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Collaboratively Building a Teaching Model (TTTC) in a Doctoral Science Education Program: An Autoethnography

by

Alton G. Declaire

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in Curriculum and Instruction
with a concentration in Science Education
Department of Teaching and Learning
College of Education
University of South Florida

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Keywords: Co-mentoring, constructivism, concept-mapping, emergent design, well-being

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ABSTRACT

This autoethnography illustrates benefits of doctoral education consistent with the holistic paradigm underlying today's society and development of a practice-research-practice cycle useful to science teacher educators. Emergent hypotheses indicate ways to increase a doctoral student's well-being, intellectual risk taking, production of creative products, and expedite in-depth learning. The hypotheses were derived from the processes and pathways I used to make sense of the learning opportunities afforded me and features of my experience that led to my well-being and maintaining my enthusiasm despite the significant life challenges I encountered and the tedious parts of the doctoral process.

The original research question was, "What is the impact of the learning experience in a science education doctoral program on a middle school science teacher's professional practice?" Impact was evident in four areas of practice: As a learner, a middle school science teacher, a novice science teacher educator (teaching and researching); and as a professional from public health. Co-mentoring and emergent design constructivist teaching and learning were keys to my intellectual and psychological transformation. I documented my perceptions of events, including several culture shocks, and my emotional responses to events as they occurred. I used metacognitive and reflexive processes to reflect (revisit and record my constructed understandings). Outcomes were my occupational satisfaction, determination to be an agent of change in science education, an illustration of an emergent constructivist process to educate doctoral students, and an original teaching model, the Three-Tiered-Transformative-Classroom (TTTC) for teaching middle school science and use in teacher education.

CHAPTER 1: INTRODUCTION

The following chapter explains the background of myself personally, occupationally, and academically before I entered my doctoral program. It also outlines my current belief system in teaching and learning, as well the purpose and value of my dissertation study. The chapter concludes with definitions of terms that appear in this dissertation.

Researcher Background

The text below provides a biography of what brought me to the doctoral program. It lays out my background professionally as a third career middle school science teacher. It also provides a summary of my personal life before becoming a doctoral student. Further, I discuss my academic background and a specific outcome of my doctoral work integrated into my occupational development as a teacher. In the following text I provide details of that integration as a doctoral educational product (teaching model TTTC). This product emerged from my doctoral studies examining and learning from an occupational tool (classroom inquiry teaching method), which I had been developing in my middle school classroom before entering the doctoral program.

Introduction

My perceptual screen influenced this research. I will, therefore, share my experiences as a student in schools K-16 that influenced my perceptual screen. These experiences establish the context for this autoethnography focused on my learning and teaching experiences as a doctoral student. My perception of how people teach and learn, as I recall growing up through the public school system, was entirely determined by what happened during the 181 days of a school year,

within the walls surrounding a classroom full of other learners my age. Inside this contained unit of human learning, I was shown that what students work to learn is that which a teacher builds and gives students to learn. In other words, I learned there is one definitive authoritative person assigned to each of the subjects I am required to learn. This person is called the assigned teacher. I thought for years the role of a teacher was to either help me learn what it was I needed to learn, or not help me. I learned to expect that in order to understand anything, there needed to be an authoritative figure designing the process to bring me to understanding.

I developed a strong fear of failing and needed excessive amounts of time to memorize facts early in my school career. I begged and pleaded with both my mom and middle school teachers to place me in non-honors classes, although my test scores and classwork indicated otherwise. It took until the end of middle school before I was out of honors classes. By the time I reached high school, every class I had was levels below my ability to learn. I grew comfortable with the ease of life in school. This of course did not prepare me at all for higher education. The comfortable level of passive learning I had done during my four years in high school increased my fear of failing so much that I avoided any path to college. My guidance counselor intervened and placed me in specific courses my senior year to get me a grant to go to a community college. I waited a year after high school to use my grant. When I went to cash in on it, I faced typical higher education pitfalls that occur quite often when tuition is free. The pitfalls could have easily been overturned and would have eventually provided me the free schooling I needed, but my fear of failing in any way overshadowed the little desire I had to continue my education.

I got a job in the fast-food industry when I graduated from high school. I realized in my late twenties that I had no escape from the career I had as a fast-food manager with no education beyond my high school diploma. Further, I realized the fast-food occupation would take a toll on

my psyche if I decided to make a lifetime career out of it. I was still very hesitant to start higher education in any form. I had learned how to survive in the authoritative fact memorizing arena called school, but I did not know how to thrive in that system. I was not the best at memorizing, nor did I have much skill in social interactions. Higher education was never an experience I wanted to live. This personal belief led me to the decision I made when applying to a community college and choosing courses. I chose the quickest program that would gain me a new job. This was the Emergency Medical Technician (EMT) Program. It could be completed in one full time semester and passing a state exam was occupation.

My traditional belief about teaching and learning did not change much in the few months of my first higher education experience, nor did it change much when I returned to a community college to expand my education as a medical provider in a paramedic program one year after becoming an EMT. This paramedic program was a much more intense program of learning. The number of facts I was required to memorize, regurgitate back to both classroom and lab instructors, and apply in real life far exceeded my ability. I ended up withdrawing from the program before I even finished the first semester of it. I recall a feeling of great relief when I officially withdrew my position in the program and returned my textbooks to the bookstore for a fraction of the price paid for them. At that point, in my thirteen-year relationship with formal education and the brief time I spent in higher education, I was so confident in my ability to fail at that moment in the bookstore I somehow gained peace in my acceptance of failing. I was at peace with this loss even though it cost me money that I could have used to support my wife and child. I felt that I could accept my lot in life and just work for a living.

Not even a year later, I found myself in the middle of a divorce. I began to pawn my belongings to get myself back in school again. This time I applied for a much longer program that required more traditional style college courses. I felt if I was going to fail at love and marriage, then seeing myself fail at higher education wouldn't be so bad. If anything, it would get my mind off my life outside of the classroom and gain a focus I never had. The ironic thing about this new choice in community college medical programs (nursing this time), is it required a great many traditional science courses that required me to memorize a heck of a lot more to regurgitate than I ever did before. I did feel greatly overwhelmed by the pressure.

I eventually switched from nursing to science education, because of an inspiring experience with an anatomy professor. Circumstances at the University of South Florida, when I entered from the community college, led me to begin a second major in public health. I eventually went on to graduate school and earned a master's degree in public health.

Life in higher education required more social interactions from me, because now I was taking classes with a variety of college students and not being secluded to a twelve-student self-contained paramedic course. I look back and wonder how I was able to stick through all the memorizing, especially in the science courses. There were now two things that made me feel uncomfortable with formal education: memorizing facts and social interactions.

I was turning 30 and facing one of my greatest fears, higher education. I look back on this time, which was over 10 years ago, and I wonder if what I was dealing with in my personal life pushed me to face my fear as a late starting college student. I wonder if facing the fear of failing in higher education was consuming enough for me to be successful in higher education and deal, or not deal, with the emotions I was facing with my failure in marriage. (Whatever the root of

motivation was back then, it pushed me far enough for me to be sitting here, at age 42, writing my thoughts about teaching and learning for my doctoral dissertation.)

My ability to overcome my fear of higher education did not change my perception of teaching and learning. I just learned to become a better fact memorizer and rubric follower. In fact, it perpetuated my old belief that learning involves more fact memorizing and reinforced my belief that teaching should be didactic. This belief was still there despite the education courses I took to enable me to pass the teacher certification test said otherwise. There was a common belief among most of my fellow education majors: We all agreed with the idea of student-centered classrooms and non-authoritative learning, but we had never seen or been a part of this modern way of learning. Most science education majors thought that our excitement and deep understanding of the subject would capture the kids' attention long enough for us to teach them ways to memorize correctly.

I did not start teaching until I was 34 years old. At that time, I was ending my second career as an Emergency Medical Technician. My perception of teaching and learning began to quickly change and evolve when I formally started teaching as a third career, late starting teacher. When I was given the keys to a classroom where 150 kids came to learn from me, I started questioning my current belief of what this whole teaching and learning relationship really was. I began to question how practical and how stressful it was for one person, one teacher, to get 150 kids to learn what science really was. I found out quickly that it was not only impractical, but it was also greatly stressful for any one person to achieve this on his/her own.

Out of desperation, I began to employ top students from each class to help me with the entire process of teaching and learning. How "hands off" and how "lazy" my approach to teaching appeared became an ongoing joke among faculty at my school. They all agreed,

however, that they wished they could give up control in their classroom, because it was so exhausting keeping a strong hold on middle school learners. They take advantage of teachers who are too relaxed. These same teachers also admitted to me and their colleagues they wanted to see their more challenging students step up and own their learning process with their peers in the classroom, as they saw happen in my classroom. In other words, students who typically give these traditional style teachers an array of classroom distractions, found ownership in their learning process when they did my style of classroom in which the learner is the creator, editor, executor, and evaluator of a shared classroom learning experience.

This new way of teaching I developed out of occupational desperation (due to the unfortunate circumstances facing all new teachers) began to quickly emerge into my signature as a professional teacher. Having this student-centered and evolving classroom model (TTTC) as my identification increased my confidence about implementing a new way of teaching with all current and prospective students of any age. It also increased my confidence as a learner enough to enable me to enter a science education doctoral program at age 39, after three years of teaching middle school science in a school filled with low level learners. Many students were involved in disciplinary action related to their defiance of teachers or other school authorities, being arrested for criminal activity, or initiating trouble with peers.

Developing a classroom model of students teaching students inspired me to investigate the way in which learners learn with other learners. In other words, as a teacher learning how students learn, I shifted my original focus from trying to emulate the perfect student who could regurgitate multiple facts I threw at them, to how various levels of learners can help each other learn during the shared learning process. I started to study and learn how social development outside the classroom influenced the varied levels of grouped learners, and how these daily

interactions continually evolved throughout the school year as students became more comfortable with this new classroom structure of learning. I continuously clarified and modified the procedures I used in my classroom by applying each idea I explored during my doctoral program. Eventually a distinct model (TTTC) emerged labeled, Three-Tiered Transformative Classroom (TTTC). Here are the participants' roles establishing the structure of the TTTC as I presented them (2021) in my unpublished doctoral qualifying examination.

Three-Tiered Transformative Classroom (TTTC) Model

The following details provide the working operation of a classroom inquiry teaching model I have integrated into my teaching profession as a middle school science teacher.

Teacher

The teacher's role for the TTTC model is explained in the list below.

1. Provide a topic to 'Designers' from the district guide and benchmarks to investigate
2. Suggests initial possibilities for approaches to lesson structure and potentially useful tools
3. Confers with 'Designers' on an as-need basis to critique and provide guidance for quality improvement
4. Critiques content accuracy of initial lesson and assessment draft
5. Confers with 'Instructors' on as-need basis
6. Critiques emerging instructional plan
7. Confers with 'Testers' during implementation of lesson
8. Serves as resource to all class members on an as-need basis

Designers

The student in 'Designer' role for the TTTC model is explained in the list below:

1. Obtain topic (content benchmark) from the teacher
2. Investigate topic to develop understanding and construct personal meaning
3. Represent constructed meaning in a concept-map or video
4. Design a lesson to teach other students what 'Designers' understand
5. Design assessment for outcomes of learning from emerging lesson plan
6. Teach the lesson to 'Instructors'
7. Administer assessment to 'Instructors'
8. Obtain feedback from 'Instructors' about the degree to which the lesson is comprehensible, teachable, assessed, potential pitfalls in the meaning-making process (constructing meaning), and recommendations for improvement of lesson and assessment
9. Revise lesson plan accommodating feedback from instructors
10. Repeat steps 4, 5,6, and 7
11. Serve as resources to 'Instructors' and 'Testers' while 'Instructors' implement lesson with 'Testers'

'Designers' work within their tier with minimal parameters and assistance from the teacher. Once I confirm the accuracy of their understanding of a topic, they draft a lesson plan by responding to the question, "How will this information translate effectively to my classmates?" They expect their final lesson and assessment products to emerge from an iterative process of collaboration and feedback from classmates in other tiers.

They test their lesson by teaching it to participants in the instructors' tier**.** As the semester progressed, 'Designers' were divided into subgroups based on their expertise:

a) Digital Mapping Crew - were taught how to use the C -map program (https://cmapcloud.ihmc.us/) and would be able to build C -maps and digitally arrange and rearrange concepts on the maps. Their ultimate objective was to take the study guide objectives provided by the district and incorporate those concepts into a series of C-maps that would become a digital textbook.

b) Lab Designers (digital or physical) took information from the C-map digital textbook and other sources to design lessons complete with instruction and assessment components. They converted adult language in which activities were written to middle school friendly language.

c) Video Makers took lessons students were having difficulty with and transformed them into visual versions students could more easily understand.

Instructors

The student in the 'Instructor' role for the TTTC model is explained in the list below:

1. Enact the lesson provided by 'Designers' to test it
2. Analyze a lesson for the degree to which it is comprehensible, teachable, assessed, potential pitfalls in the meaning-making process (constructing meaning), and recommendations for improvement of the lesson and assessment for self and other learners.
3. Give 'Designers' feedback to guide revision of the next lesson and assessment
4. Review revised lesson and, or assessment
5. Repeat steps 1, 2, and 3

6. Determine classroom management requirements, including materials dissemination and procedures to organize students
7. Implement the revised lesson with ‘Testers’
8. Collect feedback from ‘Testers’ regarding meaning they make and questions they generate
9. Provide feedback to ‘Designers’ about how understandable and teachable the lesson is and make recommendations for improvement of lesson design

‘Instructors’ teach the lessons created by ‘Designers’ to the ‘Testers’. They follow the instructions and assessments and make changes based on feedback from the ‘Testers’. This feedback is given to the ‘Designers’, who adjusted their thinking to make continuous improvement on future lessons more successful.

Testers

The student in the tester role for the TTTC model is explained in the list below:

1. Enact lesson
2. Engage in assessment
3. Provide feedback to Instructors regarding their cognitive and emotional experience while enacting the lesson (i.e., confusing questions, concepts not addressed, etc.)

Mechanical, behavioral, or cognitive issues that arise for the ‘Testers’ during the implementation of the lesson and assessment are addressed by the ‘Instructors’ with additional support from the ‘Designers’, and the teacher.

