friend explained that it really was not. Matt's experience with evaluation highlights some important points about the role evaluation and feedback can have in instructional improvement.

Bandura (1995) defined self-efficacy as "the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations" (p. 2). Bandura (1977) attributed the development of self-efficacy to four sources: performance accomplishments, vicarious experience, verbal persuasion, and physiological states, with performance accomplishments exerting the most impact on self-efficacy because fear is involved. When a person believes s/he has successfully performed, fear is lessened and self-efficacy increases. When a person believes s/he has failed, fear is heightened and self-efficacy decreases. Both Matt and Jay had beliefs about their performances as teachers and accompanying levels of self-efficacy. In Matt's case, his perception of his performance was that he was a good teacher until he received feedback that indicated otherwise; additionally, according to Bandura, Matt's self-efficacy level dropped with the poor review of his teaching and his fear level about teaching performance increased. Bandura also notes that self-efficacy is specific to specific skills, so Matt's decrease in self-efficacy was in specific areas of instruction, based on the feedback from his evaluation.

There are four categories that educators could fit into regarding their own perception of their instructional performance compared to the actual adequacy of their instructional ability as depicted in table 7.

Table 7

Teacher Perception Versus Actual Instructional Ability

Current Perception Matches Reality	Current Perception Does NOT Match Reality
The teacher believes s/he is good/adequate at instruction and in reality is a good or at least adequate instructor.	The teacher believes s/he is NOT good/adequate at instruction and in reality is an adequate instructor.
The teacher believes s/he is NOT good/adequate at instruction and in reality is NOT an adequate instructor. (Jay in his early career)	The teacher believes s/he is good/adequate at instruction and in reality is NOT an adequate instructor. (Matt prior to his evaluation)

Jay's interview data suggests that he understood that his teaching performance wasn't adequate. He said:

> I could just tell they didn't understand what I was talking about. I knew they weren't learning the content. Formative assessment is second nature to me. It's pretty simple: You teach, you check to see if they learned it by walking around, asking questions, looking at their work, and you're doing that naturally as a teacher.

Jay was cognizant of his instructional inadequacy, whereas Matt was not aware until someone else pointed it out. If teachers' perceptions of instructional performance adequacy were plotted on a linear spectrum, Jay would be near the end labeled "accurate perception," and Matt would be near the other end labeled "erroneous perception." In his interview, Matt said, "I thought I was doing a wonderful job and I wasn't." Both Jay and Matt apparently had some significant deficiencies in their instruction early in their careers. However, Jay recognized the weakness on his own, while Matt needed to have it pointed out to him.

Postulations regarding differences in perception. One key role of evaluation, whether done summatively or formatively, is to validate or invalidate teachers' perceptions about their own teaching. The researcher has two postulations about why Jay and Matt showed such differences in perception that may be worthy of consideration for administrators tasked with teacher evaluation. The first postulation is that the students an educator teaches impact the teacher's self-efficacy as an instructor. Jay was working with lower level high school students. When his instruction wasn't adequate, their behavior or verbal responses may have provided that information to him, which should cause Jay to lower his self-efficacy or maintain a self-efficacy that was already low. However, Matt was teaching college chemistry at the time of his evaluation that led to his transformation. Students in a university chemistry classroom setting probably have a different set of behavioral norms than students in a low level high school classroom. Matt's students may have felt that his instruction was inadequate but failed to present any obvious clues to that in their classroom behaviors or in any feedback to Matt. Therefore, student feedback built up Matt's self-efficacy level or allowed him to maintain a higher level of self-efficacy about his teaching. Additionally, students in Matt's university level class had a significant investment in the class. They paid for the course, had an expectation of having to do work outside of class to be successful, and needed the course to move into a career. These students may be unwilling to risk the loss of their investment by communicating information to their professor about instructional inadequacy. Also, to get into a university chemistry class, students may have learned to work around teachers with instructional deficiencies. In contrast, Jay's students had very little investment in their math and science classes. Such students are often labeled "at risk" because they have a past record of failing classes, behavior issues, low grades, etc., and they are at risk for failure and dropping out of school. These students may feel they have very little to lose if

they express their dissatisfaction with a teacher's instruction. Therefore, one potentially important difference between Matt's and Jay's early experience as educators is the feedback they received from their students about their teaching and the impact that feedback had on their self-efficacy.

Zimmerman (2000) notes that self-efficacy differs from self-concept in that self-efficacy is specific to individual performance tasks. Even though Jay's self-efficacy about his instructional performance was lower, he could have maintained a much higher self-concept about himself as a teacher. Jay's experience in managing people during his time as a store manager could have promoted his self-concept as someone who can make a difference and work effectively with others. It is conceivable that his self-concept provided the security to recognize his instructional performance shortfall and address the associated self-efficacy level for instructional adequacy.

For the second postulation about why Matt and Jay had different perceptions of their own effectiveness, the researcher noted that their preparations for assuming the teacher role were very different. At the time Matt had his transformation-prompting evaluation, he was an adjunct university professor who had experienced the traditional preparation for that position. In his interview, Matt noted, "I had never gone through any of those [teacher training] experiences at that point." He had a graduate degree in chemistry and no teacher education coursework. The valued traits in a science professor seem to focus more on deep scientific thinking and important research pursuits. Matt said in his interview, "I had taken the university route because I was interested in becoming possibly a professor and I would have focused on research, although I love teaching." The importance of credentialing and publication in higher education fosters the idea that if a science professor has a PhD, does innovative research, and is published, they must

be a good professor. Matt was coming from the higher education preparation and culture, and it is logical to suppose that he believed his teaching to be adequate because he had the traits valued in a university culture. Perhaps, he also taught like the models in his own past university education. Matt recognizes that he is very fortunate to have had the evaluation of his teaching done by someone who experienced teacher preparation coursework and understands the technical aspects of instruction. He described the person who evaluated his teaching as "…a wonderful teacher. He was trained as an actual high school teacher. He has a master's in science teaching. He knows how it's supposed to be done."

In contrast, Jay's route to teaching was through a teacher preparation program that included methods courses and student teaching. Jay did not discuss how his preparation impacted his view of teaching, but it's reasonable to think that his coursework and student teaching experiences primed him to evaluate instructional adequacy based on student learning. Jay said, "You teach, you check to see if they learned it by walking around, asking questions, looking at their work, and you're doing that naturally as a teacher." Therefore, Jay's view of what constituted adequate instruction may have been drastically different from Matt's view due to the preparation each experienced. Jay used the word "naturally" in his description of teaching above. It is also plausible that the difference between Matt's and Jay's perceptions of their own instruction is entirely due to the individual differences they have as people.

Implications. There are several points in this analysis for educational leaders who design teacher evaluation systems and do teacher evaluations. The first is to recognize the perception, or self-efficacy, the teacher has of their own teaching. The interaction between the administrator who is evaluating and the teacher being evaluated will be very different depending on what the teacher believes about their own instruction. In Matt's case, the information was extremely

difficult to hear because Matt had to change his solidly formed belief that he was a good instructor. When a teacher already knows that they have deficiencies, an evaluation that confirms their own thinking will be received differently than one that invalidates their thinking. Secondly, school administrators should consider short-term and long-term reactions to their evaluations. Matt shared about how difficult it was for him to hear what his friend thought of his teaching: "At the time it was very painful, although I did not...I did not react well to it inside, although I took it in stride in reacting to him and with others." It took some time for Matt to process the information, change his perception of his own teaching, and choose to make alterations in his teaching. Due to Matt's erroneous perception that his own teaching was "wonderful," the evaluator was in a very difficult position of having to present a case to Matt to illuminate his misperception. While Matt admits that he did not initially react well to the information, he did exactly what was needed in the end. He was able to change his perception and make significant changes for improvement. Now, even though it is still painful for Matt to talk about this evaluation experience, he embraces the role it had in making him the educator he is today. Matt's experience highlights the importance of recognizing that initial reactions are often temporary and should be recognized as such by administrators and teachers.