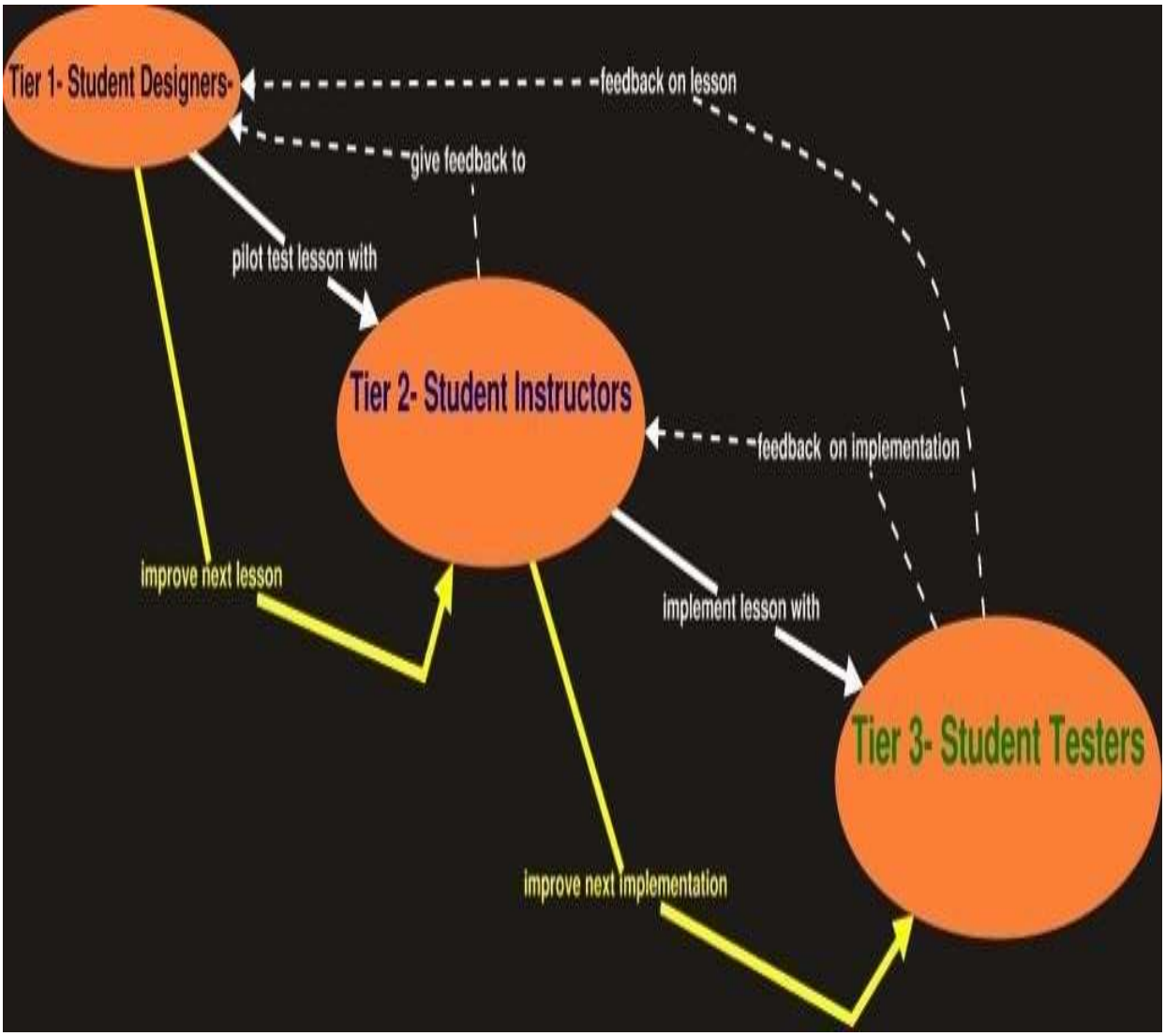

Figure 1. The Three-Tiered Transformative Teaching Classroom model (TTTC)- Student Roles, Version 3 (Latest Version)

Continuous Assessment

'Designers' and 'Instructors' share the work they have accomplished at the end of each class period with me, the teacher. I assess the accuracy of the content knowledge being constructed, efficacy of emerging lesson and assessment tools, and provide feedback, including potential pitfalls and guidance for next steps.

‘Instructors’ assess the lesson and assessment tool the ‘Designers’ developed for how engaging, comprehensible, and usable the information is, and provide ‘Designers’ feedback for refinement. Assessment tools may include laboratory worksheets, group whiteboard analysis, concept maps, games, oral questions, or journal writing. ‘Instructors’ also assess the performance of ‘Testers’ for involvement in the learning activity and performance on assessment rubrics created by the ‘Designers’ to determine content learning.

‘Testers’ assesses the lesson for its ability to communicate content and appropriateness of the assessment rubric. ‘Testers’ assess the implementation procedures used by ‘Instructors’ and provide feedback to both ‘Instructors’ and ‘Designers’ regarding the learning experience.

The teacher assesses the degree to which all students engage in their respective groups with appropriate social and cognitive behaviors. These include, but are not limited to, assessing the working process of ‘Designers’, the content accuracy of initial lesson and assessment draft, and the communication with the ‘Instructors’. Similarly, the teacher continuously assesses the working process of the ‘Instructors’, the working process between Instructors and ‘Designers’, and the working process between ‘Instructors’ and ‘Testers’. The teacher is consistently on the lookout for emerging content misconceptions and potential confusion caused by delivery of instruction among tiers.

Assigning Grades

‘Designers’ and ‘Instructors’ are assigned an A+. They are removed from that tier and placed in another tier if their performance is not worthy of the A+ grade. Participants in the ‘Tester’ tier is assigned a grade based on the points earned for their performance on the assessment tool accompanying a lesson and observed participation in the lesson.

The preceding description of the TTTC teaching model emerged from the collaboration process I experienced with my doctoral supervisor throughout my studies in the science education doctoral program. This collaboration process facilitated the change in my self-concept as a learner and as a teacher. It is a major aspect of this study.

Ontology

The lens with which I view the world is relative to the experience of the individual. Taylor (1978) explained the perceptual lens I align with the most, stating "…truth is relative because meaning is contextual and being is relational. Contextualized meaning and relational being joined to form relative truth disclosed through symbolic awareness" (p.41). In my autoethnography, I built meaning from my experience in a doctoral science education program. This meaning is personal and relative to the culture of which I became a participant and an observer. I was observing and studying the relative truth that was symbolic to my value and belief system, and I was actively engaging in this same world as a participant building meaning from the experience.

Epistemology

Constructivism, the way I believe knowledge is acquired (epistemology), is through direct experience (Muller, 2018). I build meaning from my experience when new knowledge is integrated into existing knowledge. Since this is a continual process, and in my study, I am both the researcher and participant, the stories of my experience and the study of those stories cannot be compartmentalized. They influence each other. Smith (2003) commented that both myth (story) and scientific knowledge (research) are relative to each other in terms of epistemology, what we believe and how we know it.

Purpose and Research Question

This is my story as a doctoral student developing a practice—theory—practice cycle. This study describes my journey as a middle school science teacher progressing from my intuitive practices, devised out of desperation to survive as a beginning teacher; to clarifying what I was doing and codifying it into a model (TTTC); to studying extant literature (theory); to applying the extant theory to my practice by refining my emergent model (TTTC); to applying the model (TTTC) to additional audiences; to revising the emergent model (TTTC) further (knowledge spiraling); and to contributing to the literature base.

The purpose of this research study is to investigate my learning experience in the doctoral science education program, and how this experience impacted my professional practice through the development of a teaching model (TTTC) I used in my middle school classroom and in two undergraduate science teaching methods courses. I think this study is important to the field of science education research because it provides a concrete example of constructivist teaching and learning in higher education that emerged from a co-mentorship relationship between my doctoral supervisor and me. The effects from this higher education teaching and learning experience improved my own practice as a learner, my practice as a middle school science teacher, prepared me to be a science teacher educator in higher education, and enhanced my occupational and personal well-being. The focus question of the research guided the emergent methodology of the study allowing me to gain critical insight into the impact a science education doctoral program had on a working professional teacher:

"What was the impact of the learning experience in a science education doctoral program on a middle school science teacher's professional practice?"

An outcome of this investigation was a set of recommendations to add to the Association for Science Teacher Education (ASTE) recommendations for what should be included in all science education doctoral programs. These recommendations emerged from data analysis in this investigation that was qualitative in nature, practicing a critical analysis of the contributing factors impacting the educational experience. Emergent questions guiding the nature of the learning experience follow:

"What were the characteristics of the relationship between my doctoral supervisor (teacher) and me (the doctoral student learner)?"

"How did my teaching practice change while I was a learner in my doctoral program?"

To answer these questions, the data were collected using qualitative research methodology, described by Denzin & Lincoln (2003) as a research practice in which the researcher can transform a world within a world that they are studying through a series of interpretative representations of what would have been invisible. To discover the characteristics of the learning experience and the impact of that experience on my teaching practice, important emerging data were collected from reflexive journals; concept maps; observational field notes; discourse with a critical friend; narrative life stories of learning experiences; and a summative reflection of the program and my professional practice. These data sources and the collection of such are consistent with qualitative research methodology. Denzin and Lincoln (2003) noted that a case study exploring the personal experience of a subject would require personal artifacts to represent a meaningful life experience. In my case for this study, the meaningful experience encompassed a time in my life in which I simultaneously was a doctoral learner of science education and a teacher at middle school science.

Clough (2002) noted the importance of studies that investigate qualitatively the educational experience of both the student and teacher from subjective perspectives. These varied and specific points of view provide critical insights into the complexities involved in meaningful learning experiences. In this study, I examined my perspective as a student in my doctoral program and the relationship I had with my teacher (doctoral supervisor) who functioned as my co-mentor and critical friend.

Value of Study

This study (a) produced recommendations to enhance doctoral programs in science education and (b) contributed a model (TTTC) for middle school science teaching practice supporting early career and experienced middle school science teachers. Findings were supported by, and support literature (extant theory).

My dissertation is an examination of my experience in the doctoral science education program at the University South Florida's College of Education. My study encompassed the program, including time I spent completing the required course work, the qualifying exams for Ph.D. candidacy, and preparing to write the dissertation proposal. I investigated my doctoral science education experience through an autoethnography with a constructed narrative story explaining how learning educational theory contributed to building an original teaching model (TTTC) grounded in theory. The investigation examined the work process I engaged in with my co-mentor to evolve and refine the model from our continual research on how the model worked in practice. We used an iterative process that resulted in improving the model and articulating how the model worked. I focused on the anatomy and physiology of my educational (cultural) experience in generating grounded theory (explanation) on work processes I used with my co-mentor studying existing theory to support development and describe the evolution of my

teaching model (TTTC). I anticipated the emergent theory would be applicable to other students' learning experiences, in a much wider context, to facilitate other doctoral students' well-being and development of theory from practice and practice from theory.

Definition of Terms

The following are the definitions of terms used frequently in my dissertation.

Autoethnography

Kim (2016) described autoethnography, "as a form of narrative research that seeks to systematically analyze the researcher's personal experience all embedded in a larger social and cultural context" (p.123).

Doctoral Science Education Program

According to the University of South Florida (2021), a student in this Ph.D. concentration will increase his/her knowledge in education by engaging in the process of research. A student from this program will increase his/her scientific literacy by engaging in a variety of student experiences. University South Florida (2021) noted these experiences are designed to build practical and theoretical knowledge about the nature of science and build understanding of a variety of scientific perspectives to practice critical thinking. Further, a student will increase his/her knowledge of science pedagogical content knowledge embedded in our culture and history. The student will also build scientific literacy during this program by creating meaningful questions and research designs original and important to the field of science education (University of South Florida, 2021).

Constructivism

This is a theory in education suggesting learners build and integrate new understanding from their existing knowledge base through meaningful experiences (Matthews, 1998).

Co-Mentorship

Co-mentorship is defined as a mutual mentoring relationship, connecting people of varying levels of power and privilege (Mullen, 1999). Seven steps involved in establishing a co-mentorship include the following: clarifying values, analysis of personal contributions, analysis of expectations, collecting data, developing guidelines for selection, choosing a co-mentor, and initiating a relationship (Mosser et. al.,1987).

Concept Mapping

A concept map is a schematic diagram introduced by Novak & Gowin in 1984 to help learners build meaning to what they are learning through metacognitive practice. The learner visually identifies new concepts and connects them to relatable concepts (new and/or existing) within propositions to develop themes, trends, and patterns. Concept mapping provides an experience for learners to integrate new information into existing information using metacognition. It helps learners to learn how to learn (Novak & Gowin, 1984).

Teaching Model

A teaching model depicts the behavior of the teacher and the learning environment used *(*Joyce Hwee Ling Koh et al., 2014). It is also considered to be descriptive teaching strategies defining instructional goals, processes used to reach those goals, and pathways used to help students understand how to learn (Eggen,1978).

Association for Science Teacher Education (ASTE) Science Teacher Educator

A science teacher educator defined in broad terms, according to the Association for Science Teacher Education (2021), is someone who educates science teachers. ASTE argued this general definition diminishes the professionalism of the educator. A science teacher educator is defined by continuing professional development and contributions to the field in any of these domains: knowledge of science; science pedagogy; curriculum, instruction, and assessment; knowledge of learning and cognition; research/scholarly activity; and professional development activities (Association for Science Teacher Education, 2021).

Professional Standards

These are guidelines established by a professional group through consensus used to maintain the quality of education and performance of group members. They established such standards to guide the education of prospective science teacher educators (Spector, et.al., 1993).

Practice

I am using practice as a noun indicating the application, implementation, or exercise of an idea, belief, or method, as opposed to theories relating to it.

CHAPTER 2: LITERATURE REVIEW

The content in this chapter describes four domains of extant literature related to my dissertation. The aim of this chapter is to provide the reader with gaps in the extant literature that are relatable to each other, thus providing support for the focus of my dissertation. In this chapter gap were identified based on their relationship to my dissertation study. overarching focus for this dissertation work is to mitigate these gaps found in the extant literature.

Introduction

The following areas of literature are directly relevant to this study: the nature of doctoral education, constructivism, co-mentorship, and concept mapping.

Nature of Doctoral Education

I did not find a current comprehensive report on the status of science education doctoral programs in the United States in my literature review, nor was I able to find any current research report empirically examining factors which contribute to the doctoral experience in science education. I broadened my literary review with a more general search of doctoral education, inclusive of all types of Ph.D. programs and the experiences reported in them. I did this to establish a clearer baseline about doctoral programs and factors that commonly affect the doctoral experience studied in modern literature. I was able to review some important trends. Although this search was limited to very few empirical studies, it was important to review these studies for the development of my dissertation. Pyhältö et al. (2012) stated, "... there is a need to obtain a deeper understanding of the nature of the Ph.D. process and the problems students face as well as how these problems relate to their well-being during the Ph.D. process" (p.1).

The first portion of my review identifies the nature of doctoral programs. The second part identifies common problematic experiences of individuals enrolled as doctoral students. The last comprehensive study I found on the status of science education doctoral programs was in 2002 by Paul Jablon. This report continued the work Robert Yager published in 1980, which investigated graduate science education from 1960 to 1980. Jablon reviewed science education in doctoral programs from 1980 to 2000. Yager (1980) noted the average number of credit hours used to concentrate on philosophy, sociology, and the history of science in doctoral programs was 4.5 out of 60. Jablon (2002) noted this low average had not changed over the twenty years following Yager's report. The Association for the Education of Teachers in Science recommended there should be an inclusion and increase of these topics in all programs (Butts, 1977). Butts (1977) commented, programs, however, refused to acknowledge this low concentration on those subjects was a problem. Not even half of doctoral science education programs had one course devoted to the history of science in 1999 (Jablon, 2002). Only 20% of programs in 1998 required their doctoral students to take a nature of science (NOS) course, despite the K-12 movement of NOS in school curriculum (McComas, 1998). In Jablon's study (2002), only 27% of programs had courses on science school change. The study noted that doctoral science education programs are expected to develop change leaders by students having experience being apprenticed to someone who is effectively leading a systemic change project. Only a quarter of doctoral science education programs, however, required their students to be a part of a school change project (Jablon, 2002).

Jablon (2002) suggested that recipients of Ph.Ds. in science education are expected to facilitate school change through the preparation of future science teachers. This can be stimulated through exemplary teaching of pre-service science teachers in undergraduate science

teaching methods courses. He noted only 34% of future science educators were mentored to be proficient in teaching these methods courses in their doctoral science education program.

According to Jablon (2002), the number of doctoral science education graduates increased from 1960 to1980 (Yager, 1980), but since then the amount declined. He also noted course requirements in doctoral science education programs had not changed since Yager's report (Jablon, 2002). There has been an increasing trend from Yager's report (1980) through the end of the century of doctoral science education programs being integrated in larger Curriculum and Instruction departments (Jablon, 2002). Jablon (2002) recommended there should be funding for more comprehensive studies on doctoral science education programs to analyze the quality of the curriculum and the program's ability to produce change agent leaders in the science education community.

Using a more general search on doctoral programs, according to Walker et al., (2008), current and future doctoral education face the same problem it has always faced; half of Ph.D. students are lost to attrition. Those who do not drop out typically take a longer time to finish their programs, often resulting in a diminished zeal for their chosen field. They examined the Carnegie Initiative on the Doctorate (CID) project that studied 84 various doctoral programs. This project, sponsored by The Carnegie Foundation for the Advancement of Teaching, also addressed how teaching plays a role in current doctoral programs. According to Walker et al. (2008), doctoral education has a responsibility to our society for the formation of scholars. These scholars provide the advancement of our culture through innovations and solutions to problems discovered by research and the teaching of that research. Doctoral programs successful in the formation of scholars, created an educational experience that provided scholarly integration of both research and teaching. According to the Center for the Integration of Research Teaching

and Learning, (supported by the National Science Foundation), STEM fields are now embracing teaching as a research method to gain more insight into the doctoral learning experience to advance outcomes of both students and teachers (Walker et al., 2008).

In addition to scholarly integration, other successful doctoral programs that produced scholars placed a focus on advancing the development of their intellectual community (Walker et al., 2008). Walker et al. (2008) noted the stepping-stones (course work, comprehensive exams, dissertation proposals, research, and dissertation writing) taken by doctoral students in their path to a Ph.D. present a series of cultural discourse opportunities with professionals in their selected field. According to Thomas Bender's essay (in Glode, 2006) these opportunities often fall (2018) to the wayside for doctoral students, because most department cultures have not provided a safe environment for both students and faculty to engage in creative discourse. There is a lack of shared governance and openness among all members. Thomas Bender (Golde, 2006) concluded that providing a safe intellectual community to encourage doctoral students to engage in discourse with faculty members is essential to the curriculum of a doctoral education, thus critical to the formation of scholars. An effective intellectual community should be part of the doctoral curriculum. There is unnecessary financial tension between research and teaching because there is a similarity between learning new knowledge and research generating new knowledge (Cuban, 1999). In order for doctoral programs to groom students into scholars, if learning is the goal of the intellectual community, these programs must relieve the tension between the function of research and teaching and integrate the importance of both of them into the doctoral curriculum (Walker et al., 2008).

Another essential element (found in the CID project) needed by doctoral programs to generate scholars in their fields is the training of stewardship among their students (Walker et al.,

2008). According to what Walker et al. (2008), when programs implemented this quality training for their learners, it prepared them to foster creativity and advancement in their discipline. Stewardship provides individuals with a sense of value and responsibility within their community. This is consistent with Jablon's (2002) call for doctoral science education programs to produce change agent leaders motivated to pursue systemic school change. If these Ph.D. recipients hold a deep value of stewardship about their role as a scholar, then their drive to be change agent leaders for schools will be inherent.

The project also noted that doctoral students who drop out or lose their passion for their field tend to report the same burdens that many dissatisfied faculty members report (Walker et al., 2008). These burdens included pressures of debt, low pay, and overworked lab and instructor positions. According to Walker et al. (2008), these findings raise serious issues in the future of the formation of scholars in the doctoral education system. Continual investigations into what works and what does not work in doctoral programs is essential to the advancement of higher education, thus affecting the future of research, teaching, and our society (Walker et al., 2008).

Walker et al. (2008) commented: "A fully formed scholar should be capable of generating and critically evaluating new knowledge" (p. 12). This ideal demonstrates that a Ph.D., at its central core, is a research degree. This means members in higher education should not lose sight of the importance teaching has on the inquiry process and the development of research. "The scholarship of teaching and learning entails basic but important tools that can and should be carried in every professor's repertoire" (Huber and Hutchings, 2005, p. 1).

Historically there has always been a debate in higher education about the balance between research and teaching. In 1906, the Association of American Universities asked the question, "To what extent should the university investigator be relieved of teaching," (found in

Walker et al., 2008 p. 23). Walker et al., (2008) noted that the Manhattan Project in 1945 provided a large amount of federal funding to university research resulting in the expansion of doctoral education. This federal funding widened the infrastructure for second tier institutions to provide Ph.D. programs in science education. In the 1960s, the trend continued fueling federal funding for universities with the Defense Education Act of 1957. All the federal support to universities provided an explosion of doctoral education throughout the 1960s. This newfound wealth in academia forged new strong alliances of research teams that reduced the amount of time spent in the improvement of teaching in higher education. Because of these strong alliances, the gap between the importance of research and teaching grew wider and more permanent. Walker et al., (2008) argued these alliances are still prevalent in higher education today. The focus of research as the primary source of funding for the life of the university clouded the judgment of the structure of doctoral education throughout the 1960s. There grew a demand for more doctoral education to focus on research projects that benefited from federal funding for the university. By the end of the 1960s, funding of federal education research grants started to decline, jeopardizing the future livelihood of the universities. (Walker et al., 2008).

What does this topic and the history of this debate have to do with the status of doctoral education today? The trend of education funded by federal grants reshaped the responsibilities of not only faculty, but doctoral students as well (Walker et al., 2008). Time once used to improve the quality of teaching in higher education was now replaced with time to improve the quality of research (Thelin, 2004). After 1945, time spent on a doctoral education increased from two to five years (Berelson, 1960). This is in part due to the time needed to build and run expensive federal grant projects, resulting in less time for doctoral supervisors to spend time

educating their doctoral students (Walker et al., 2008). Doctoral students became cheap labor as free lab tech and teaching assistants for doctoral supervisors responsible for large federal grants.

The post war federal education funding support for a more highly educated society resulted in an increase in undergraduate and graduate populations. (Walker et al., 2008). This increased the demand for more college teachers. The debate about balance between improving the quality of research and the quality of teaching ensued (Walker et al., 2008). The number of students in higher education decreased following the earlier inflation of college student populations (Breneman, 1975). Federal funding for university research began declining starting in 1969, and the doctoral degree admissions stopped showing signs of growth (National Board on Graduate Education, 1975). Despite the demands from doctoral students (current and former) to revolutionize the doctoral degree programs in order to reduce attrition, the changes made to these programs and new programs that opened, did not provide anything new. Most of the programs remained traditional in nature (Bowen & Rudenstine, 1992). By examining the history of doctoral education, Walker et al. (2008), pointed out forces of federal research funding in the doctoral enterprise still have negative residual effects in how these programs operate today. In other words, the debate of how important teaching is in relation to research in the higher education community has been debated continually since the start of the previous century. The impact of this unresolved long-standing debate on the education of a student obtaining a research degree (Ph.D.) in teacher education (Curriculum and Instruction) is critical to the shape and life of that program for the individual student. The discourse and balance between research and teaching in a doctoral science education program requires evaluation and analysis of what works and what does not work in the program. This dissertation explains the way my doctoral program functioned in the formation of my scholarship while I was simultaneously practicing as a

teacher. This will be valuable to the historical debate in higher education that argues the comparative merit of research and teaching in a Ph.D. program.

My doctoral experience described in this dissertation comes from a very specific context within a very specific world. Because I described a very particular environment that influenced my working process as a student, it was important to view common factors seen in other doctoral experiences from different doctoral environments. This allowed me to compare the factors influencing my doctoral experience, with factors of influence on other doctoral experiences. According to Pyhältö, et.al (2012), most doctoral students reported problems, "…related to the general work process" (p. 5). Since I used the collaborative working process I shared with my doctoral supervisor as a focal point of my dissertation story, it was important to identify the comprehensive factors surrounding this process. According to Sverdlik et.al (2018), previous research surrounding this process. According to Sverdlik et.al (2018), previous research investigating the impact doctoral programs have on the learner, identified three main factors of influence. These factors included the learners' experiences with their supervisors, engagement in their community of scholars, and the collective value system between the learner and their doctoral supervisor. Sverdlik et al. (2018) noted, despite the slight increase in doctoral program enrollment from 1998 to 2010 (OECD, 2013), the attrition rate for doctoral students has remained high for over 50 years. According to MELS 50% of doctoral students drop out of their program (found in Sverdlik et al., 2018). Gardner (2009) pointed out, historically, research investigating high attrition rate in doctoral programs typically focus on factors involving institutional and cultural issues of influence on the student's ability to stay in the program. Sverdlik et al. (2018) argued, most of these research studies claiming to be empirical in nature do

not examine the personal life of a doctoral experience, and how these elements affect their ability to finish and thrive in a program.

Current studies which examine the doctoral student's personal and professional wellbeing have found high stress levels among most doctoral students (Kernan et al., 2011). According to Hughes (2011), studies that aim to examine positive emotions related to the doctoral experience more often report negative emotions among students, and difficulties with personal relationships while in the program.

Sverdlik, et al. (2018) conducted a study examining more comprehensive factors affecting doctoral experiences. In this study, the most influential external (university/institutional) factor on the doctoral experience is the student's relationship with their doctoral supervisor, as well as departmental regulations and expectations of the student's program. Sverdlik, et al., (2018) also identified important internal factors of the doctoral experience, such as motivation, writing skills, academic identity, and self-regulatory practices. Personal relationships and resources available inside and outside the university serve as both internal and external factors influencing the doctoral experience. According to Sverdlik et al. (2018), the factor with the most positive influence on doctoral experiences is supervisor relationships built on mentorship. Supervisor relationships were the most studied, as well as the most influential factor found in current and historical research investigating doctoral experiences. Studies which reported positive doctoral supervisor relationships generally included open communication with frequent feedback. Sverdlik et. al (2018) investigation commented that even though doctoral students preferred a mentorship relationship with their supervisor, higher student satisfaction and more positive emotions were prevalent when the supervisor (acting as a mentor) still assumed guiding and support leadership roles. High levels of student burnout and depression

were more prevalent in studies noting low levels of student leisure time. The demands placed on doctoral students in these programs resulted in increased social isolation. This isolation resulted in an unhealthy life/work imbalance. This imbalance was found to be the strongest predictor of distress among doctoral students. Research on the positive factors of influence on student motivation during the doctoral experience included departmental culture supporting student value and agency. According to Sverdlik, et al. (2018), departments that engage their doctoral students in a professional community have shown an increase in motivation and success. Current research has found student lack of motivation as the main reason for graduate school dropout. Research on the unstructured nature of doctoral programs found students with better self-regulation skills can maintain motivation throughout their doctoral programs, thus resulting in higher completion rates (Sverdlik, et al., 2018).

Pyhältö et. al (2012) investigated multiple studies on doctoral experiences and found the most common contributions to the general work process problems were lack of scholarly community and the supervision of their program. Previous studies had shown problems doctoral students tend to face are often associated with the individual student's perception of value in his/her scholarly community. Pyhältö et al. (2012) suggested doctoral experiences include a student experience in the scholarly community to act as a deterrent to student dropout. This could also serve as a factor for increased student motivation (Pyhältö et al., 2012).

Examining all the contributing influences on multiple doctoral experiences from Pyhältö et al. (2012) and Sverdlik, et al. (2018), indicates future doctoral education should develop efforts to reduce the isolation of the student by increasing the opportunity for collaborative learning through general work processes. These work processes should be embedded within a nurturing scholarly environment guided by a support network of mentoring and supervising.

The experience investigated in this dissertation examined the collaborative general work processes I engaged in with my co-mentor (doctoral supervisor). My doctoral supervisor also assumed a leadership role providing me with the guidance and support I needed to maintain confidence during times of distress. She provided me with experience in her scholarly community empowering me to overcome personal, professional, and academic challenges. By providing a literary 'backbone' from reviewing empirical studies on the historical nature of doctoral programs, a deeper understanding of how current comprehensive factors influence the modern doctoral student was established for the investigation of my dissertation. Since my dissertation focused on a comprehensive analysis of factors that influence the collaborative working process I experienced with my doctoral supervisor, then it is appropriate to compare these factors to current literature. The goal was to learn from this comparison in order to gain insight to help improve future doctoral science education experiences.

Constructivism

Muis, et al. (2016) commented, the learning process in current education centers on the construction of knowledge built from students' experiences. Pande & Bharathi (2020) pointed out how focus in education requires the advancement of the learners' thought processes. Bruner (1961) and Vygotsky (1962) established the Constructivist Learning Theory which addresses how learners advance their thought processes by continually building on them. Bada & Olusegun (2015) commented that to construct knowledge a learner must be active in the process itself. Pande & Bharathi (2020) pointed out that when teaching the constructivist learning process, curriculum and instruction must depend on the facilitation of a learning experience.

Lewin (1988) commented Constructivist Learning Theory centers on the real experience of the learning process, thus the basic core of the theory can be rooted in Piaget's teaching and

learning concepts of truth and relativism. Von Glasersfeld (1998) noted typical teaching excludes the fundamental reality of the learner's experience, which is at the core of constructivist thinking. This is evident when examining what and how teachers teach learners. Cross (2001) argued teaching constructivist learning cannot emerge from clear organized set structures; instead, the learner must experience the messy reality of problem solving to exercise a creative thought building process. A major component of my study reflected on the learning experience involving an examination of problematic situations and the creative thought process needed to build solutions to the problems. This study demonstrated how the teacher of my experience (doctoral supervisor) facilitated a creative process needed to resolve my problematic learning situations. This constructivist approach to teaching will demonstrate an alternative learning experience which rejects a teaching process rooted in standardized structures not adaptable to emerging subjective realities of a learner.

According to Ahmad et al. (2012), problematic situations align with constructivist theory because these realistic experiences "…prepare(s) students for problem solving in a complex environment" (p. 4). From this exposure to reality, learners will practice knowledge by using and improving critical thinking, problem solving, and analytical skills (Ahmad et al., 2012). Grabinger & Dunlap (1995) as well as Lebow (1993), commented on how these experiences are designed to be meaningful to individuals building their own knowledge from it, thus this learner can only build that knowledge through social interactions. Despite how personal the constructivist learning process may be, the problematic situations and the problem solving of those situations are dependent upon other learners in that learning environment.

It is essential to recognize that the constructivist learning process is important in a higher education learning environment (Entwistle et al., 1993; Jonassen et al., 1993). In this

dissertation of my higher education learning experience, the learning process (built upon my realistic problems) involved a collaborative working environment. I was able to solve emerging problems with my program supervisor, who took the roles of co-mentor and critical friend. According to Kafai & Resnick (1996), generative learning strategies are an important principle of constructivist learning. They described them as active processes which do not only generate educational products, but also generate solutions to problems the learners may face. The problems in my study are realistic to my personal experience as a middle school science teacher. They were neither abstract nor conceptual. We studied the problems surrounding the active use of my developing teaching model (TTTC). These real-world problems are consistent with the constructivist learning process demonstrating one of the 5 principles described by Grabinger & Dunlap (1995) called Authentic learning contexts. Authentic learning contexts are experiences requiring systematic problem solving in non-abstract situations facilitating student ownership of the constructivist learning process (Bostock, 1998). In my role as a learner of doctoral science education, I was studying (with my co-mentor) solutions to real problems I was facing with my continual use of a developing teaching model (TTTC).

Co-operative support was another principle of constructivist learning identified (Grabinger & Dunlap,1995). Bostock (1998) pointed out, this principle, when enacted in the process to help solve real world problems within realistic situations, enables students to gain critical insight through different perspectives from collaboration. This study demonstrates this principle used to solve my realistic problems. My dissertation examined the collaborative working process on a teaching model (TTTC) I used to solve problems I faced as a teacher. The mentorship relationship facilitated by my program supervisor was a co-operative support relationship, which allowed the learning experience to become collaborative in nature. This

evolved into a co-mentorship relationship. My investigation demonstrates not only my own constructivist learning as a doctoral student (the mentee), but also constructivist teaching from my supervisor (the mentor). According to O, C. K. (2020) constructivist teaching can be effective in higher education in various contexts stating: "Constructivist teaching then, is not a settled pedagogy, but the concept is used in different ways in different contexts..." (p. 3).

My study demonstrates a concrete example of university constructivist teaching presented in a different way, through the context of a co-mentorship. The investigation of this relationship aligns with current interests examining constructivist teaching in higher education settings. O, C. K. (2020) stated: "In recent times, there has been a strong focus on moving university teaching away from so-called 'instructivist', lecture-centered mode… towards a more student-centered 'constructivist' approach, centered on active learning and students' own construction of knowledge" (p.1).

According to Sjoberg (2010), constructivist teaching and learning theories all suggest that for students to build knowledge from their experiences there must be a strong relationship between the teacher and learner. The co-mentorship relationship in this study examines the emerging strength in the relationship and the ability of the relationship to facilitate the constructivist teaching and learning process. This addressed O, C. K. (2020) statement, "…there is a strong need for more critical attention to how these practices are being taken up within higher education in different ways and across different contexts" (p. 10).