Matt's experience also suggests two other important points: the relationship between the teacher and evaluator matters and hard conversations are catalysts to positive change. Administrators are often chosen as administrators because they are nice, positive people. It is human nature for administrators to like to make people happy whenever possible and especially to keep the teachers they work with every day happy whenever possible. It would have been very easy for Matt's friend who evaluated his teaching to say that everything was great and avoid a difficult conversation, but both Matt and his friend, who was also his supervisor at the time, are

too professional for that and so Matt received sincere feedback about his teaching. As in Matt's case, hard conversations about education are needed, are part of being an educational professional, and are catalysts to positive change. Additionally, in those hard conversations it helps if the evaluator provides specific and concrete feedback. For example, in Matt's case, the feedback included that his print on PowerPoint slides needed to be larger and he needed to slow down his presentation of content. The friendship between Matt and the person who evaluated his teaching did survive the difficult conversation. The relationship between the evaluator and teacher was important in Matt's eyes. Matt respected the evaluator. In his interview, Matt said, "[the person who evaluated him] is a wonderful teacher. He was trained as an actual high school teacher. He has a master's in science teaching. He knows how it's supposed to be done." The evaluator was also someone Matt considered to be a friend. Would Matt have been willing to change his perception of his own teaching and make improvements if he did not respect his evaluator or if he did not value the relationship with his evaluator? Perhaps, but the professional learning of teachers is analogous in many ways to the learning of students under those teachers. Three of the teachers in this study transformed their instruction by transforming the way they related to students. The teachers worked to better understand and relate to students because they recognized a need to engage students on a personal level in order to more effectively teach them. In analogous fashion, administrators who attend to relationship building with their teachers may be more effective in prompting learning by the teachers especially when that learning involves hard conversations and major perceptual changes.

Summary of why teachers transform instruction. In summary, based on the study data, why teachers transform instruction is steeped in learning done by the teacher, which seems obvious. After all, a person probably cannot make changes without first learning something new,

but the learning done by the teachers in this study involved deep personal learning. Therefore, implications for educational leaders concerned with teacher learning, include providing for and supporting teacher learning in directions chosen by the teacher. Just as teachers benefit from a metacognitive shift toward student-centeredness, educational leaders benefit from a metacognitive shift toward learner-centeredness wherein the teacher is the learner and has the authority to direct their own learning path. This concurs with Standards for Professional Learning established by Learning Forward (2015):

> The decision to call these Standards for Professional Learning rather than Standards for Professional Development signals the importance of educators taking an active role in their continuous development and places emphasis on their learning. The professional learning that occurs when these standards are fully implemented enrolls educators as active partners in determining the content of their learning, how their learning occurs, and how they evaluate its effectiveness (para. 2).

Vega (2015), in reviewing teacher development research, also wrote about empowering teachers to take leadership roles in professional learning:

> Teacher leadership is also critical for school improvement efforts to succeed. Accomplished teachers are most knowledgeable about how students in their school or district learn, and thus they are ideal candidates to lead professional learning and curriculum development efforts (Vescio et al., 2008; Webster-Wright, 2009; Accomplished California Teachers, 2012) (para. 4).

Teacher self-efficacy about instruction is fed and refined by feedback from students and evaluative feedback from administrators. Recognizing a teacher's current self-efficacy level is important in working with teachers to improve instructional effectiveness. While there are

numerous other connections in these cases to the four theories of the conceptual framework, described in Chapter 2, many of them do not result in important points and pragmatism on the part of the researcher prevents idle analysis. In summary, the key conclusions, with implications to educational leaders, include the following:

- Intense learning done by the teacher is often a precursor to instructional transformation. Therefore, ensuring teachers have the time, support, and opportunity to learn themselves is critical. This connects to brain-based learning theory and supports the practice of allowing teachers to take content based courses as professional development.
- Teachers who make the metacognitive shift from teacher-centeredness to student-centeredness make significant and comprehensive changes in their teaching. The challenge for educational administrators and teacher educators is to prompt the use of metacognition, which is needed for this change to occur.
- Teachers need to recognize that their own experiences with growing up and with education as a student differ from the experiences of many of their students. Teachers should use their own prior experiences in teaching and will according to adult learning theory, but they may need assistance to understand situations outside that of their own experience.
- Teachers will apply what they are learning as they go through workshops or other learning opportunities if given the time. Professional learning or development can take advantage of the practices adults use to learn if they are spread out and provide teachers the opportunity to apply the learning in their own classrooms.

How Teachers Transform Instruction

The second overarching question in the study was about how teachers transform instruction. Again, the data sets were analyzed for patterns in teacher learning and for notable points. The patterns include teacher ownership of the transformation and a change in perspective for the teacher in student-centered transformations. Interesting points from the study data about how teachers transform instruction include a lack of profession-specific vocabulary and a tendency to value student feedback data. The conceptual framework, described in Chapter 2, used as the lens for investigating the research questions is formed from the principles of brain-based learning theory (Leamnson, 2000), metacognition (Flavell, 1979), adult learning theory (Knowles, Holton, & Swanson, 2005), and self-efficacy theory (Bandura, 1977). Research Subquestion 2c asks about how the conceptual framework created for the study links to the data. Analysis of connections to the conceptual framework are embedded into the sections below.

Events or experiences related to teacher learning to change instruction. Research Subquestion 2a asked about patterns in events or experiences teachers used in learning new instructional strategies; therefore, data analysis was used to identify patterns about how teachers learned to transform their instruction. The notable patterns included a sense of ownership each teacher had of the transformations implemented and a change in perspective needed by teachers to make student-centered transformations.

Teachers developed their own materials. In review, Kate transformed her math instruction by learning through a structured professional development session and then trying it with her classes. Matt integrated lab probes into his teaching because he saw them in use and saw the potential they offered his students. He reworked his lab curriculum to made use of the probes. Bree implemented weekly quizzes on vocabulary and devised a system of rewards with a theme

well suited to pop quizzes. It is at least interesting, and perhaps important, that the teachers did not all see some other teacher use these instructional methods with great success. Kate said, "you have to figure out how to put it in your classroom," which indicated that she was left more or less on her own to design lessons for her students based what she had learned about math from her Intel Math training. Matt mentioned that he spent immense time designing and running through lab lessons with the probes before using them with students: "I would troubleshoot the labs in the evening to make sure that they were working well and that I understood the procedure." Similarly, Bree indicated that she and her colleague figured out how they wanted to reinforce vocabulary for students:

> I stress vocabulary and I'm using more ways of memory techniques for the kids. I do flash cards with the kids. It's one way of doing it. You know, exposure, exposure, exposure. Telling them, showing them, practicing with them, whenever you do the vocabulary, this is how you can remember it, this is how you can do that. Even using bribery.