Co-Mentorship

This dissertation examines the working relationship I engaged in with my doctoral supervisor. The relationship is described as a co-mentorship. According to Shapiro (2020) constructivist thinking is central to mentoring. He stated constructivism in "…theory and practice profoundly undergirds mentoring" (p. 77). The constructivist frame of mind is cognitive of individual feelings and experiences in a mentorship, because "...each individual constructs his/her own meanings in and of any situation" (Shapiro, 2020, p.76). I examined the co-mentorship relationship that used constructivist thinking to build meaning from my doctoral experiences. My doctoral supervisor and I used constructivism to solve problems and learn from the situations we encountered. The co-mentorship greatly affected my development as both a learner of doctoral science education and a teacher at middle school science.

The co-mentorship examined in this dissertation influenced the development of a teaching model (TTTC) used in my professional practice. It provided me with ownership and shared power in my learning process, which emerged from the collaborative study of this model (TTTC). Researching constructivism in co-mentoring advanced doctoral science education because: "Alternative mentoring ideas and processes are gradually broadening mentorship theory and slowly changing academic relationships and practices" (Mullen et al., 2020, p.425). According to Huizing (2012) and Kroll (2016), benefits of mentorship relationships in higher education learning experiences are becoming more evident in current literature. My study characterizes the nature of the co-mentorship process during my doctoral experience. This process contributed directly to the development of the teaching model (TTTC) I practiced in my middle school classroom. The collaborative working process used to build my model (TTTC) demonstrated benefits supporting co-mentoring. According to Mullen (2009), co-mentorship

helps the development of teaching and learning in various social situations to educate the mentee. The co-mentoring process facilitates holistic teaching and learning (Mullen, 2009).

My co-mentor spent time improving the quality of my studies, professional practice, and our working relationship. Johnson (2006) and Shea (1994) described mentoring to be a developing relationship where the expert responds to the emerging needs of the less experienced to maximize progression and achievement. Mullen (2009) commented co-mentoring relationships are learning partnerships. Implementation of co-mentorship relationships between doctoral students and their supervisors could help address the vast number of challenges facing these students and their low program completion rates. "Programs that boost higher graduation rates and student satisfaction sponsor intentional mentoring by dissertation chairs and through program (e.g., cohort) structures" (Mullen, 2009, p. 13). According to Dorn & Papalewis (1997), faculty who used mentoring with their doctoral students were able to improve their completion rates, as well as the quality of writing and inquiry conducted by their students.

Mullen (2009) pointed out, a co-mentoring model engages the adult because the learning process is reciprocal with shared power between an adult teacher (mentor) and an adult learner (mentee). The co-mentoring relationship described in this study emerged from a relationship of shared power between two adults: my teacher/doctoral supervisor (the mentor) and me as a doctoral student (the mentee). Reciprocal learning was central to our relationship.

My dissertation investigates the co-mentoring working relationship to provide new insight into doctoral science education. Mullen (2000) noted: "Co-mentoring has the potential to infiltrate and reshape the socialization process in leadership, teacher

development, and higher education" (p.5). "Co-mentoring relationships need to be developed in an effort to generate new structures of human partnerships"(Mullen, 2000, p.9). One of the central characteristics of the comentoring model (TTTC) involves shared decision- making and shared governance (Mullen, 2009). The direction and emergent design of my doctoral program coursework evolved from shared decision-making between myself (mentee) and my doctoral supervisor (mentor).

Concept Mapping

During my doctoral experience I used concept mapping to help me learn. This practice helped to improve the development, understanding, sophistication, and articulation of a teaching model (TTTC) used in my middle school classroom. Concept mapping also helped me build my knowledge base of educational theory and allowed me to critically reflect on the doctoral learning process. According to Safdar (2012): "The use of concept maps stems from the information processing theory of learning" (p. 55). Knowledge (built in a propositional network) is unique to each person's individual experience. As new information is learned, the network changes and more linkages are formed between concepts (Safdar, 2012).

My learning experience, facilitated by the co-mentoring process, was documented in a collection of concept maps. Concept mapping provided me with a visual practice to improve the teaching model (TTTC) I was using in my professional classroom teaching middle school science. I also used concept mapping to help make sense of what I was learning in the doctoral program. These maps were used to articulate and study the teaching model (TTTC) I was testing in my middle school classroom. This process provided a new type of visual learning experience in educational theory.

According to Ausubel's (1963;1966) meaningful reception learning theory**,** the learner derives meaning out of concepts through the visualization of concepts in a cognitive structure. Concept mapping illustrated the connections I was discovering between doctoral coursework and my professional practice. The concept maps collected during this timeframe function as a learning timeline. They visually recorded the development of my conceptual network and emerging understanding of educational theory. By examining this timeline, a graphical story of my doctoral learning experience emerged from this collection. Safdar (2012) described concept mapping at its core, "…is Ausubel's theory of learning, which tells us that meaningful learning depends on integrating new information in a cognitive structure laid down during previous learning" (pg 57). I described the building process used for a teaching model (TTTC) I practiced in my middle school classroom. This provided my doctoral learning process with a meaningful experience visually captured through a collection of concept maps.

According to Novak & Gowin (1984), concept maps provide a visual cognitive map for the learner as they build meaning from connecting developing concepts. I built concept maps while I was studying my assigned doctoral course work. I used concept maps to help me analyze my learning experiences with my co-mentor. The use of concept mapping in education aligns with constructivist thinking: "Concept maps are useful tools to help students learn about their knowledge structure and the process of knowledge construction. In this way, concept maps also help the student learn how to learn (meta-learning)" (Safdar, 2012 p.57).

During my doctoral experience the use of concept mapping helped me learn how to learn. Concept mapping allowed me to make sense of the model (TTTC) I was using in my teaching practice. According to Biniecki & Conceição (2016), concept maps allow the adult educator to practice critical analysis. If the adult practitioner builds concept maps to reflect on their

teaching profession and uses educational theory to derive meaning from the maps, then this demonstrates characteristics of critical analysis (Biniecki & Conceição, 2016). Critical analysis is defined as a, "...process of reflection, higher-order thinking, and synthesis leading to meaningful learning, knowledge construction, perspective transformation, or solving of community problems" (Biniecki & Conceição, 2016, p. 52). During my doctoral experience I used concept mapping for visual critical analysis. This practice helped me transform my perceptual lens of how I learned and how I taught. The emerging teaching and learning problems I encountered provided me opportunities to use concept mapping as a visual learning tool. I was able to improve my understanding of educational theory by building on a graphical network of knowledge (concept maps) emerging from these connected experiences.

CHAPTER 3: METHODS

The content in this chapter explains the research methodology, (the study of the research methods used) and the research methods appropriate for this study.

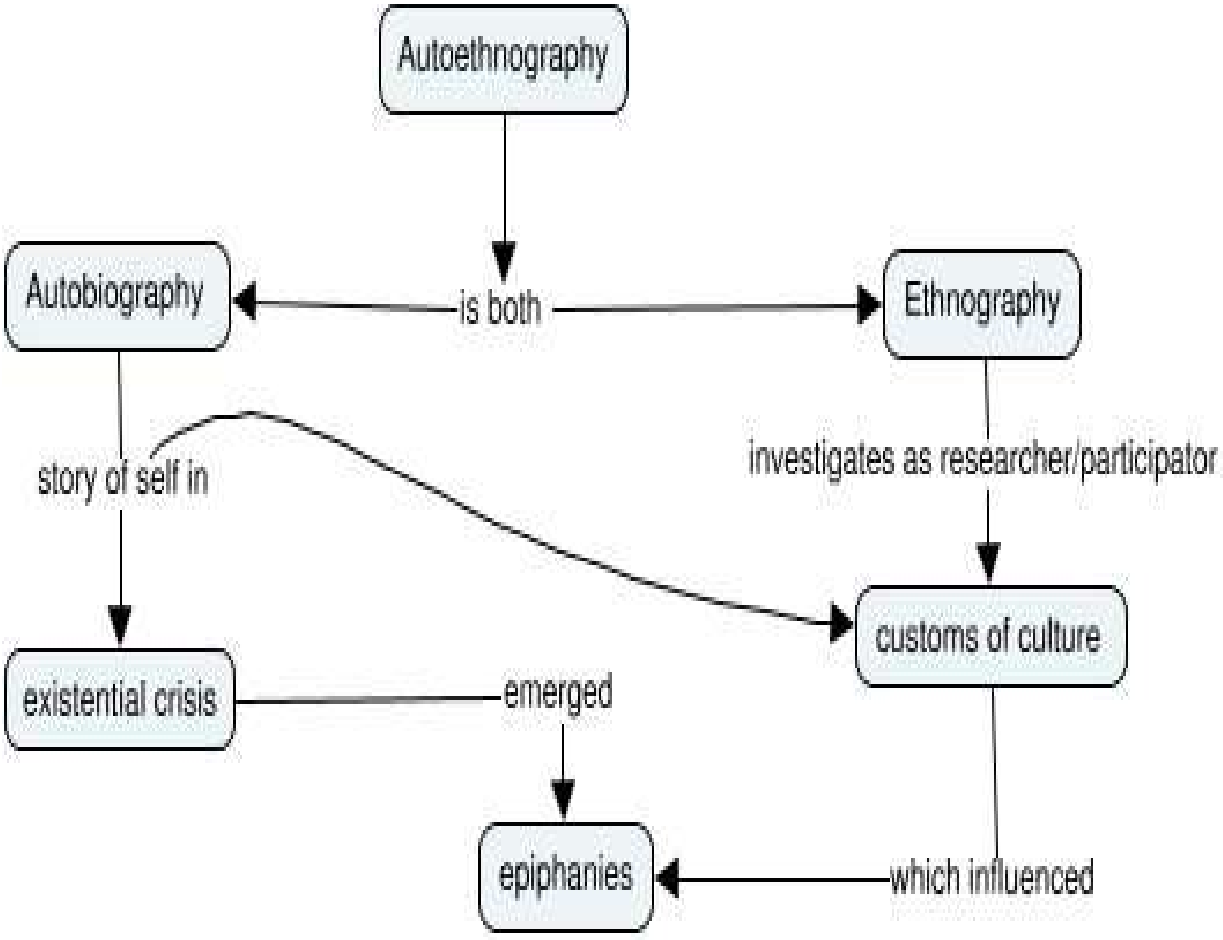

Figure 2. Autoethography Explained

** This figure and the section that follows it, my interpretation of what autoethnography means to me in the context of my dissertation is explained.*

Autoethnography Explained

I chose autoethnography for this inquiry, because it allowed me to study my own thought processes, revealing what influenced my progression from a frustrated, disillusioned, beginning middle school science teacher to a person satisfied enough with my career to learn to teach others to embark on the same career. I perceive my experience as a science education doctoral student enabled me to improve my practice as a classroom science teacher, while simultaneously teaching me to be a science teacher educator and researcher in a higher education institution. I want to engage others through the intimacies of my lived experience reconciling the complexities between theory in science education and practice.

As a research method, autoethnography uses autobiography and ethnography (Ellis, et al., 2011). When using autobiography, the author illustrates personal epiphanies of their life, in which specific events changed their direction in significant ways (Bochner & Ellis, 1992; Couser, 1997; Denzin, 1989). The author of an autobiography analyzes an existential crisis resulting in a personal epiphany (Zaner, 2004). Ellis, et al., (2011) explained, epiphanies examined in autobiographies, "…are self-claimed phenomena in which one person may consider an experience transformative" (p. 275). I constructed an autobiographical story of the learning experience I encountered while being a student in a doctoral science education program. During this time, I experienced multiple epiphanies about the teaching and learning process. These epiphanies influenced the development of a teaching model (TTTC) I used as a middle school science teacher. The experience was transformative for me as a doctoral student learner and as a middle school teacher. I described my transformation and explained how the doctoral program enabled me to analyze an array of existential crises. This provided me with learning opportunities to advance my understanding of science education. The epiphanies

discovered in the program changed the trajectory of my life forever. This new trajectory is what facilitated the growth and sophistication of the teaching model (TTTC) I used and still use in my professional practice today. The transformation from the program experience provided me with confidence to continually use and adapt my teaching model (TTTC) to the evolving learner. This confidence encouraged me to build my understanding of educational theory as a doctoral student through the real-life connection I experienced as a teacher.

In an ethnography, a researcher uses shared experiences to illustrate the value and belief system of a culture with insiders and outsiders (Maso, 2001). To achieve authenticity, the researcher must observe the culture and engage in the practices of the group being studied (Geertz, 1973; Goodall, 2001). In other words, the researcher is also the participant in their own investigation (Ellis, et al., 2011). In this dissertation I was the researcher and participant investigating the culture surrounding my doctoral science education experience. The culture influenced me as a doctoral student and a middle school science teacher. During this transformative time, I was able to research my changing belief and value system in both cultures of the education system: one as a learner in doctoral science education, and the other as a science teacher at a middle school. Participating in these cultures influenced my personal story of a collaborative working process (see Figure 2).

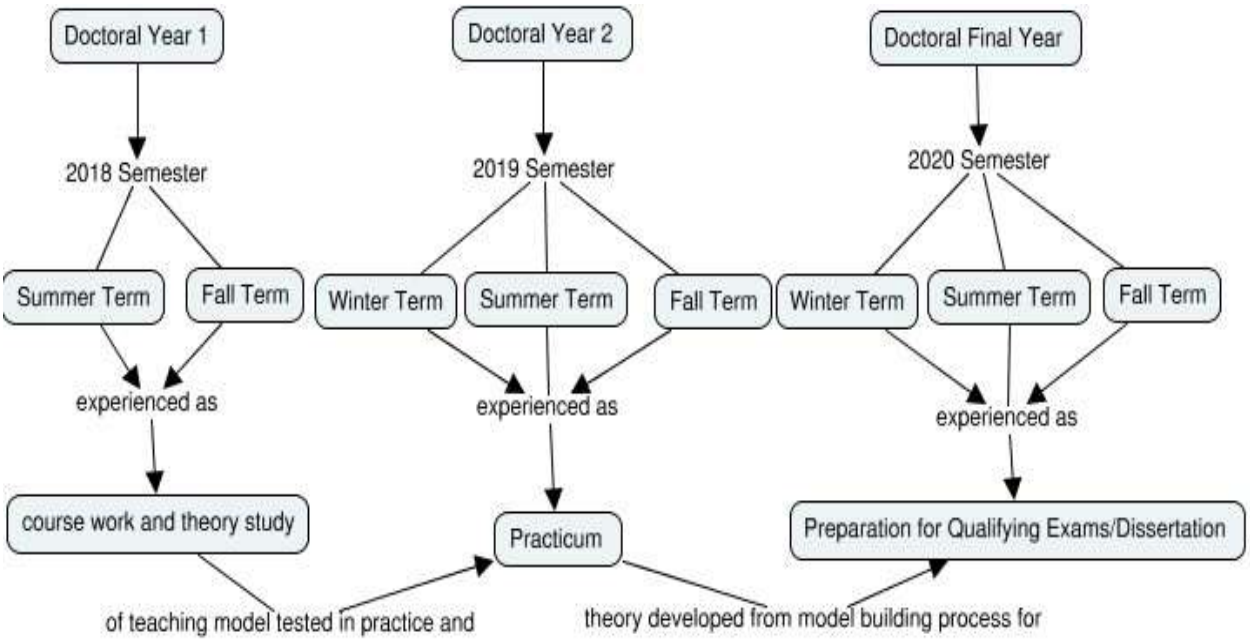

Figure 3. My Doctoral Experience Timeline

The timeline in Figure 3 illustrates the sequence of events that will be used in the construction of the narrative for this dissertation. It chronologically illustrates the set of course events separated by semester. These events also included coursework, practicums, and preparation for the qualifying exam. At the bottom of this figure, the timeline describes the development of the teaching model (TTTC) used as stimulus for most coursework and course experiences.

Design for the Data Collections

The approach used for this dissertation was emergent design grounded theory. Taber explained when using emergent design:

> …it is not possible to plan the research in detail at the start, as the researcher has to be responsive to what is being learnt as the research proceeds. Indeed, in a 'grounded theory' approach...it is totally inappropriate to set out a definite account of a research schedule and the data to be collected at the outset, and the

> flexibility within the design is seen as a strength as well as an essential part of the methodological approach. (Taber, 2013 p. 78-79).