One pattern in the data is that for the content related transformations each teacher invested his/her own ideas and time in figuring out how to make the changes. They were not handed a script or a curriculum or even lesson plans. They created their own lessons, based on their own ideas, for students. The teachers had ownership of the transformations.

The personal ownership the teachers in this study described regarding their transformations fits well with adult learning theory, specifically the tenets of motivation and learner self-concept. The teachers' investment of time and thought, especially when they significantly changed their own thinking as a pre-cursor to the transformations, indicates deep motivation in the teachers. This study did not get to the source of that motivation for the

teachers. However, the data from this study can offer some insight into the motivation. Given the absence of quantitative academic achievement data used in making the transformations, it seems logical to conclude that student test scores were not a significant motivational force. Conversely, given the immense attention to student learning and student relationship building in the study data, those may be substantial motivational forces for these teachers.

In order to make the transformations, the teachers must have felt empowered to change and this speaks to their self-concept. Self-concept and self-efficacy are closely linked (Zimmerman, 2000). Self-concept is an overall construct that includes self-knowledge and self-evaluative feelings (Marsh & Shavelson, 1985, as noted in Zimmerman, 2000), so the teachers believed that they could learn what was needed in terms of how to make the transformation. Self-efficacy focuses on performance expectations for specific tasks (Bandura, 1977). In other words, the teachers' believed they could handle all aspects of the transformations in feeling empowered to alter their instruction, even if they had concerns about specific aspects of the performance of instruction.

Change in perspective. For the student-centered transformations, each of the teachers discussed a point at which they began to look at their classroom and their own teaching from the viewpoint of their students. Matt said, "I did not put myself in the students shoes…and I was making assumptions about the students that I should not have." Once the teachers began to see education from the students' perspective, they started to interact differently with their students. They now take time to inquire about the personal lives of their students and they look for signs of difficulty. During his interview, Jay shared a specific observation he made about a student and his method of addressing it: "I did that today with a young lady. I know she has been off her game and come to find out she's been off her medications for several conditions. I sat with her

and we worked together for an hour." All three teachers provided evidence in the study that they took time to interact with students on a personal level. Jay's students wrote about how well he knew what was going on with them, as evidenced by this note he received from a student:

> He cared that we were happy and that we knew we were loved. He knew if one of his students was feeling down or needed someone to talk to. To this day, I am not sure how he pulled that off. How did he know? Did our eyes beg for his kind and wise words? Were we that obvious? Time and time again he knew that I needed someone to tell me that everything would be ok and that soon enough I will be an adult and in complete control of my own life, whatever that means.

During Bree's classroom observations she sat down with kids and interacted with them on their level. Matt's interactions with students during his classroom observations included some that showed interest in the personal lives of the students, such as when he said, "Nice to see her yesterday. Tell her we missed her" to the class in reference to a chronically absent student.

However, it's more than simply showing interest in or interacting with students. The teachers changed their view of students and even their view of education. Rather than define education as content teaching, the teachers implied that they began to view education as human interactions around content. Their focus in making these student relationship transformations shifted from what they did as teachers to what their students experienced. It's a shift from content instructor to human development facilitator and the change in understanding of their role as teachers changed the way they interact with students on a daily basis. Making this shift in their own thinking is an example of a metacognition. Implementing changes such as asking students about their own lives or listening specifically for signs of student difficulty or student

comprehension, such as in Kate's math teaching, also strengthens the neural pathways involved in focusing on learners and so brain-based learning theory is also illustrated in this process.

Teachers' descriptions of their own instruction. Research Subquestion 2b inquired into how teachers described their own instruction and the transformations they made in instruction. Strong (2011) identified the lack of an operational definition of teacher effectiveness. The researcher believes that in order to generate an operational definition of teacher effectiveness, the profession of education needs to be able to employ a clearly-defined, profession-specific vocabulary. Therefore, the data was analyzed for evidence of such vocabulary. One pattern that emerged from the data was related to how the teachers described their own instruction by using student feedback in the descriptions.

Profession-specific vocabulary. This research question was written to examine how teachers speak about instruction. Instruction is a technical skill and there is profession-specific vocabulary associated with instruction. For example, Kate could have discussed her transformation as changing from direct instruction to indirect instruction. What Kate actually described in speaking about her transformation was the challenge of "letting go and letting the kids explore on their own because as the teacher you're supposed to know what you want them to do, how you want them to do it, what you want your outcome to be…" During her interviews, Kate used only a few education specific terms. At one point she talked about the Common Core and how her transformation fit with the Common Core instructional philosophy:

> I've found that over the last three years that it's like pulling teeth getting kids to think that way because they're so used to being...the answer's everything. You do the problem, you get the answer, you've got the right numbers in the right order, therefore you are a good math student and you're done. And you don't have to think about why these things work

> and everything. But what I found is that now I am teaching Common Core math in the classroom and that's essentially what Common Core wants you to do. They want you to go back to that beginning and look at all the different aspects of the numbers and how they work together and why they work together that way. The Intel training has really played forward into what I need to be teaching in the classroom now because that's the curriculum that we have. It started just as, ok this is going to be a math training to further my knowledge about math, but it's really gone a long ways toward furthering the math knowledge for the students in the classroom, too.

She also used the term "standard algorithm" in explaining that in her transformation the standard algorithm would be the last piece taught in a math lesson. The only technical term Bree used was in discussion with the researcher during the classroom observation and that term was "Cornell notes." Bree could have explained her transformation to focus on vocabulary with pop quizzes as providing regular formative assessment to students or explained her use of treats for high quiz scores as an extrinsic reward system. Jay used more educational vocabulary in his interviews. He talked about his use of formative assessment and his efforts to differentiate for students:

Formative Assessment:

> I could just tell they didn't understand what I was talking about. I knew they weren't learning the content. Formative assessment is second nature to me.

Differentiation:

> Well, the most basic differentiation I'll use is: first, I know that if I'm lucky about 30% of my class can learn from two examples on the board. So I cover it. I have taught long enough to know which questions…I've taught 8th grade to 12th grade and I've tutored all the classes to college algebra. I did that for five years so I know what they need to know

> at each level. I know the same mistakes are made whether you're in 7th grade or in the first or second year of college. They are making the same mistakes. I choose my examples. They have to be part of the core content. I know my curriculum and I choose relevant examples that will teach the curriculum. At the same time I pick my questions either on a test or in class that will have them look or use the areas that I know will cause them the most trouble. So I can point them out. I then model that, those questions. I have them take notes usually, then I assign an assignment. I've arranged the class in a way that they're sitting with people they like and I usually have somebody who learns it on the board and somebody who learns quickly from somebody close. So then I am usually left with a tier of three to five kids in any classroom that can only learn it when I sit next to them. So then I move around the room and I sit right beside them. They are not going to learn it off the board. And then I try to address their specific issues. Then, once they get going, they can usually work with the people beside them. At the end of it, in my assessment, I pick questions very specific to the skills that I want them to learn in math and they are allowed to retake their tests. I reteach the content. They can retake the test. I will change the questions so they have multiple opportunities to have access to that knowledge if they didn't get it the first time. We have an after school tutoring program which I lobbied pretty hard to have implemented and we have that four days a week so I have them stay after school for that.

Matt used several technical terms from science such as “titration” and “spectrophotometer,” but he did not use any technical terms associated with his instruction, except to say that one of his future goals was to differentiate instruction. He was the only one to understand and use the fixed

versus growth mindset information, but the researcher prompted that by first using the terms in an interview question.

Why didn't the teachers use more educational terminology? Communication is a vital skill in teaching and these educators spend their professional lives explaining ideas to teenagers. Therefore, they may have learned to communicate concepts using vocabulary suited to teenagers. Educational leaders would rarely expect a secondary teacher to explain to his or her students that today they would be using indirect teaching or cognitive dissonance or peer tutoring. Teachers might explain to students that in today's lesson they would be exploring a topic in an activity or seeing a demonstration and then discussing it, or working in pairs. The lack of technical terms in the teachers' data for this study might be due to a necessary lack of technical instructional term use in their own teaching. Another possible explanation for the scarcity of technical educational terms related to instruction by the teachers is that they do not know the terms. It's important to note that the teachers may know the instructional methods themselves but not know the educational labels for the methods. The teachers in this study were able to clearly explain what transformations they made in their instruction.

Implications. At this point, the question of consequence might be asked. Does it matter? One could argue that since the teachers could clearly explain what they were doing related to instruction that it really doesn't matter. Or, one might contend that having and using a professionally-based vocabulary is important for collegial communication. Another perspective is that instruction is a technical aspect of education and the profession should treat it as such. Matt mentioned the chemistry lab process of titration in his interview. Learning the skill of titration involves both learning the manual manipulation of the titration apparatus and the chemistry content that explains the need for and the results of the titration. The reference to

titration triggers immediate understanding of the conversation for other scientists knowledgeable about the process. In analogous fashion, educators should have the same type of profession-specific vocabulary around instruction. When Jay used the word "differentiation" to explain his transformation, he immediately clued the researcher in to what he was doing. Learning to differentiate instruction is both learning the skill of how to differentiate as well as learning why and when to differentiate. One question the researcher still has, that would benefit from further investigation, is whether teachers believe they know how to use instructional methods, but do so without deep understanding of why and when to use the methods. Implementation of instructional methods without deep understanding could impede the efficacy of use. Questions along this line in the mind of the researcher arose after the classroom observations of Kate and Bree. Kate was clearly still working out how to facilitate learning through student to student discourse and Bree was still learning to use the Cornell notetaking as an instructional strategy. Would some education about the methods themselves help these teachers? If so, how can that be provided, given the ownership teachers might want in making instructional improvements?

The analogy between learning a chemistry lab skill and a teaching skill breaks down in one important way. Titration is the same basic process, done for the same basic reason every time. Due to the enormous diversity among students in a classroom, differentiation can take many forms and teachers must often learn multiple ways to differentiate. For this reason, one could even maintain that instruction is more technical than chemistry lab procedure. Additionally, because differentiation, and most other instructional methods, can have many forms, educators can have difficulty agreeing on a definition for the term. The lack of common understanding and agreement poses a barrier to establishing a strict professional vocabulary for instruction.

Student feedback. Based on this study, teachers discussed their instruction both in terms of what they do and in terms of what students do and say. For example, Bree talked about how she does pop quizzes, Kate discussed how she supports student learning by asking questions, and Matt specifically said that he made larger print on his PowerPoint slides and started providing review sheets for tests. Kate explained what her students do and say during math lessons now. Jay described student behaviors and dialogues between himself and students. Given the emphasis the teachers in this study have on student-centeredness, it is logical that they would describe not only what they do as teachers, but what their students do and say related to instruction.

The teachers clearly explained how student behavior changed due to their transformations and for some of the transformations, they provided data from students to show the student reaction to the transformation. Jay shared the thank you notes that students had written to him, including one that said:

> I feel like you change a lot of people for the better and you don't even realize the amount of influence that you spread, but us kids are always listening and changing. That's the thing about us, we don't like to talk much about what is going on in our heads, but the slightest little thing someone says can change us entirely. I am comfortable with voicing what is going on in my head nowadays since I am a bit older and slightly more mature. But, I can tell you confidently that there are a lot of kids who get influenced by you. So I would just like to say thank you for all of this.

Kate disclosed recaps of conversations with students that she had regarding the change in her math teaching, such as,

> I have kids that come up and say, “You know what? I never understood math before. I didn't understand what they were trying to tell me, what they were trying to get me to do,

> but if I do it this way, like you showed us that we could or we found that we could, if I do it that way, it makes sense to me and I can keep on doing that."

Bree shared a note a student had written to her. Matt shared about some feedback he received from students:

> I got a lot of very private feedback from not only students, but also other faculty members that had my students after I had had them. Also faculty members that had students who were family members, like sons and daughters who were in the courses that I taught. It was pretty much unanimous that they really appreciated the fact that I treated the students with respect…

The teachers indicated that they deeply valued the reactions and comments from their students.

In conclusion, for the research question of how do teachers describe their own instruction and the transformation of instruction, the teachers in this study did not use a lot of educational jargon or technical terms. However, they did include discussion of their own actions and thoughts as well as responding actions and comments from students. In sharing the comments personally provided to them by students, each of the teachers showed much more emotion than in discussing other types of feedback. Two of the teachers teared up in sharing the information during the interviews.

Summary of how teachers transform instruction. In conclusion, regarding how teachers transform instruction, the following patterns and notable information, with implications for educational leaders is provided:

- The teachers invested significant time and energy in making transformations that were their own. They did not use a prescribed plan to change but created their own plan and therefore had immense ownership of the transformation. The level of motivation and self-

efficacy involved in the change process is notable. Based on the study data, educational leaders who want to support real change in instruction must support the teachers by understanding the time and commitment involved for the teachers. Additionally, educational leaders can be instrumental in removing barriers that might interfere with the motivation of the teacher to see the change through. Teachers who are transforming instruction may also benefit from the external validation educational leaders can provide, which can boost the self-efficacy of the teacher. According to this data, what teachers do not use is someone else's plan for instructional change. The teachers need to make their own decisions about how to transform instruction.

- The transformation to be focused on students is a critical transformation, but can take various paths to complete. The teachers in this study did different things to make this change. The common piece was simply that they shifted their perspectives to look at education through the eyes of their students. Educational leaders can assist teachers in making this transformation by asking the right questions at the right times. For example, rather than asking a new teacher how things are going, an administrator might ask about what the students are enjoying most in the new teacher's class. A subtle shift to asking questions that bring the teacher's focus to the students might help with the transformation.
- The teachers did not use a lot of profession-specific terms in describing their teaching. Educational leaders have the opportunity, and perhaps also the need, to establish a common vocabulary with their teachers for the work they are doing together. For example, if the school faculty is working to differentiate learning opportunities for

different students, the work can benefit if the group establishes a common understanding of the word "differentiate."

Conclusions

The overarching conclusion of this study is about student-centered instructional practice. In some sense each of the six transformations in the study was done to try to be more student-centered. For Kate's transformation in math teaching, the key instructional strategy was student discourse and therefore very much student-centered. Bree's described her change to focus on vocabulary as a way to try to help students learn better, and Matt altered his labs to include the lab probes so that students would get better data. However, three of the teachers (Bree, Jay, and Matt) specifically discussed transformations where the focus was meeting the basic emotional needs of the students. The opening paragraph of this dissertation quotes Fryshman (2014) as stating that "We are choking on data, but there are few if any properly validated experiments, and therefore no real knowledge about what constitutes quality teaching" (para. 2). The results from this study indicate that student-centeredness, in the form of more comprehensive understanding of students' perspective, is a major component of quality teaching and that teachers must learn to be student-centered in order to completely meet the learning needs of students.