Clough & Nutbrown (2002) pointed out; emergent design research emerges from the personal values of the researcher. They argued it is impossible for the design of a study to follow an objective point of view. Clough & Nutbrown (2002) suggested the researcher acknowledge his/her personal inclusion in the study, and one should be conscious of one's personal thought process in decisions for design. I remained cognitive of my evolving thought process used in the development of a story based on my personal experiences. Being mindful of this changing thought process, provided authenticity to the re-telling of these experiences. Having flexibility in the design used for constructing and analyzing the story enabled the entire process to emerge from a genuine point of view.

The construction of this story changed as I reviewed data collected during my experience as a doctoral student. The story itself also functioned as emerging data and the design of how I continued to collect these data (the writing of the story) unfolded as I began to construct the story. The story was about a meaningful learning process. The design of the story and analysis of it was also a meaningful learning process. Using emergent design to construct this dissertation helped the learning process to unfold authentically.

Data Sources

The following data sources are from a variety of educational and professional products collected during my doctoral experience. Each data source provides the ability for me to use emotional recall (Ellis, 2004) in the construction of the autobiography for this autoethnography. The data sources used in conjunction with each other, tell a comprehensive story surrounding the doctoral experience. This allows me to recall events, which influenced the experience. By

reviewing the data collected during these events, I can construct an authentic narrative for this dissertation. These data sources include reflective journals, informant feedback, field artifacts, concept map collection, and summative program reflections.

Reflective Journaling

In this data source, I used formal school district lesson plan reflections and yearly teaching practice self-reflections to help record the doctoral experience. A third reflection piece is a life story narrative. I constructed this story to illustrate the use of my teaching model (TTTC) while I was at work.

Professional Practice Lesson Plan Formal Evaluations

In this first part of the data source, the development of my teaching model (TTTC) was examined by comparing the formal lesson plans with each other. Each lesson plan was composed yearly for an administrator to evaluate my classroom where I actively used the teaching model (TTTC). These data demonstrated how the model (TTTC) would be used for a particular lesson the administrator would observe. The articulation and the description of the model (TTTC) for these lessons can be analyzed in these data. These were evaluated in conjunction with my doctoral experiences to assess the sophistication of the model (TTTC) over time, and how the model (TTTC) built and used in my practice.

Professional Practice End of Year Reflections

This second category of my reflective journaling involves a formal end of year self-practice evaluation of my professional school year as a middle school science teacher. These summative data were assessed for the inclusion of the teaching model (TTTC) in my overall profession during a particular school year. This part of the journaling was also analyzed for how I articulated the functioning of the model (TTTC) in my middle school classroom. These data

were compared to the educational process I was experiencing during my doctoral program. These summative reflections of my professional school year were assessed for connection to my practice of the model (TTTC) with my growing understanding of educational theory.

Life Story Narrative- *Finding Larry*

This life story narrative, written in real time, reflected on the active function of the teaching model (TTTC) in my middle school science classroom. I included this in the reflective journal because it provides insight into how the developing teaching model (TTTC) directly impacted my daily routine as a middle school science teacher. It's a snapshot presented as a life story narrative examining an application of the model (TTTC) as it was evolving because it was being used as a focal point in my doctoral coursework. Understanding the extended context to this story helps to illustrates the impact of learning educational theory in my doctoral program.

Informant Feedback

My doctoral supervisor provided guidance I needed during my experience. She was a long-standing member in the higher education culture. Her support and continual feedback relating to my participation in this culture provided me the insight I needed for membership in this community. The data sources for this informant feedback included: email communication, meeting notes, and an evaluation of the teaching model (TTTC).

Email Communication

I revisited the communications I engaged in with my doctoral supervisor. These communications evaluate the working process experienced during my time as a doctoral student. The communications included discussions of doctoral coursework and connections to my teaching practice. The collaborative working process used in building the model (TTTC) was evident in these communications. Additionally, there is specific communication in these emails

that provide insight into how the building process was being used to deepen my understanding of educational theory from meaningful experiences.

Meeting Notes

I met with my doctoral supervisor frequently during the program. She was the assigned professor for most of my coursework. We also met to discuss the direction and connection my professional teaching practice had with certain coursework. During the meetings, I collected notes highlighting issues, topics, and problems. I also recorded notes addressing program structure, professional practice connection, and educational theory. They typically focused on the development and study of the model (TTTC) I was using in my middle school classroom. These data provide a timeline tracking the process we used to build the model.

Teaching Model (TTTC) Evaluation

My doctoral supervisor conducted a formal evaluation study examining a sophisticated version of the teaching model (TTTC). These data were compared with other data evaluating less sophisticated versions of the model (TTTC). It was also compared to data evaluating the model (TTTC) after her formal evaluation. This part of the data source is entirely from the perspective of my doctoral supervisor who worked with me to build this model (TTTC). It provided me with an alternative point of view highlighting a different perception of the model's (TTTC) sophistication status at a particular time in my program. Her insight provided me with an important member check and cultural viewpoint shared while building this model (TTTC).

Field Artifacts

This data collection contains a variety of education products I constructed as a doctoral science education student. The reasoning for examining such a vast data set was to gain insight about the specific doctoral education culture that influenced the development of my teaching

mode, the TTTC. These types of artifacts included products collected from traditional coursework, ATE conference paper and presentation, practicums CANVAS coursework pages developed for Science Teaching Methods courses 4310 and 4320, as well as a video bio-introduction used for my last practicum experience. It also includes a collection of Concept Maps I built while learning in these courses and studying my teaching model (TTTC). All these artifacts were collected for my coursework as a doctoral science education student. Collectively these varied educational products provide insight into the story highlighting the development of my model (TTTC). The range of data used for this source provides deeper understanding into the culture that influenced this development process. Examining the cultural influence on my experience was essential to authenticity. It provides truthfulness to the subjective reality I was experiencing during these times.

Traditional Coursework

This first section of the field artifacts provided insight into the nature of the doctoral program in which I participated. I reviewed educational products from assignments in various courses. These included courses not assigned to my doctoral supervisor. I assessed the coursework I produced which used the TTTC model as a function for the product. My translation of the model (TTTC) within the context of the coursework was used to provide a background to the culture surrounding my personal story. This was used in conjunction with the other data sources to facilitate the emerging story line. Since the story focused on the collaborative building of this model (TTTC), these artifacts were revisited to provide a deeper context of the culture influencing this building process.

ASTE Conference Paper

This educational artifact was used as a coursework experience assigned to me from my doctoral supervisor. The product focuses on my assessment of the model (TTTC) at a particular point in the story of my program. This will provide more understanding of the educational culture surrounding my articulation and function of this model (TTTC). By reviewing this paper written at a particular point in the development of the model (TTTC), the storyline was reassessed for authenticity.

ASTE Conference Presentation

The product used for this presentation is the ASTE paper focusing on the explanation of the TTTC model. This was used as another coursework experience assigned to me by my doctoral supervisor. The way in which the presentation is built to articulate the model (TTTC) itself and the function of the model (TTTC) for my professional practice provides me with a better understanding of the educational culture surrounding my doctoral experience. Evaluating both ASTE field artifacts as coursework provides another dimension to the educational culture influencing the events for this story. I collected these products during my time engaged in the doctoral science education world. This provided context and allowed me to revisit the cultural impact on the building process of the model (TTTC).

4310 Practicum Canvas Coursework

During my coursework, I was provided practicum experiences in the higher education setting to prepare myself to teach science education courses. In this preparation of curriculum and instruction for pre-service science teachers, I collaborated with my doctoral supervisor to use versions of the TTTC model for the undergraduate students to experience and learn. The university uses a software system called, CANVAS, to provide a central location for students to

access course information. I collaborated with my doctoral supervisor to design course pages in CANVAS. We used our current understanding of the teaching model (TTTC) at the time of the practicum to help with the teaching process of undergraduate students. The CANVAS course pages for this practicum experience (4310) were specifically designed for an Elementary Science Teaching Methods course. I evaluated the CANVAS pages developed for this course and assessed the status of the model (TTTC) during this time of my program. This artifact provided cultural context where I transitioned into my professor internship. The use of the model (TTTC) during these practicum experiences provided the second arch in the timeline of the story (see Figure 3). This arch of the story described a transitional time during my experience. I transitioned from my role as a doctoral student sitting in a classroom, to practicing the role of a professor in an undergraduate classroom. The time used to incorporate the teaching model (TTTC) into undergraduate coursework was evident when I reviewed these CANVAS course pages. This artifact was assessed for the cultural change I went through during this transition. By using this cultural artifact, I was able to add another dimension to the environment surrounding the development of the model (TTTC).

4320 Practicum Canvas Coursework

This artifact provided the story of my second practicum experience in the doctoral program. The events surrounding the development of the model (TTTC) used for this internship were extracted from an assessment of the designed CANVAS course pages. The cultural experience I encountered during this practicum (4320) was evident upon the review of these course pages. We designed the course using the model (TTTC) as the central point of the coursework design. The undergraduate course was called Teaching Methods in Middle School Science and was to prepare pre-service science teachers. Our full inclusion of the TTTC model

for these undergraduates seemed appropriate to their coursework at the time. By reviewing the model (TTTC) from these CANVAS course pages, the story of this dissertation added another dimension to the cultural backdrop. This dimension involved the environment of the science educator. Examining this artifact, which documented my participation in this facet of higher education, described cultural influences surrounding my story.

Concept Map Collection

These data provided a visual timeline tracking both the sophistication and articulation of TTTC. In this collection are maps I built for coursework which focused on examining my model and coursework that did not. Reasoning for the inclusion of all course maps I constructed was for me to revisit how I was used concept mapping and the CMAP software digital mapping system as a learning tool in my doctoral program. The maps visually track my growing competence in the application of it in the doctoral education culture and the integration of it to evolve my teaching model. Comprehensively examining the map collection provided insight into the doctoral cultural influencing our building of the TTTC model.

Summative End of Program Reflections

After the coursework for the program was completed and my qualifying exam was approved, I reflected on all the events experienced during my time as a doctoral science education student. This was a comprehensive self-reflection of the learning process experienced while building the model (TTTC) with my doctoral supervisor. I was able to reflect from a summative perspective on my time as a doctoral student.

Narrative Construction

In order to build my chapters for the narrative of this study, I examined the data collected from the sources I listed. These data collectively documented the time I spent in my program building the TTTC and using this process as a learning mechanism for doctoral education. I reviewed these data comprehensively using a summative point of view to build narrative presentation through critical reflection of real events and cultural influences from participant and an observer perspective.

By examining all the documented evidence from the data sources collected during my experience, I constructed the chapters of the overall story. While constructing these chapters, I exercised emotional recall in the re-telling of what happened during this time. Emotional recall helped to keep the integrity of the original experience intact while I was rewriting the experience through a narrative story (Ellis, 2003).

Quality Evaluation Factors of Ethnography

According to Richardson (2000), five factors of ethnography (cultural study) can evaluate the quality of an autobiography (narrative story) for autoethnographic research. How these evaluation factors relate to quality of my autobiography (narrative story) for this dissertation are explained individually in the subsections that follow.

Substantive Contribution: What is the Value for Understanding the Society in my Story?

We live in a scientifically and technologically driven democratic society. It is, therefore, essential for all citizens to be scientifically and technologically literate. Science teachers in K-12 schools are charged with initial formation of such literacy. They are educated by university science teacher educators. The quality of the education of science teacher educators is, thus, of critical concern to society.

Aesthetic Merit: How Does the Design of my Story Appeal to the Reader?

I wrote my story in the first person to draw readers in and make them feel as if they are living it with me. I also used different formats of narrative storytelling to keep the reader's attention throughout my autobiography:

- Narrative Story I used intertwining first person short stories.
- Narrative Story II used a dialogue play format.
- Narrative Story III used introspective short stories and monologues.

Reflexivity: How did I Address my Subjectivity and Bias in the Story?

I addressed my subjectivity and bias in the design of the story by describing my emerging thought process and changing value system directly in my narrative.

Impact: How Does my Story Continue the Conversation?

The recommendations for science teacher educators derived from my ethnography (the study of my story) can be tested by university professors with future doctoral students, thus continuing the conversation.

Expression of Reality: How Does my Story Convey a Real Experience?

The story reports real events during my doctoral program. I used the data I collected during these actual events to construct a narrative that is true to my lived experience. The story was written from my point of view as an active participant and observer in the higher education culture which influenced these events.

CHAPTER 4: STRUCTURE OF MY NARRATIVE

I continuously shifted my stance from me as the doctoral student to me as the teacher at middle school science while writing this autoethnographic narrative. My intent was to compare what was happening simultaneously in both roles and how one role was affecting the other. It may be confusing if one is not aware this is intentional. This is like a pas de deux in a ballet where each partner is independently responsible for his/her own body movements, yet they frequently depend on each other to complete a body movement and create a whole picture.

There are three emergent threads running throughout my study. They are woven together into a tapestry labeled, my narrative. The threads come together, intersect, intertwine, separate, and come together again multiple times throughout the narrative, as if in a dance performance. The threads include a couple dancing (doctoral student learner and middle school teacher), the lighting director shining the spotlights to enhance the performance (the professor co-mentor), and the audience take away (doctoral student's well-being and the TTTC model).

To elaborate, the threads include (a) my learning process and pathways in the doctoral program; (b) the transformation of that learning into a model (TTTC) for a middle school science classroom, including the origins, clarification, and refinement of the TTTC to benefit a broader audience than my own students; (c) the actions and effects of the supervising professor in the university enacting the role of co-mentor, and (d) the cognitive and emotional events propelling growth and inspiring my psychological well-being.

The threads emerged from analyzing my three years of experience in the science education doctoral program at the University of South Florida (courses in table 1). I learned

multiple dimensions of being a future university science teacher educator during these three years. I am amazed by the depth of insight I developed about qualitative research, the power of emergent design, and their relation to my practice. How I learned in the doctoral program and what factors influenced my well-being were the most important aspects of my experience. My understanding of how middle schoolers learn science increased, and the way teaching pre-service science teachers differs from that was a surprising outcome of my doctoral experience. What it takes to survive in the professoriate, and how change occurs in educational systems rounded out my learning during these past three years systems

In Table 1 Semester 2/Fall 2018, 7/Fall 2020, and 8/Spring 2021 stories were not included in any Narrative story collection for this dissertation. This is partly due to the vast scope of the material. By excluding these stories from my overall narrative for this autoethnography, two of Richardson's (2000) ethnographical factors of an autobiography's quality were evaluated:

1. Exclusion prevented possible data saturation during analysis of my autobiography, thus preserving the impact of my narrative story.
2. Exclusion increased the evocative nature of Narrative Stories I-III by keeping the reader's interest with a shorter autobiography, thus preserving the aesthetic merit of my narrative story.

Table 1. Courses Taken During my Doctoral Experience and their Narrative Stories

Narrative#/ Semester	**Courses Titles, Practicums-** ***Spector Assigned Courses***	**Narrative Title** ***Short Story Titles***
Narrative Story I		The Exposition
1/ Summer 2018	Philosophies of Inquiry	*Philosophies of Inquiry*
	Visual Methods in Qualitative Research in Education	*Visual Methods in Qualitative Research in Education*
	Qualitative Research in Education I	*Qualitative Research in Education*
	Statistical Analysis in Educational Research I	
	Independent study- *Spector course*	
2/Fall 2018	Current Trends in Science Education	
	Statistical Analysis in Educational Research II	
	Math/Science Educational Policy Change and School Improvement- *Spector Course*	
Narrative Story II		The Conflict
3/Spring 2019	4310 Practicum	*The Critical Event of the Practicum and my Doctoral Experience: An Ethnodrama*
	Science Teaching and Learning- *Spector Course*	
	History, Sociology, and Epistemology of Science Education	*The Negotiation of the Critical Event*
4/Summer 2019	Directed Research in Science Education - *Spector Course*	*Continuing to Grow*
Narrative Story III		The Resolve
5/Fall 2019	4320 Practicum	*Another Practicum: The Novice Teacher Educator Tries Again*
	Implementation Science - *Spector Course*	
	Research in Science Education- *Spector Course*	*An Epiphany*
6/Summer2020	Directed Research in Science Education - *Spector Course*	
7/Fall 2020	Teaching and Learning in Content Areas	
	Directed Research in Science Education - *Spector Course*	
8/Spring 2021	Qualifying Exam- Research on the TTTC- Describing how it works and related literature	

The department housing the doctoral science education degree did not offer four courses required by the science education doctoral program during my three years on campus, because there were not enough students to attain the minimum number of students required for each class. My doctoral supervisor, Dr. Spector voluntarily taught those courses to me, without compensation, to enable me to complete my program in a timely fashion. Being aware of this reinforced my belief that she was committed to my growth and well-being.