For each teacher in this study, learning to be student-centered required a metacognitive shift. They had to look at education from the student perspective and redefine their own role as the teacher. One way to express this change is that they initially viewed themselves as content providers, but they then redefined their position to be more of a student development coach with a responsibility to communicate content. Why teachers transform instruction centers on their own learning as they experience life as a teacher. Intense experiences, such as working with very

troubled students or having their own well-established perceptions seriously challenged, exposed a need for learning by the teachers, and these teachers responded first by learning themselves and then by transforming their instruction. In order for brain-based learning to occur, the teachers in this student demonstrated the use of metacognition, the important role self-efficacy has, and adherence to adult learning theory in order to make the transformations.

How teachers transform instruction focuses on claiming ownership of their own instructional practices and changing the ways in which they interact with students. Once the teachers determined that a change was needed, they invested serious time and energy into redesigning lessons. They demonstrated the necessary self-efficacy and motivation to figure out how to make the transformations. The teachers also extended their metacognitive shift in thinking about student-centeredness to include ways to engage with students on a personal level. As the transformations were implemented, student reactions and verbal feedback were very important in validating whether the teachers' efforts were successful.

Future Study

The aim of this study was to identify areas for future study related to teacher learning and teacher effectiveness. The cases in this multiple case study highlighted the importance of teachers' learning to be student-centered. This is a small study, limited both to a specific region and to secondary math/science teachers, but the prevalence of student-centeredness in the study indicates a need for more research attention. For example, if a random sample of one thousand teachers spanning all elementary and secondary grades were asked to describe a transformation they made in their own teaching, would approximately half of the teachers choose to discuss a shift to better understand the student perspective? What do first year teachers understand about student-centeredness, and does that data indicate a need for a change in teacher preparation

curriculum or experiences? Is there a correlation between teachers who are student-centered and student learning? In other words, can research work demonstrate that the type of transformation to student-centeredness discussed by the teachers in this study is a critical component of teacher effectiveness?

Further research into the mechanisms of why teachers choose to learn would be beneficial. While this study identified a connection between intense, personal experiences for the teacher with instructional transformations, there is much more to be studied about why teachers choose to learn. Extended qualitative case studies of teachers as they are learning would be beneficial in this area. Each of the teachers in this study were well into their career, but deep examination of teacher learning at each stage of the career would be important to create a comprehensive picture. Teachers who journal or blog about their own development could provide a rich source of data for a more in-depth study.

Important questions that require more research include the following: Why do some teachers learn while others don't, when both teachers have the same experiences? For example, in this study, Kate talked about attending the Intel Math workshop series with two other teachers in her district, but those two other teachers did not make the transformation that Kate made. How does the educator responsible for professional development of teachers differentiate so that all teachers learn? The researcher is very interested in the impact mindset, as described by Dweck (2008), has on teacher learning. Would determining mindset provide useful information in designing learning programs for teachers? Must teachers with a fixed mindset (Dweck, 2008) be approached differently in terms of learning than teachers with a growth mindset? Does mindset correlate to student learning or teacher effectiveness? In similar fashion, what role does self-efficacy (Bandura, 1977) have in teacher learning? The same questions posed around mindset

can be asked for self-efficacy. Are there other variables of teachers that must be developed in order for teachers to learn or in order for teachers to be effective? How can teacher education faculty, educational administrators, and instructional coaches collect and use information about teachers learning preferences/styles/needs to better serve the profession?

How teachers learn and how they make changes in instruction is an essential area of research in teacher development. From this research the concept of teacher ownership was identified as an important component. Research into how educational leaders promote teacher ownership and balance teacher ownership with school improvement agenda based initiatives may be needed. For example, administrators may embrace the idea of teachers forming professional learning communities around specific initiatives that are determined with administrator input, but the administrators may not embrace teachers choosing the initiatives themselves. Studies of barriers to teacher empowerment could provide interesting and useful data to educational leaders. How do teachers move toward professionally-based empowerment during their candidate and induction years? Does a sense of being empowered or of ownership correlate with student learning or teacher effectiveness?

Metacognition (Flavell, 1979) and validation are also important concepts in how teachers transform instruction. More study into the ways teachers develop and use metacognition in their profession is needed. The benefit of understanding how teachers use metacognition could be developing strategies to increase the use of metacognition by novice or ineffective teachers as a method for learning and increasing effectiveness. The teachers in this study made metacognitive shifts. In order to transform instruction, they had to understand that they needed a change in perspective or they needed to learn new information. Do ineffective teachers recognize that they need to learn or do something differently? Would training in the use of metacognition help them

recognize when professional learning was needed? Validation from students, in the form of verbal feedback and behavior, was important to the teachers in this study. More research into how teachers seek feedback, process the information, and use the feedback could be done. Also, a larger study of whether student feedback is the most powerful form of feedback to teachers, as this study suggests, could be done.

Summary

The goal of this multiple case, qualitative study was to explore teacher learning and identify further directions for research work that would move the profession forward toward an operational definition of teacher effectiveness. This work indicates the importance of student-centeredness as a focus of teacher learning and as a needed component of teacher effectiveness. It also suggests other areas for future research in teacher learning such as self-efficacy (Bandura, 1977), metacognition (Flavell, 1979), mindset (Dweck, 2008), teacher ownership/empowerment, and teacher validation. What began as an interest in teacher quality, evolved into a study of why and how teachers transform instruction as a way to explore teacher learning, concludes with more questions, but it offers directionality for future work toward the needed operational definition of teacher quality.

References

Baker, L. (2009). Metacognition. Retrieved from http://www.education.com/reference/article/metacognition/

Baker, B. D., Oluwole, J. O., & Green, P. C. (2013). The legal consequences of mandating high stakes decisions on low-quality information: Teacher evaluation in the race-to-the-top era. *Education Policy Analysis Archives, 21* (5), 1-71..

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84* (2), 191-215. doi:10.1037/0033-295X.84.2.191

Bandura, A. (Ed.) (1995). *Self-efficacy in changing societies.* New York: Cambridge University Press.

Blondy, L.C. (2007). Evaluation and application of andragogical assumptions to the adult online learning environment. *Journal of Interactive Online Learning, 6* (2), 116-130.

Brookfield, S. D. (1994). Self-directed learning. Retrieved from http://infed.org/mobi/self-directed-learning/

Brophy, J. (1986). Teacher influences on student achievement. *American Psychology,* 1069-1077.

Creswell (2009). *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, CA: Sage Publications, Inc.

Christmann G.B., Balgar, K., & Mahlkow, N. (2014). Local constructions of vulnerability and resilience in the context of climate change: A comparison of Lübeck and Rostock. *Soc. Sci. 3,* 142–159. doi:10.3390/socsci3010142

Conlan, J., Grabowski, S., & Smith, K.. (2003). Adult Learning. In M. Orey (Ed.), Emerging perspectives on learning, teaching, and technology. Retrieved from http://epltt.coe.uga.edu/

Darling-Hammond, L., Holtzman, D.J., Gatlin, S.J., & Heilig, J.V. (2005). Does teacher preparation matter? Evidence about teacher certification, Teach for America, and teacher effectiveness. *Education Policy Analysis Archives 13* (42), 1-51.

Dawson, T.L. (2008). *Metacognition and learning in adulthood.* Northampton, MA: Developmental Testing Service, LLC.

Dweck, C.S. (2008). *Mindset: The new psychology of success.* New York, NY: Ballantine Books.

Egan, K. (1997). *The educated mind: How cognitive tools shape our understanding.* Chicago, IL: The University of Chicago Press.

EUPISD. (2014). About the EUPISD. Retrieved from http://www.eup.k12.mi.us/site/Default.aspx?PageID=38

Fenstermacher, G.D., & Richardson, V. (2000). On making determinations of quality in teaching. Retrieved from http://www-personal.umich.edu/~gfenster/teaqual14ss.PDF

Filler, Aaron (2009). The History, Development and Impact of Computed Imaging in Neurological Diagnosis and Neurosurgery: CT, MRI, and DTI. *Nature Precedings*. doi:10.1038/npre.2009.3267.5

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-development inquiry. *American Psychologist, 43* (10), 906-911.

Fryshman,B. (2014). Let's be honest: We don't know how to make great teachers. *Education Week Teacher*. Retrieved from http://www.edweek.org/tm/articles/2014/08/11/fp_fryshman_teacher_quality.html

Giedd, J., Blumenthal, J., Jeffries, N., Castellanos, F., Liu, H., Zijdenbos, A. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. *Nature Neuroscience, 2,* 861–863.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage.

Hayden, J.A. (2014). Introduction to health behavior theory 2nd Ed. Burlington, MA: Jones and Bartlett Learning. Retrieved from http://samples.jbpub.com/9781449689742/Chapter2.pdf

Helms-Lorenz, M. and Jacobse, A.E. 2008. Metacognitive skills of the gifted from a cross-cultural perspective. In M.F. Shaughnessy, M.V.J. Veenman, & C. Kleyn-Kennedy (Eds.), *Meta-cognition: A recent review of research theory and perspectives* (pp. 3-43). New York, NY: Nova Science Publishers, Inc.

Hookway, C. (2015). Pragmatism. *The Stanford Encyclopedia of Philosophy*. E. N. Zalta (Ed.). Retrieved from http://plato.stanford.edu/archives/spr2015/entries/pragmatism/

Hull, J. (2013). Trends in teacher evaluation: How states are measuring teacher performance. Retrieved from http://www.centerforpubliceducation.org/Main-Menu/Evaluating-performance/Trends-in-Teacher-Evaluation-At-A-Glance/Trends-in-Teacher-Evaluation-Full-Report-PDF.pdf

Kennedy, M. (2008). Contributions of qualitative research to research on teacher qualifications. *Educational Evaluation and Policy Analysis, 30,* (4), 344-367. doi:10.3102/1062373708326031

Knowles, M.S., Holton, E.F. III, & Swanson, R.A. (2005). *The adult learner: The definitive classic in adult education and human resource development.* Burlington, MA: Elsevier Inc.

Kolb, D.A. (1984). Experiential learning: Experience as the source of learning and development. Upper Saddle River, NJ: Prentice Hall, Inc.

Konrad, K., Firk, C., & Uhlhaas P.J. (2013). Brain development during adolescence: Neuroscientific insights into this developmental period. *Dtsch Arztebl Int., 110* (25), 425–431. doi:10.3238/arztebl.2013.0425

Krupp, J.A. (1982). *The adult learner: A unique entity.* Manchester, CT: Adult Development and Learning.

Leamnson, R. (2000). Learning as biological brain change. *Change*, *32* (6), 34-40.

Learning Forward. (2015). Standards for professional learning. Retrieved from https://learningforward.org/standards

Learning-Theories.com. (2015). Summaries of learning theories and models. Retrieved from http://www.learning-theories.com/

Levine, J. (2014). Jack Mezirow, who transformed the field of adult learning, dies at 91. *Teacher College Newsroom, In Memoriam.* Retrieved from http://www.tc.columbia.edu/news2/9698

Lipowski, E.E. (2008). Research Fundamentals: Developing great research questions. *American Journal of Health-Systems Pharmacy, 65,* 1667-1670. doi:10.2146/ajhp070276

Marzano, R.J. (2007). *The art and science of teaching: A comprehensive framework for effective instruction.* Alexandria, VA: ASCD.

Maxwell, J.A. (2004). Causal explanation, qualitative research, and scientific inquiry in education. *Educational Researcher, 33* (2), 3-11.

Mead, S., Rotherham, A. & Brown, R. (2012). The hangover: Thinking about the unintended consequences of the nation's teacher evaluation binge (Teacher Quality 2.0, Special Report 2). Retrieved from http://bellwethereducation.org/sites/default/files/legacy/2012/09/Teacher-Quality-Mead-Rotherham-Brown.pdf

Merriam, S. B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. *New directions for adults and continuing education, 89,* 3-13.

Mezirow, J. (1990). *Fostering Critical Reflection in Adulthood*. J. Mezirow (Ed.). San Francisco: Jossey-Bass Publishers.

Mezirow, J. (1996). Contemporary paradigms of learning. *Adult Education Quarterly, 46* (3), 158-173.

Michaels, S. & O'Connor, C. (2012). Talk science primer. Retrieved from http://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

Michigan Department of Education. (2005). Michigan school improvement framework. Retrieved from https://www.michigan.gov/documents/SIF_4-01-05_130701_7.pdf

Michigan Department of Education. (2014). School improvement framework 2.0. Retrieved from http://www.michigan.gov/documents/mde/School_Improvement_Framework_2_-_07-28-14_465125_7.pdf

Miles, M.B., Huberman, A.M., & Saldana, J. (2014). *Qualitative Data Analysis: A methods sourcebook.* Los Angeles, CA: Sage Publications.

Milligan, F. (1999). Beyond the rhetoric of problem based learning: Emancipatory limits and links with andragogy. *Nurse Education Today, 19,* 548-555. Retrieved from http://www.umsl.edu/~henschkej/henschke/beyond_the_rhetoric_of_problem-based_learning....pdf

Murphy Paul, A. (2011). What babies learn before they're born. Retrieved from http://www.cnn.com/2011/12/11/opinion/paul-ted-talk/

National Center for Educational Statistics. (2015a). Fast facts: Back to school statistics. Retrieved from http://nces.ed.gov/fastfacts/display.asp?id=372

National Center for Educational Statistics. (2015b). Fast facts: Teacher trends. Retrieved from http://nces.ed.gov/fastfacts/display.asp?id=28

National Research Council. (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

No Child Left Behind (NCLB) Act of 2001, Pub. L. No. 107-110, § 115,. Stat. 1425 (2002).

Obama, B. (2008, May 28). Full text of Obama's education speech. Retrieved from The Denver Post: http://www.denverpost.com/ci_9405199

Ostrosky-Solis, F., Garcia, M.A., Perez, M. (2004). Can learning to read and write change the brain organization? An electrophysiological study. *International Journal of Psychology, 39* (1), 27-35.