She required me to continuously write reflections on my learning experiences. These reflections were used to stimulate dialogic interaction throughout the program with my supervisor. Here are the sources of my reflections that we discussed:

- courses taken with other professors (without supervisor)
- courses taken with supervisor as the instructor of record
- teaching strategies used and student responses in my middle school classroom
- teaching strategies and student responses from two science teaching methods courses I co-taught with supervisor
- directed research on my developing teaching model (TTTC)
- interactions between my supervisor and myself

My doctoral supervisor's career for half a century was as a change agent devoted to implementing a paradigm shift in science education. She used qualitative data tables summarizing her extensive work as reference points for pre- and in-service teachers to learn what is expected of them as professional teachers in this holistic society. The nature of this type of society and the characteristics which follow this perspective provided me with a foundation of understanding why this paradigm shift was unsupported in the public classroom. Using Dr.

Spector's work on paradigm shifts comparing societal (Spector, 1993) and education (Spector & Ball, 2014), I was able to find self-efficacy throughout my experience. This provided me with confidence to explore further applications within my own paradigm shift the classroom both professionally (teaching middle school) and academically (doctoral student). It also provided me with a sense of professional community knowing that there is a historical struggle I share with past, present, and future school change agents all fighting the oppressive forces of a dominant controlling paradigm. Referring to her work on societal (1993) and educational (2014) paradigm shifting for clarity and connection during my doctoral journey, reminded me that the oppressive nature of the dominant paradigm is an ongoing, evolving fight that will always need new perspectives, therefore it places a high value in the development for effective novice change agents. The understanding of this as it emerged from experience supported by literature and literature supported by experience, the value of myself as a learner became an inherent virtue within my belief system. The relatable features of this paradigm shift are inherent in all the classes she has taught and in all her publications as a qualitative researcher. It is, therefore, no surprise that my experience as her doctoral student was constructed and emerged from the holistic paradigm.

The Writing Process

I went through seven cycles of writing to ascertain the content of my autoethnography for my dissertation. Each cycle was written through a different lens:

1. The first cycle described from memory what happened in my doctoral program experience.
2. The second cycle described what happened in my doctoral program experience while examined the data sources (artifacts/products) from my experience.
3. The third cycle described what happened in my doctoral program experience while I referred to the first and second descriptions as data and explained why my experience happened the way it did.
4. The fourth cycle described from memory what happened to me while I was writing the previous three descriptions.
5. The fifth cycle described what happened to me when I was writing the previous four descriptions while examining the four descriptions as data sources.
6. The sixth cycle described from memory why the writing process affected me and why I affected the writing process.
7. The seventh cycle selected key features of my doctoral program experience to include in the narrative for this dissertation.

CHAPTER 5: THE NARRATIVE

The content in this chapter is a result of research analyzing my reflections on my doctoral program experience. The first part of this chapter, “The Exposition" addresses the first semester (Summer 2018) of my doctoral experience. It is structured as three connected short story narratives describing the events at the beginning of my experience. The second part of this chapter, “The Conflict ", uses ethnodrama to describe the critical event in my doctoral experience. It seemed appropriate to present it as central to the narrative, because this event was profoundly significant during my doctoral experience in the Spring semester of 2019 and as I analyzed the narrative inquiry cycles, I wrote in the Summer of 2021. The critical event was translated into an ethnographic drama (dialogue play) and not a traditional autobiographical narrative. The critical event was central to my doctoral experience moving forward. It changed my perceptual screen significantly and my approach to the remainder of my doctoral experiences. The influential nature of this singular event is illustrated structurally by this narrative being focused only on this event.

The ethnodrama is followed by narratives addressing my decision-making and an example of the way I accommodated my approach to teaching undergraduates because of the critical event. The last part of my narrative, “The Resolve”, provides examples of the impact of the doctoral program on my middle school teaching, the evolving nature of the TTTC, and the epiphany I experienced at the end of my doctoral program experience.

Narrative Story I- The Exposition

I hadn't been inside a traditional classroom as a student for quite some time. Prior to this first semester of my doctoral program, my master's was entirely online. The only higher education classroom I recall walking into during that time frame was an education course three years earlier to satisfy my teaching license requirements. On these first nights of my first semester in the doctoral program, my walk into these courses at the University felt different from my past experiences as a college student. This time, unlike other experiences, I felt a greater sense of purpose and direction before these orientation nights even started.

Unlike any other time spent before a term began, I was an integral part of the planning process of learning. Dr. Spector included me in the planning of my own coursework before I even knew what the coursework was going to be. We spent months in advance before reviewing my thoughts, beliefs, and desires for what I wanted to do in my program of study.

I wanted to find an effective way to teach nursing students working for a clinic in India how to teach science to their patients (the community) when I came to Dr. Spector directly after completing my Masters in Epidemiology in the College of Public Health. I had worked on a project there with a Clinical Field Supervisor of nursing and physician assistant students who were gaining medical experience interning at walk-in clinics in rural India. My part in the project was taking the patient care data the students collected, coding it, and running statistical analysis to determine the medical needs of the community.

I encountered the same issue in that project as I did in my work as an emergency medical technician, breaches in communication of science among various levels of medical professionals with differing science expertise and with the public. It was obvious to me that those with science

knowledge needed the additional skills and knowledge of a science educator to mitigate communication problems.

When I became a science teacher, I noticed similar gaps communicating science among the various levels of science understanding among the students who were designing activities, the instructors who were teaching the activities, and the testers doing the activities in my TTTC classes. I also learned there was a well-known communication issue between scientists in all fields and the public. Thus, it made sense to me to integrate science and education expertise from the College of Public Health with the College of Education. Dr. Spector agreed, and we brought together a doctoral committee representing both colleges.

It was made very clear to me that my overall goal would be to integrate my India research project into the work in all my courses, even though only one out of the five courses I would be taking at the University the summer of 2018 would be with Dr. Spector. It did not matter that I had no specifics for the coursework prior to the semester starting, because the intention of all my work was to use my research project as the mechanism of learning. The strategy to use all my assigned courses as a platform from which to build my project provided me with a sense of direction and a feeling of purpose. This feeling was new to me as a student in formal education. I had never felt confident in my intellect nor ability to connect socially in educational settings. The idea that I had a pre-established project, personal to my endeavors and plans to integrate it into all my coursework, gave me a sense of identity I never had before.

Philosophies of Inquiry

My first doctoral course was the Philosophies of Inquiry. This was a night course. I had printed up the articles we needed to read before class that first night. I was sitting outside before class started highlighting points in the literature that got my attention. One article commented on

how professors commonly complained students who attend college typically look to the professor for what and how to think. This provided context for me about the way Dr. Spector had been doing the reverse with me prior to this semester even starting. I entered the classroom full of adults from varied educational professions and age groups. Typically, I feel very nervous entering a classroom. I felt the same type of angst at the start of this night, especially after being away from the higher education classroom so long. My Master's program was entirely online.

The professor had the room arranged in a familiar College of Education classroom arrangement. The seats formed a circle facing the front of the room to facilitate an open discussion. I was never comfortable in a discussion style classroom, but I did expect this from a College of Education course. I sat on the end of one side of the circle. Once the professor began class, she required each person to introduce themselves in relation to their doctoral work. Even though this was an introductory course, I soon found out that students were at varying stages in their programs. I was, however, confident in what I would tell the class about my program work even though this was my first semester, because I had spent almost five months in discussion with Dr. Spector exploring possible ways we would go about the program. My sense of importance of the work I had planned did not diminish its value despite my peers in these courses. I was able to maintain my self-worth even though there students farther ahead in their program work or in professional positions far more important than mine.

One of the selling points for my prospective program work was there would be more than just the College of Education represented on my doctoral committee. Dr. Spector told me this was a rare condition and a paradox when considering the function of a college of education at a research university. She explained not only were there very few cross-college doctoral committees at the College of Education, but there were also very few cross-departmental

doctoral committees. She noted the function of a college of education should be to bridge the gaps between disciplines since all disciplines require teaching. A university is an institution of higher education, education is in the name of the entire game, why isn't the College of Education "sticking its nose" in all the research that is being conducted?

Once I had addressed the class explaining my idea for the India Project around which my program was arranged, the professor of the course commented to the class how rare it was to have a cross-college committee at the College of Education. This validated my growing confidence in my prospective work.

As this course progressed, Dr. Spector and I looked for assignments that would provide opportunity to work on the India Project. One assignment required me to assess epistemological differences within a paradigm. I was studying the constructivist paradigm that semester, per the recommendation from Dr. Spector. This perceptual lens aligned with the approach she was using with me for my learning process. I was required to present the assignment involving the epistemological shift on the last day of class in this Philosophies of Inquiry course.

Dr. Spector designed possible ways to approach the India Project with me. She used my existing knowledge and understanding of how to go about the India Project to help me assimilate the new knowledge I was accumulating during this first semester. She achieved this by continually discussing with me the content I was encountering in every course. Together, we reflected on how this content could help reshape my approach to the prospective research for India. For this epistemological paradigm assignment, I used the work of a researcher suggested to me by another professor in a different course that semester. The professor suggested I use this researcher's work because it aligned with the India project I had discussed and used for assignments in that course as well.

Even though we had spent most of our time focusing on the preparation of the India Project, Dr. Spector did initiate discussion with me about an alternative project idea. There were several reasons for doing this, including the financial and logistical realities of going to India and time. My time for most of the summer term was dedicated to being a doctoral student. Soon this time would have to be shared with my role as a middle school science teacher. Dr. Spector knew it was difficult for a learner to separate their study from their practice when using a holistic approach to teaching and learning. She was curious how I would approach this year of teaching after my work in the doctoral program. She asked very important questions as this first summer of coursework was coming to an end:

> What are you going to do differently when you start this year of teaching? What did you learn this summer as a doctoral student of science education that you will integrate into your middle school science classroom model (TTTC)? How will you be able to dedicate time to the India Project, doctoral coursework, and teaching full time?

These questions affected the way I perceived all the ending projects in my summer courses, including the presentation on the last night in this Philosophies of Inquiry course, because we had started discussing them before the summer ended. For example, I decided to use the CMAP software application Dr. Spector had introduced me to instead of a PowerPoint to present my work to the class.

I noticed the peers in my class taking photographs of my map as I presented the map to the class. I used the icons embedded in the map to reveal the resource material for my presentation while I worked through the connections I established for my assignment. The software allowed me to centralize data I was using for projects. This gave me a much-needed

graphic organizer, not only for presentations in courses, but also for my own thought process doing projects and assignments.

Most questions from my peers were about my use of the CMAP software after I explained my messy unfinished map to the class. They were disinterested in the content in my presentation. Instead, they seemed much more interested in how I presented the content. The discussion quickly turned into what the CMAP application was, how to use it, and how I planned to continue to use it. I began to talk about my teaching model (TTTC) I had been using over the years in my 8th grade classroom (previously described on pages). I told the class that my current discovery of the CMAP software would be the new catalyst I had been looking for in my middle school classroom, and I was going to use it to facilitate content understanding through student designed educational products. Since Dr. Spector had used this software as an inquiry tool for me to investigate my doctoral coursework this summer semester, I was going to do the same for my 8th graders that following fall (2018) term.

Visual Methods in Qualitative Research in Education

In another first semester course, Visual Methods in Qualitative Research in Education, the assignments required me to understand both the need and use of visual methods in qualitative educational research. The professors informed me that this was the first time the university offered this course, and the course itself was a relatively new modern course not offered at most universities. They encouraged the class to use their current research for required assignments in the course.

I quickly understood that this was not an introductory course in the doctoral program after hearing my classmates' introductions the first night of class. Most of my classmates were over halfway through their program work. They had very clear ideas of how to go about their

prospective research. I felt more out of place, because this course appeared to have much less diversity in participants' program experience than the introductory Philosophies of Inquiry (POI) course. The confidence I had when attending the POI course on one night of the week was different than in this Visual Methods course on a different night in the same week. I observed less of a sense of enthusiasm among my classmates for their chosen research, and more of a sense of exhaustion from the realities of their work that would later be facing me in my program, when talking with these classmates.

The content of this Visual Methods course was designed for the doctoral student to add a deep understanding of how to use varied visual data in their research. Dr. Spector saw this course as the perfect opportunity for me to capitalize on the open-ended project assignments by engaging in preliminary research on the India Project.

Another opportunity designed into this course was the experience I needed in using qualitative analysis software. Circumstances prevented me from gaining a foundation with any traditional qualitative research software applications: On the night the course was assigned to introduce these applications, everyone in the class was unable to access the software provided by the university. I had encountered this same issue when trying to gain access to the quantitative software for my online statistical course that same term. Since I knew the solution to this mechanical issue, I spent most of that night teaching the professors and my classmates how to gain access to the software. Unfortunately, this resulted in time needed to learn a new software language because time was spent helping my peers gain access to the software.

I discussed these events with Dr. Spector after class that night in her office. We talked about the time constraints involved in the summer semester. She suggested I ask permission from my professors to learn and use the CMAP software application. It had a more open-ended

creative graphical format than other applications. She suggested this software might be useful in tracking my growing knowledge base as I moved through the entire doctoral program.

I began to use the software and quickly realized this was a different language entirely. Unlike my previous experience with quantitative analytical software, CMAPS was entirely open-ended and completely dependent on the user's need for how the data would be organized, coded, and analyzed. It presented me with emergent flexibility in the structure of how I could organize, analyze, and present on-going data being collected. Because of my extended use and frustration with a quantitative software system required in the graduate program for my Masters, this newfound freedom and creative function I experienced while using the CMAP software revolutionized the way I thought about learning and research. The choice of using CMAP software alone was not the sole reason for my transformation. It was also the support system provided to me from Dr. Spector in all my courses.

I requested to use the CMAP system for my work in this Visual Methods course. My professors immediately encouraged my inquiry into its use with my classwork. Each assignment in which I used the software to explore how I could organize, analyze, and interpret qualitative data enabled me to begin to shed my initial feeling of inadequacies among my classmates. I used the software to do all my assignments in this course, including weekly literature and discussion tasks. Using this software to help me with the learning process and research of my work during this first semester provided me with a deeper grasp of not necessarily how I was going to go about my doctoral work, but it gave me a vital learning tool to help me with the "how" in my prospective India Project work.

One of the most evident assignments in which I used the software can be seen in the map placed in Appendix in Figure A1 (Visual Methods Course Nurse Project). For this assignment, I

explored my India Project and presented my paper with this map to guide the reader through the research and data I collected for the research project assignment. This map also included the visual data I used for the project embedded in the icons “data image-nurse classroom” and “nurse classroom 2”, centrally located within the content. The literature I used to build the framework for this project is also embedded in this map under the icons “Novak” and “Rogoff”, located near the top and on each side of the map. What I found very useful in my constant use of this software was how it organized the materials I needed, as well as my thoughts for an assignment. Having the map present in an empty word document for any given assignment provided me a sense of direction and motivation to write whatever it was I needed to write, just as it is meeting the same need I have right now in writing this story.

As crude as this map appears to be, it did spark an interest in my group, class, and professors. Their interest in my use of the software in this class, where most of my classmates were much farther in their program than I was, provided me with confidence in what and how I was doing my work.

Figure A2 ‘Visual Methods Course Final Group Project Map’ (see Appendix A) displays the last map made in my Visual Methods course. Every assigned group was required to make a visual presentation for the class based on their assigned group readings. Both of my partners were much farther in their program than I was in my group. I suggested my group use the CMAP software for our presentation, and I offered to take on the task in building the map and embedding our data into it. I was excited to exercise and display my current understanding of how to use the CMAP program to a class unaware of how the software worked.

The icons embedded in the map displayed the items we used for our presentation. One of my group members commented to the class that using this software demonstrated an alternative

approach to how presentations are typically presented to classes. The professors in the course also noted to the class how using this software is a visual method in presenting visual data. I had a deeper understanding of the novelty of what Dr. Spector had initiated with me.

No classmate nor professor ever discouraged me, which was another contributing factor to my growing confidence in my novice and convoluted use of the software. I felt immediate peer and cultural acceptance using a software language that I was newly exploring. This initial interest in how I was using the software to conduct the research to do my assignments encouraged the creative side of my learning process. The acceptance I perceived to take chances and use this software for all my coursework contributed to an overall confidence in my role as a student in the qualitative educational research culture. I never felt as much autonomy, security, and support in the education system as I did during this first semester of my doctoral program. I was able to feel just as secure and confident at the end of this advanced program course as I did in the introductory program courses that semester. This reaffirmed the direction in which Dr. Spector was guiding me in my learning process. She was providing me with an open-ended inquiry where, for the first time in my life, I was not only encouraged to exercise creativity in my learning process, but I also felt support and security in the system to continue to be creative and use emergent design in what and how I learned.

Qualitative Research in Education

The last on-campus course I took the first summer in 2018, Qualitative Research in Education, was a large introductory course for doctoral students. The class met the last half of the summer and had more students in it than any other course I took in my program. There was an equal mix of teachers, administrators, and university staff members. It had little diversity in program experience because most of the students were not that far in their program. By this time

in the summer, I had gained confidence in my work with Dr. Spector and was using the CMAP software regularly to help me learn all my coursework. For every assignment in this compressed course, I used the software to present and learn all the content material. This included weekly discussion boards. The professor encouraged creative ways of doing classwork. She professed that this was at the core of qualitative research. I felt motivated to use my maps for my required posts in discussion boards and was excited to be a possible pioneer in doing this traditional university task in a different way. Both the India Project and my constant use of the CMAP software provided me with the confidence to explore and discover content material in my courses in a different way.

During the course meetings, we quickly needed to pair up with another student to work on a class project to be presented on the last day of class. By kismet, I was sitting by a student who was not a teacher, but an administrator in the district in which I worked. This was kismet, because in the independent study course I was doing with Dr. Spector, I was examining the history of why new education programs rarely get institutionalized. We had focused on the idea that during implementation of a program the design gets lost in the many layers of translation it has to go through before it reaches the intended consumer (students) in the classroom. My project partner could provide insight from the administrative side on how a program design gets translated to her before it reaches me as a teacher in the classroom. I made a summative map (see appendix-Figure A3) visually translating our project to use for in our presentation of our paper to the class. The map contains all the data we used to build our research project. For this one assignment the digital mapping software provided a multi-dimensional layered concept map used in classroom presentation, project organization, and graphical illustration for the written research course product. Because of the many applications this one assignment allowed for me to practice

using the mapping software, it provided me more confidence to continue to explore the This also presented itself as the ending artifact for my first doctoral semester experience during the summer of 2018. e with confidence to study and produce future doctoral work for any type of situation. I felt very confident in the direction we were headed with our assignment, because of the way this topic translated to the India Project. The idea behind the India Project was there are too many varied levels of science understanding in medical systems, thus communicating science and health information among health providers in the system and the consumer of that information is often lost. This same lack of translation was true in the education system. Finding out how to bridge these gaps may provide insight into how to go about resolving the main issue in the India Project.

The on-line Statistics course was unremarkable, because it repeated what I had learned during my master's Program at the College of Public Health. I investigated literature describing pitfalls inhibiting institutionalization of science education innovations in my independent study course with Dr. Spector.

Narrative Story II-The Conflict

After the Fall term of 2018 ended, Dr. Spector placed me in a professorship practicum for the upcoming spring semester. She explained that I needed to gain practitioner experience as a science teacher educator. She arranged for me to act as a professor for undergraduate pre-service science teachers under her direct supervision for the upcoming semester. Her intention was to place me in this role so I could gain "real life" science education experience from which to construct meaning to my assigned doctoral courses for that semester. She also pointed out this would provide another perspective to the work we had already done for the teaching model (TTTC) from the fall semester in my middle school classroom. The point of the spring semester

was not merely to pilot test the TTTC in a different science education setting, but to experience the negotiation a science teacher educator must come to terms with so that one can survive being a professor in higher education.

I spent the entire time during the end of the fall (2018) semester and the start of the spring (2019) semester (about four weeks) pre-planning the structure of my first practicum experience in the undergraduate higher education classroom, a science methods course for elementary preservice teachers (4310). Dr. Spector believed I could learn more about the developing teaching model (TTTC) and the culture of higher education by pilot testing TTTC in the undergraduate classroom.

After explaining to Dr. Spector my designs for the undergraduate assignments I had planned on using, she collaborated with me to improve the designs for classroom implementation. Before the actual spring (2019) semester began, I had composed and then revised an incredible number of CANVAS pages for the undergraduates to use in order to facilitate the inquiry process. These pages explained the details and options for each assignment, while providing examples and identifying course concepts the assignments were intending to address. I had autonomy to make these assignments as open-ended and connected to each other as I desired.

Dr. Spector made it a common practice to require every student who attends class to write an exit memo/informal reflection of the course at each class meeting. She was very clear to the undergraduates at the end of each night that the reflections were not to be written as a summary, nor were they to be a survey of likes and dislikes. Instead, she encouraged the undergraduates to treat them as a "knee jerk" reaction. She explained that it was important to us (myself and her) in the role of educators to understand their immediate intellectual and emotional responses to the

events occurring in the course. The reason for this was simple. The design for the forthcoming classes following their "knee-jerk reactions" needs to be adapted to fit the emerging needs and interests of the class. She purposely did not give much time for this quiet personal reflection to be written, nor did she coax any particular focus of whatever it was they wanted to express to us about their experiences that night. This was implemented as a very casual and open-ended exercise at the end of each night to capture a genuine look into the learners' perceptions of their experience in the classroom.

Dr. Spector provided each student with one blank piece of paper. She did not pass these papers out until the end of the class. She did this to quietly discourage a student's attempt to document the events of the evening. If these blank pieces of paper were not built as personal reflexive reactions, then they wouldn't have been beneficial for the undergraduate to write, nor us to read. She explained to the class that if they did not express to us what did or did not work for the individual in class, future classes might not have much value. Her intention was to collect qualitative data subjective to the individual. These exit memos would address personal needs and interests, which in turn could provide insight into how to facilitate their advancement through the course. She wasn't assessing a particular learning objective that was required for them to understand at the end of a course. Instead, the intention was to collect genuine personal reactions to the learning experience and to study this group of students in order to design appropriate ways to support their emerging learning needs. As a result of this ongoing focused study (using these exit memos as reflection of the undergraduates' thought process), the data increased our ability to adjust the plans for these future classes and provide a deeper, more meaningful learning experience for students in the classes to come.

It became very apparent to me from the start of the practicum how much value Dr. Spector placed on collecting these data. She explained to me that without having these in hand immediately following the events of the night, any of what we design for future learning experiences in the classroom could be pointless. Each undergraduate classroom experience needed to provide a meaningful connection with the learner for the student to gain understanding of the course concepts. She also insisted it was important for both of us to study and discuss these exit memos together in the classroom before we left each night. Her point was analyzing these exit memos outside of the experience from which they were constructed in time and place would provide a less direct channel into the learner's perception of the events that occurred. The blank pieces of paper that Dr. Spector handed out weekly to the undergraduates held a collective power in how they could dictate the developing learning experiences inside that university classroom for weeks to come.

The practice of these weekly exit memos represented something much deeper than informal "knee-jerk" reactions. The composite of the thoughts collected in these memos stimulated a powerful thought process about the events that took place in that classroom when I discussed the content of the memos with Dr. Spector at the end of each class. Because we took the time to read and then discuss the content in the memos immediately after they were written, it provided me with a social learning experience that facilitated a broader perspective for me as a doctoral learner and practicing teacher educator. These dialogic interactions between myself and Dr. Spector discussing the memos together gave me a window into the culture of the undergraduate learner and new doorways to my prospective doctoral work.

The content within the exit memos themselves seemed to have a level of authenticity because of the informal nature used in collection of the data. She made it clear to the

undergraduates that the memos did not count as a grade. This minimized the stress students might have experienced doing this task. She also provided the class with autonomy in how these memos were constructed by not providing a clear structure, guideline, or rubric for how they needed to write the exit memos. Dr. Spector only informed the class that the memos cannot be a summary of what happened in the class that night. She stressed weekly to the students that the exit memos should reflect their reactions to what they had learned that night in class and how it was connected to their own personal experiences presently, prospectively, and from their past both inside and outside of the classroom. If there was no connection at all to the student's personal experience, then she explained to the students that the memo needed to communicate this disconnection. Dr. Spector also told the class that if there is a disconnect, then a student should express details in the memo explaining why there was a disconnect and how we could possibly fix it. The open-ended casual and informal approach she presented to the undergraduates for building these exit memos took away typical barriers to honesty involved in formal qualitative data collection. She facilitated a natural thought process at the end of each class for the students to exercise meta-cognition without the traditional risks of "doing it right" associated with formal education. This provided an emergence of valuable genuine "knee jerk" reactions. The content in these memos gave me insight into the undergraduate perception of my assignment designs used for their inquiry practice. It also provided sincere emotional responses to my teaching model (TTTC) I had implemented for their learning process. While we reviewed these data weekly, I was able to reflect with Dr. Spector about my practice as a teacher educator. This meant that my designs for the undergraduate assignments, and my approach to "teaching" the undergraduate classroom (implementing the TTTC)) could be extracted from certain exit memos as functional data for my doctoral coursework. Since most of the data we extracted were

focused on the implementation of my model (TTTC), the memos were used to adapt/adjust the course trajectory. This process served a dual function to help improve my learning experience as a teacher educator and learning experience for the undergraduate students. The approach follows emergent design theory and functions to improve the quality of learning for both the students and the practicing teacher educator (myself) exercising the role of professor to the undergraduate students in the classroom.

Our discussions each night after class ended for the undergraduates centered around the content in these exit memos. We reflected on the events that occurred during class and the responses we observed from the students in the class compared to their written thoughts related to these events in the memos.

Since each class is designed to engage the undergraduates in discussion and active participation, there is a continuation of classroom noise during most of the night. Because Dr. Spector makes the exit memo a routine end of class practice for the undergraduates, an audible shift would occur at the end of each night. The noise of multiple voices being heard, and various sounds of activities would come to an abrupt closure. This shift from loud to quiet occurred once students began writing memos and then turned them into Dr. Spector or me as they exited the classroom.

I recall the minimal and various sounds in the classroom during these times, while I was reading memos to myself and trading them for new ones with Dr. Spector, the sound made by the classroom door slamming shut, the movement of backpacks being thrusted over student's shoulders, and the occasional whispered question undergraduates would ask us on their way out of the classroom for the night. These quiet sounds represented not only the end of one learning

environment, but the start of a new one. The undergraduate classroom transformed into my doctoral classroom at this point each night every week.

The Critical Event of the Practicum and my Doctoral Experience: An Ethnodrama

My experience during the third semester of my doctoral program changed the way I viewed teaching and learning in the holistic paradigm, while functioning in a dominant paradigm culture. The following is a vignette (in the form of an ethnodrama) of a critical event during this semester. It influenced my thinking thereafter. In the script below 'SPECTOR' is Dr. Spector my co-mentor and doctoral supervisor, and 'ALTON' is me.

The following took place in the classroom of my first practicum (4310). The students just left for the evening. It was the 3rd week of testing my teaching model (TTTC).

SPECTOR

It appears to me there's a definite pattern forming. Have you read these exit memos yet?

ALTON

Yes, have you read this pile?

SPECTOR

Not yet, and I don't know how you're reading all of this so fast. I hope you're not just skimming through them. By skimming, you really miss the importance of what the student is saying indirectly. Taking the time to think about what is implied in these exit memos is an important exercise in qualitative research. There are characteristics about this group that are evident if you examine these exit memos closely.

ALTON

Well, I don't need to read too much into them. I know what they are telling me.

SPECTOR

Which is what?

ALTON

Stop trying to teach us your model It's the same thing they were trying to tell me last week, and the week before that, and damn even on the first night I introduced the idea. The only difference now is they have become increasingly more direct.

SPECTOR

Did they ever tell you why they don't like your approach?

ALTON

No, I guess not.

SPECTOR

I didn't think so. I wasn't sure if in all your "skimming" through these weekly exit memos you were able to catch how upfront they are with their emotions and belief system.

ALTON

No, I got the idea. They do not want to test the model anymore. I have been hoping it would turn around. Maybe Teria and Madison, the only ones who got what I was trying to do, might be able to convince the rest of them to keep moving forward with this new way of learning. It sucks, because all my time in planning the implementation of the model is lost.

SPECTOR

Are you suggesting we stop testing the model?

ALTON

I don't know, what do you think?

SPECTOR

Well, let me be candid with you and remind you that this isn't my first time teaching elementary pre-service teachers. I was able to avoid it for several years by using my grant money to buy myself out of teaching that course. In fact, from my experience, most secondary education faculty do not want to teach this group of students.

ALTON

Why is that?

SPECTOR

Because of the very same frustration you are going through now. Elementary people have a culture that is different from the culture that you and I have lived in as secondary teachers. I learned that the hard way when I got stuck teaching it. That's why I did so much research on the elementary methods students. They are entirely different learners. I know that doesn't mean anything to you right now, but it will once you work through this dilemma and understand these students' prior knowledge and beliefs. When you experience 4320 (middle school science methods) next semesters, you will see the differences. So, what do you think is at the core of what the undergraduates are expressing to you in these exit memos week after week?

ALTON

It tells me they don't want to think on their own. They want me to tell them what to teach and how to teach it. I feel conflicted. On one hand I want to honor their choice and empower the collective voice the undergrads are expressing in their weekly exit memos to us. They are being honest. Even though it feels like a personal rejection of my labor and thought, I want to give them the support in their choice to either use the model (TTTC) to learn, or not use it. I want to make sure they see that we responded to their voice, so they do the same for their students.

However, I am having trouble accepting the outcomes that can go along with the choice expressed in these exit memos.

SPECTOR

What exactly is troubling you?

ALTON

I believe teaching science requires teaching students to do inquiry. You cannot expect a person to teach science through inquiry if they have not learned through inquiry. Inherent in the holistic paradigm is constructivist teaching through inquiry. Therefore, my frustration is from this belief that they have not understood yet. Since they refuse to keep trying to learn in the holistic paradigm, they may not have this important experience as a learner before they become teachers. I believe that a teacher needs to have this experience as a learner first. This helps them realize how effective it is to learn through open-ended inquiry. This realization of how much more effective it is, compared to how they have been learning their entire time in formal education classrooms, could inspire them to provide the same for their future students. If they never have this meaningful experience as a learner, then how and why would they ever consider it worth facilitating for their own students? If this is not experienced as a learner, then the chances of them using constructivist teaching in dominant paradigm schools is greatly reduced.

SPECTOR

Why do you say it is so necessary? Couldn't they just learn it as they go?

ALTON

Maybe, but I think the damage is worse once the dominant paradigm student becomes the teacher. From my experience, I learned that being a dominant paradigm teacher was meaningful

to me, but not the students. It took me until I became a doctoral student to ask myself the important questions that I should have reflected on before I became a teacher.

SPECTOR

Which is what?

ALTON

Who is responsible for learning? What is the role of the teacher? What is the role of the learner? I never considered these fundamental questions. I felt it was my inadequacy as a new teacher if they didn't get it. Many teachers also tried to tell me that it's the level of children I teach. All new teachers must start at the bottom of the barrel when we teach. Once you have put your years in, then you can teach students at the top of the barrel. The better behaved and smarter kids will get whatever you throw at them.

The personal detriment I felt from my inability to build learning experiences my students would connect with put me at odds with them unnecessarily. The students' rejection of my work as a teacher became very personal and damaging. What I built for them to learn from turned out to be only meaningful to me and me alone. I never realized how important it was for students to practice autonomy, because I never experienced what autonomy felt like when I learned a subject. I missed the point of what teaching is meant to do. It is to facilitate a learning process for the student to become empowered through the practice of inquiry and freedom of choice in the processes they use to learn.