Paris, S.G., & Winograd, P. (n.d.). *The role of self-regulated learning in contextual teaching: Principles and practices for teacher preparation* (CIERA Archive #01-03). Retrieved from http://www.ciera.org/library/archive/2001-04/0104parwin.htm

Phillips, D.C., Burbules, N.C. (2000). Postpositivism and Educational Research. Rowan and Littlefield Publishers, Lanham: Maryland.

Schön, D.A. (1983). *The reflective practitioner: How professionals think in action*. United States of America: Basic Books Harper Collins Publishers.

Silver, H., & Perini, M. (2010). The eight Cs of engagement: How learning styles and instructional design increase student commitment to learning. Retrieved from http://lackawannaschools.org/cms/lib/NY19000337/Centricity/ModuleInstance/865/TheEight_Cs_of_Engagement.pdf

Simon, M. K. (2011). Dissertation and scholarly research: Recipes for success (2011 Ed.). Seattle, WA, Dissertation Success, LLC. Retrieved from http://dissertationrecipes.com/wp-content/uploads/2011/04/AssumptionslimitationsdelimitationsX.pdf

Stewart, P. W., Cooper. S. S., & Moulding, L. R. (2007). Metacognitive development in professional educators. *The Researcher, 21* (1), 32-40.

Strauss, A. & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Newbury Park, CA: SAGE Publications.

Strong, M. (2011). *The highly qualified teacher: What is teacher quality and how do we measure it?* New York, NY: Teachers College Press.

Taylor, L. & Parsons, J. (2011). Improving student engagement. *Current Issues in Education 14* (1). Retrieved from http://cie.asu.edu/ojs/index.php/cieatasu/article/viewFile/745/162

Tough, A. (1977). Major learning efforts: Recent research and future directions. Retrieved from http://files.eric.ed.gov/fulltext/ED156828.pdf

US Department of Education. (2016). Upward Bound program purpose. Retrieved from http://www2.ed.gov/programs/trioupbound/index.html

Vagle, M.D. (2014). *Crafting phenomenological research*. Walnut Creek, CA: Left Coast Press.

Vega, V. (2015). *Teacher development research review: Keys to educator success*. Retrieved from http://www.edutopia.org/teacher-development-research-keys-success#graph2

Vernier Software and Technology, LLC. (2016) Company. Retrieved from http://www.vernier.com/company/

Williams, D. (2011). Qualitative inquiry in daily life. Retrieved from https://qualitativeinquirydailylife.wordpress.com/

Yin, R.K. (2014). *Case study research: Design and methods.* Los Angeles, CA: Sage Publications.

Zimmerman, B.J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology 25*, 82–91. Retrieved from http://www.itari.in/categories/ability_to_learn/self_efficacy_an_essential_motive_to_learn.pdf

Zuelke, L.A. (2008). Relationships among science teacher qualifications, instructional practices, and student science achievement (Doctoral dissertation, University of Florida).

Appendix A: Recruitment E-mails

Recruitment E-mail for School Administrators

Note: I know all of these administrators personally from both my time at the ISD and from working with them for student teacher and field work placement. If I didn't know someone personally, I would alter the e-mail to introduce myself.

Hi (administrator name),

I am working on my doctoral dissertation in educational leadership at Eastern Michigan University and I am interested in how teachers develop their instructional abilities. My research project involves interviewing and observing secondary math and science teachers about a transformation they have made in their instruction. When the transformation occurred is not important, so it might be something they have been doing for a long time.

I am seeking your permission to contact your middle and high school math and science teachers to ask if they would be willing to be a participant in my research study. The study has been approved by the institutional review boards of both LSSU and EMU as appropriate human subjects research work. I am asking participants to do two interviews of about one hour each in length, which would be set up on their own time, and then at least one observation during one of their classes so that I can see their transformed instruction in action. While I am asking teachers to sacrifice some of their own time, I am hoping that they will enjoy talking about their own instruction with another educator.

Please let me know the following:

- May I come in to your school to observe the teacher if they volunteer to be a participant in the study?

- If I may come in to observe, may I e-mail your secondary math and science teachers, with a cc to you, about whether they are interested to be a participant in the study?

Thank you so much!

Barb

Recruitment E-mail for Teachers (cc to Administrators)

Note: Again, I know many of these teachers personally, but for any that I do not know, I would include an introduction to myself.

Hi (teacher name),

I am working on my doctoral dissertation in educational leadership at Eastern Michigan University and I am interested in how teachers develop their instructional abilities. My research project involves interviewing and observing secondary math and science teachers about a transformation they have made in their instruction. When the transformation occurred is not important, so it might be something you have been doing for a long time.

I have received permission from your school administrator to contact you and invite you to participate in this research study. The study has also been approved by the institutional review boards at both LSSU and EMU as appropriate research involving human participation.

If you are a participant in this study you will undergo two face to face interviews with me. I would be happy to meet with you at your own school after school for these. Each interview is designed to take about an hour, but may be longer depending on our conversation. The interviews will be recorded in audio format so I can later transcribe them and analyze them. Your interview answers become a set of data for my project. The topics of the interviews will focus on instruction and how you learned to provide instruction to students. We will also talk specifically

about one transformation you made in your instruction at some point in your career. The transformation can be any significant change you made in your instruction as long as you can explain why and how you made the transformation.

After the interviews, I also need to observe you teaching class at least one time so that I can see the transformed instruction in action. During the observation, I will take field notes regarding what I observe and the notes will become another set of data for my project. As part of my request for permission from your administrator to contact you, I asked for permission to visit your classroom and observe at least one lesson. So, if you are willing to participate, I am asking for a few hours of your time and for you to open up your classroom for me to observe your instruction.

The research study that I am doing is a multiple case study and so I am hoping to generate a list of teachers willing to participate in the study. I would like a list of at least ten willing teachers at the start of the project. If you are willing to be a participant, please respond to this e-mail and very briefly describe the transformation in instruction we could use for the study.

Thank you so much for considering this opportunity!!

Barb

Appendix B: Sample Interview Questions

PHASE 1: Interview Questions – time frame 1-2 hours

1. Possible Ice Breaker Questions:
    a. Why did you become a teacher?
    b. When did you know you wanted to be a teacher?
2. Study Questions:
    a. Describe the transformation you made in your instruction
        i. When did it occur?
        ii. Why did you make the change?
        iii. How does the transformation change learning for your students?
        iv. Should other teachers change their instruction as you have? Is this transformation for all teachers? (If not, why does it work for you?)
3. Concluding Statement: Summarize why the teacher made the transformation to make sure you understand.
4. Thank you for the teacher's time and willingness.

PHASE 2: Interview Questions – time frame 1-2 hours

1. Possible Ice Breaker Questions:
    a. any further questions for clarification from the first interview
    b. Please trace your journey in education from graduation from college (undergraduate) to now (their story of the positions they held in education or maybe other positions, graduate level education they might have done, etc.).
2. Study Questions:

a. How would you describe yourself as a learner? (goal is to get at fixed vs. growth mindset)
b. How would you describe your current instructional ability? (goal is to identify level of self-efficacy)
c. Describe the transformation you made in your instruction
    i. How did you learn to instruct in the new way?
    ii. What was challenging about the transformation?
    iii. What specific things made you realize that the transformation was an improvement and that you should keep using that instructional method?
    iv. Do you (or did you) talk about this transformation with other teachers? administrators? students? non-educator friends?

3. Concluding Statement: Summarize how the teacher made the transformation to make sure you understand.
4. Thank you for the teacher's time and willingness.

The general direction of the questions will follow this plan, however, the specific questions for phase two will not be completely written until after phase one.

Appendix C: Human Subjects Approval Letter

RESEARCH @ EMU

UHSRC Determination: **EXEMPT**

DATE: **November 5, 2015**

TO: **Barb Light, EdS**
Department of Education Leadership and Counseling
Eastern Michigan University

Re: **UHSRC: # 812538-1**
Category: Exempt category 2
Approval Date: November 5, 2015

Title: **How and Why Teachers Transform Their Instruction**

Your research project, entitled **How and Why Teachers Transform Their Instruction,** has been determined **Exempt** in accordance with federal regulation 45 CFR 46.102. UHSRC policy states that you, as the Principal Investigator, are responsible for protecting the rights and welfare of your research subjects and conducting your research as described in your protocol.

Renewals: Exempt protocols do not need to be renewed. When the project is completed, please submit the **Human Subjects Study Completion Form** (access through IRBNet on the UHSRC website).

Modifications: You may make minor changes (e.g., study staff changes, sample size changes, contact information changes, etc.) without submitting for review. However, if you plan to make changes that alter study design or any study instruments, you must submit a **Human Subjects Approval Request Form** and obtain approval prior to implementation. The form is available through IRBNet on the UHSRC website.

Problems: All major deviations from the reviewed protocol, unanticipated problems, adverse events, subject complaints, or other problems that may increase the risk to human subjects **or** change the category of review must be reported to the UHSRC via an **Event Report** form, available through IRBNet on the UHSRC website

Follow-up: If your Exempt project is not completed and closed after **three years**, the UHSRC office will contact you regarding the status of the project.

Please use the UHSRC number listed above on any forms submitted that relate to this project, or on any correspondence with the UHSRC office.

Good luck in your research. If we can be of further assistance, please contact us at 734-487-3090 or via e-mail at human.subjects@emich.edu. Thank you for your cooperation.

Sincerely,

Beth Kubitskey
Chair
COE Human Subjects Review Committee

Appendix D: Informed Consent Letter

Informed Consent Form

The person in charge of this study is Barb Light. Barb Light is a student at Eastern Michigan University. His/her faculty adviser is Dr. Ron Williamson. Throughout this form, this person will be referred to as the "investigator."

Purpose of the study

The purpose of this research study is to investigate why and how teachers transform their instruction.

What will happen if I participate in this study?

Participation in this study involves

- participating in at least two face to face interviews at your school with Barb and allowing Barb to observe your teaching at least one time; additional face to face interviews or observations would be used only if needed for clarification
- Interview 1, which will involve questions/discussion about why the teacher transformed instruction
- Interview 2, which will include any follow up to interview 1 and then questions/discussion of how the teacher transformed instruction
- Observation of teaching: Barb will sit in the back or off to the side of the classroom and take field notes about your transformed instruction, a brief follow up discussion to clarify any questions Barb has regarding the observation could take place immediately after the observation or at a later time either face to face or via e-mail
- Each interview will be one to two hours long, for an anticipated maximum face to face interview time of four hours over the two sessions. The observation time will be

negotiated with each teacher and may depend on the type of instructional transformation the teacher has done. The anticipated minimum observation time would be one class period, so about one hour. The anticipated maximum observation time would be three class periods (all in one day) or three consecutive hours.

We would like to audio record you for this study. If you are audio recorded, it will be possible to identify you through your voice. However, the audio recording will be treated as secure data, used only by Barb for transcription of data, and will never be published in audio format. If you agree to be audio recorded, sign the appropriate line at the bottom of this form.

What are the anticipated risks for participation?

The primary risk of participation in this study is a potential loss of confidentiality. You will be given a pseudonym in the published work. All data including audio files, interview notes, transcripts of interviews, and observation field notes will be kept in a locked and secure location. However, due to the in-depth nature of the interview and observation data, someone who knows you or your classroom well may be able to figure out your identity.

Although all questions will be about your teaching, some of the interview questions may be personal in nature and may make you feel uncomfortable. You do not have to answer any questions that make you uncomfortable or that you do not want to answer.

Are there any benefits to participating?

You may not directly benefit from participating in this research. You will be given the opportunity to talk about your own teaching, which may or may not seem like a benefit to you. Benefits to society include enhancing the information about instructional practices in the academic field of education.

What are the alternatives to participation?

The alternative is not to participate.

How will my information be kept confidential?

We will keep your information confidential by assigning a pseudonym to you and by not publishing easily identifiable data about you such as the name and details of your school or school district. Your information will be stored in a locked file cabinet if on paper and on a password protected computer if digital. We will make every effort to keep your information confidential, however, we cannot guarantee confidentiality. There may be instances where federal or state law requires disclosure of your records.

If, during your participation in this study, we have reason to believe that elder abuse or child abuse is occurring, or if we have reason to believe that you are at risk for being suicidal or otherwise harming yourself, we must report this to authorities as required by law. We will make every effort to keep your research information confidential. However, it may be possible that we have to release your research information. If this were to occur, we would not be able to protect your confidentiality.

Other groups may have access to your research information for quality control or safety purposes. These groups include the University Human Subjects Review Committee, the Office of Research Development, or federal and state agencies that oversee the review of research. The University Human Subjects Review Committee is responsible for the safety and protection of people who participate in research studies.

We may share your information with other researchers outside of Eastern Michigan University. If we share your information, we will remove any and all identifiable information so that you cannot reasonably be identified.

The results of this research may be published or used for teaching. Identifiable information will not be used for these purposes.

Storing study information for future use

We would like to store your information from this study for future use related to instructional practice and teacher quality. Your information will be labeled with a code and not your name. Your information will be stored in a password-protected or locked file. Your de-identified information may also be shared with researchers outside of Eastern Michigan University. Please initial below whether or not you allow us to store your information:

_____Yes _____No

Are there any costs to participation?

Participation will not cost you anything.

Will I be paid for participation?

You will not be paid to participate in this research study.

Study contact information

If you have any questions about the research, you can contact the Principal Investigator, Barb Light, at bjlight@lssu.edu or by phone at (906) 253-2023. You can also contact Barb Light's adviser, Dr. Ron Williamson, at rwilliams1@emich.edu or by phone at (734) 487-2807.

For questions about your rights as a research subject, contact the Eastern Michigan University Human Subjects Review Committee at human.subjects@emich.edu or by phone at (734) 487-3090.

Voluntary participation

Participation in this research study is your choice. You may refuse to participate at any time, even after signing this form, with no penalty or loss of benefits to which you are otherwise entitled. You may choose to leave the study at any time with no loss of benefits to which you are otherwise entitled. If you leave the study, the information you provided will be kept confidential. You may request, in writing, that your identifiable information be destroyed. However, we cannot destroy any information that has already been published.

Statement of Consent

I have read this form. I have had an opportunity to ask questions and am satisfied with the answers I received. I give my consent to participate in this research study.

Signatures

_____

Name of Subject

_____ _____

Signature of Subject Date

I agree to be audio recorded for this study.

_____ _____

Signature of Subject Date

I have explained the research to the subject and answered all his/her questions. I will give a copy of the signed consent form to the subject.

_____

Name of Person Obtaining Consent

_____ _____

Signature of Person Obtaining Consent Date