SPECTOR

I go over those questions you stated at the beginning of each semester in a methods course. Students answer them in writing and discussion. They describe their belief systems that way. What I think you are suggesting is they need to have experience as learners testing the

options of the holistic paradigm that contradict their dominant paradigm responses as learners. It also sounds to me like you are describing a whirlwind of powerful, uncontrollable dominant forces waiting for them after they graduate. These forces can push a new teacher further away from any holistic approach they might have considered using in their future classrooms.

ALTON

Exactly, and therefore I feel conflicted. I know I don't just think that it is a preference. I do know, without a doubt, that each teacher needs to experience being at the center of the learning process first as a student before becoming a teacher. They need to be empowered as learners, and then they can practice facilitating the empowerment of their students when they are teachers. They also commented how much they struggled with understanding science content throughout school, and they seemed terrified of having to figure out how to teach a subject of which they have no grasp.

SPECTOR

This is a part of the culture of these pre-service elementary undergraduates. When you get to teach the pre-service secondary undergraduates, they will not ask you to help them understand the content of science. The anxiety levels are different regarding this matter. The elementary pre-service teachers are also entering the public-school classrooms in their internships around the same time they take these methods courses. As you can imagine, there are a slew of contradictions that start to flood their minds as they see realities of the teaching profession within the dominant paradigm system. In addition to the harsh realities of the elementary classroom they are exposed to during the day in their internship, at night, they then enter this classroom and face an even larger contradiction; they lack understanding of a subject they are required to learn how to teach. This perpetuates their long-lasting fear of learning

science, because now they are responsible to know it before they can teach it. They tend to look to the science teacher educator of these methods courses as their last line of hope in understanding a subject with which they always struggled. Let me remind you, it is not your responsibility to teach them science. The course is called "Methods in Science Teaching." This is exactly what it is, learning different ways to teach science. Did you notice what they suggest we do, or show them to do, in the exit memos?

ALTON

Yes, they want me to demonstrate actual science lessons to teach them science.

SPECTOR

Do you see the conflict with this?

ALTON

Well, the conflict with what they don't want and what they do want, seem to be connected. They don't want to use the model (TTTC) to learn. They don't want to have a choice in how they learn. They don't want to learn by inquiry. They cannot take the uncertainty of an emergent design to learn, which is necessary for them to have a personally meaningful learning experience. They are rejecting the constructivist way of learning in the holistic paradigm. In other words, they don't want to build their own experiences. Instead, they want me to build it for them when they ask me to perform and create science lessons. This mitigates a couple of their stresses at one time. It gives them something they can copy for teaching in their future classroom, as well as a review of science content about which they are unsure. Because of their anxiety, they have no desire to learn how to teach science until they understand the subject they are learning to teach. This seems to be more of the conflict to which you are referring. As a result of the system failing them, by not requiring/preparing them to understand the content

before they reach this course, learning methods in science teaching for this course serves only as a point of frustration and anxiety.

I think maybe a huge point of the conflict and their frustration is they are anxious about coming towards the end of their teaching program. They might have expected their education (degree) would have prepare them to teach all subjects before they graduate. At this late stage in their program, they are desperate to figure out how they are going to teach a subject they still don't understand. This may explain why they just want to emulate what I do when they come to the methods course. They are trying to learn through imitation and memorization of science words. It's the exact opposite of what you've done with me. You have studied me, instead of me studying you. The latter is the traditional way of learning in public school classrooms. The dominant paradigm system's common practice is for the student to guess what's in the teacher's head. You have facilitated an environment in which I co-explore/study what's in my own head with you, and we both discover how I think while I learn. The focus is on the learner, not the teacher.

SPECTOR

This is why they reject any learning process requiring autonomy. Your model doesn't represent anything brand new to the nature of science. Instead, it is a learning mechanism to experience autonomous learning. The TTTC provides the students in a classroom a way of experiencing the nature of science by practicing inquiry. This requires the learner to take ownership and develop questions to investigate emerging phenomena. This is science.

ALTON

So, what should I do? I strongly believe in a learner exercising their voice especially within their community or culture. However, without the undergrads having the experience to

learn within their community through inquiry, it doesn't matter how much content they can learn from me. Later on, they still would have missed the most significant experience I wish I had before I started teaching.

SPECTOR

What experience is that?

ALTON

It has been my experience as a doctoral learner. I have had the experience of learning through open inquiry. It placed me at the center of the process and provided the support and ease to build a meaningful learning experience that has changed my belief system and provided me with a voice expressing what and how I learn.

SPECTOR

What makes you think they are going to learn the content of science, if they are too anxious to use inquiry to learn? If you teach them the subject of science, I assume you would use an inquiry approach. This is not familiar or welcomed in their culture.

ALTON

So even if I spent the time teaching them science instead of science teaching, I would have to use didactic pedagogy they could memorize to keep them happy.

SPECTOR

Without a doubt.

ALTON

Then it would be even more time wasted, because at that point it would just be memorizing facts.

SPECTOR

Exactly, which is why they wanted you to perform the entire act of teaching science. They wanted to copy it and repeat it in their future classroom. I could understand not wanting to learn a new way to do something if you were totally satisfied with the old way. I would have thought these undergraduates would be happy to know there was an alternative way to learn science, because so many of them had difficulties learning science via the dominant paradigm. Not so, they cling to their expectation that science should be taught in a didactic way. I could understand their position if they had been successful learning science throughout their school careers, but they were not.

Try not to take it personally. It does take some dis-equilibration to learn something new. It seems they are unwilling to deal with the least bit of cognitive dissonance. You know you still have the option of moving forward with your original plan to continue the student-centered model with the undergraduates.

The Negotiation of the Critical Event

I did reluctantly change class procedures in 4310 to somewhat resemble procedures with which the students were familiar after students submitted strongly worded mid-semester course evaluations. I was totally devastated by the negative feedback from the students. It felt very personal, despite understanding that the culture of the elementary preservice teachers is dramatically different from the culture of secondary preservice undergraduate science teachers and in-service science teachers like me. Many personal characteristics and beliefs of elementary preservice teachers are the opposite of characteristics of science and scientists (Spector & Strong, 2001). Additionally, undergraduate pre-service teachers do not typically respond well to

taking educational risks in their classroom, partly because the dominant paradigm system of the university inhibits the learner from being okay with taking risks.

Dr. Spector used the 4310 experience to make me aware of the customer service posture of so many universities now. It gives students power over professors that 8th graders do not have over their teachers. That is one of the reasons we considered changing the course back to the dominant paradigm. Since enrollment had been in steady decline for years, the system viewed the higher education student as a customer instead of a learner. The system runs on enrollment. The professor can't teach if there is no enrollment. Low enrollment means less funds, therefore, the learning experience must satisfy the consumer to encourage more investment and better word of mouth for an increase in consumer buy-in. The undergraduate's end of course formal feedback to the university can now make or break a new professor's career. If the student consumer does not like the learning (buying) experience, then the professor is at fault. If students do not tolerate the cognitive dissonance caused by an innovation designed to improve learning in the classroom, the professor is at risk. The system cannot risk more dissatisfied customers in this era of declining enrollment.

Continuing to Grow

In addition to experience teaching university undergraduates, I knew I needed experience as a researcher to fulfill my dream of becoming a university science educator in the future. I had been planning to devote the ensuing summer to analyzing the data Dr. Spector and I were collecting from my middle school classroom during the school year. Now all I wanted to do was research to figure out why the procedures that worked so well with my eighth graders failed with the undergraduates. Dr. Spector convinced me it would be in my best interest to spend my time allocated to research during the summer examining why the procedures did

work with the eighth graders instead, even though I felt a need to do the opposite. It was hard for me to let go of those emotions.

In hindsight, I have come to understand the impact of context and audience on teaching procedures. The negative experience of 4310 gave me a new perceptual lens that helped identify and articulate what, how, and why my middle school classroom procedures worked. I needed the duality of experience using my procedures in the two different contexts with two different audiences to gain more perspectives for my research data analysis leading to what became the TTTC model by the end of that summer.

It seems Dr. Spector knew that putting the spotlight on what did work would indirectly meet my emotional needs. Moving forward with our work would help me move past the despair I felt from the outcome of the teaching practicum. She said that once my teaching strategy was codified during the summer, I might have a model I could use to advance my doctoral studies and my career. She pointed out that the model could also be used as a training tool for consulting school districts to integrate into professional development. This gave me the motivation to make the mental and emotional shift I needed to complete my highly compressed, transformative, and eventful year in the doctoral program and my professional teaching.

The Association for Science Teacher Education Published a call for papers for the international conference five months after the end of the summer proposal deadline. I agree with Dr. Spector, we should submit a paper describing the TTTC as a vehicle to introduce me to the broader professional community. The proposal required a literature section. I spent much of my summer searching for literature to identify labels for, and to expand our explanations of why things were working in the eighth-grade classroom and ensuring that our design was unique in the science education enterprise and education in general. This process initiated a

practice- theory-practice cycle. The information gleaned from this literature search was incorporated into my middle school teaching and the practicum methods class I taught the following semester.

This contrasts with the more typical research model with which I was familiar, a theory into practice sequence: A researcher studies the literature, identifies a gap, designs an innovation to test to fill the gap, and writes about the outcome of implementing the innovation. I was able to explain the impact of the doctoral experience on my teaching of middle school science by the end of the summer.

Narrative Story III-The Resolve

This last narrative story includes two introspective short stories and a conclusion commentary about my entire doctoral experience. Both stories describe the same timeframe during my doctoral program (fall 2019) but approaches each with different viewpoints; 1) my second professor practicum experience teaching pre-service middle school science teachers (4320) and 2) my summative reflection of the TTTC model's evolution from the start of my program (Summer 2018) up through its use and study of the model during this second practicum. The epilogue that follows these stories uses reflexive and reflective commentary about my doctoral experience that emerged while writing the narrative for this autoethnography.

Another Practicum: The Novice Teacher Educator Tries Again

My second practicum experience was in the middle school science methods course (4320) in the Fall semester of 2019. I interacted with Dr. Spector after each class session as we had done with 4310. This semester I did not attempt to structure the entire course as the TTTC. Unlike in 4310, the TTTC was not designed as an immersive "take over" in this practicum, nor did I spend weeks preparing CANVAS pages. I familiarized myself with the CANVAS materials

Dr. Spector had used previously. The paper prepared for ASTE describing the TTTC, my professional practice using it, and how it related to multiple aspects of my career as a middle school teacher were the vehicles for teaching the model to the undergraduates in 4320 during my second and last on-campus professorship practicum.

This time the integration of the TTTC took the form of a workshop exercise with undergraduates communicating 'conclusions' about the TTTC model: What it is and how it works. Assigned groups explained to the entire class the strategies/characteristics embedded in the TTTC using real school platforms/activities I used for my middle school students. They were not providing any interactive experiences from which their peers (other class groups) would learn. Information was translated from group to group much like an epilog, describing what that group had understood from the ASTE paper and the limited group time together in which they practiced a model-based activity.

An undergraduate pointed out to me an important characteristic about the model after using it briefly in practice to prepare for her group "teaching" in the class workshop. She first asked an important question about the practice of the model in my middle school classroom, using the visual representation provided in the ASTE paper seen below in Figure 4.
"What's happening in your classroom with all the other students when they are waiting for the lesson to be designed by the designer student group at the top of your model?"

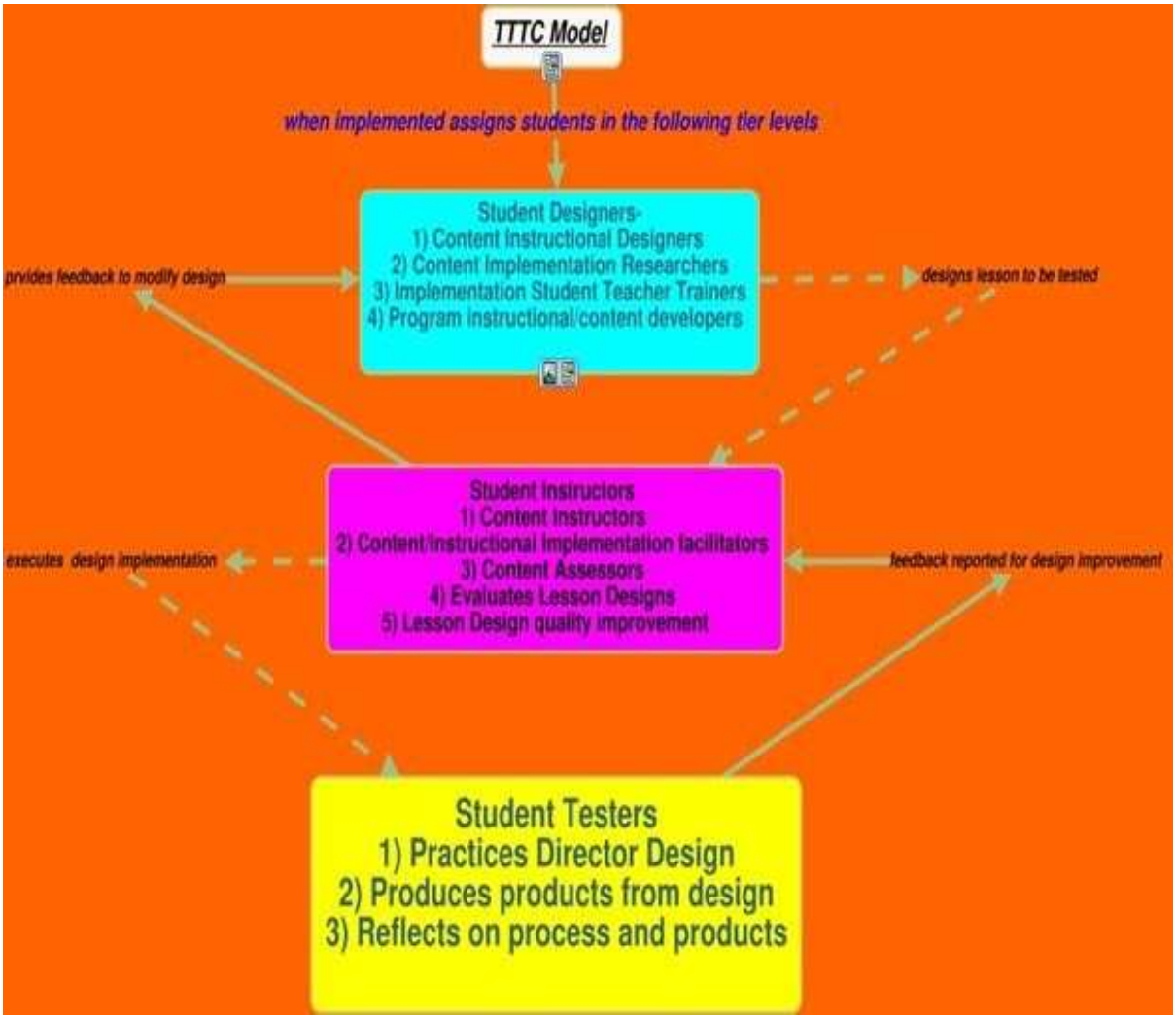

Figure 4. The Three-Tiered Transformative Teaching Classroom model (TTTC)- Student Roles, Version 2 (Built Before Version 3, 'Latest Version')

I found this to be a common question about my model. I explained to her, and many others (over the years) that although the entire class at some point will work on the same classroom product, each group works on different parts of it, in different ways, and at different times. While most of the class (two groups- instructors and testers) maybe actively engaged in (teaching with or learning from) a previous lessons made by designers, this same designer group is simultaneously constructing new lessons for the class to use later. From this realization the undergraduate explained to me that the model in practice seems to operate as an on-going

horizontal work cycle, and not the linear hierarchical vertical pathway visually presented at that time (see Figure 4). From that point on we graphically presented the model as a cycle (see Figure 1) dependent on all working groups within it. By applying this simple graphical revision, we were able to visually translate how the model facilitated constructivist teaching and learning.

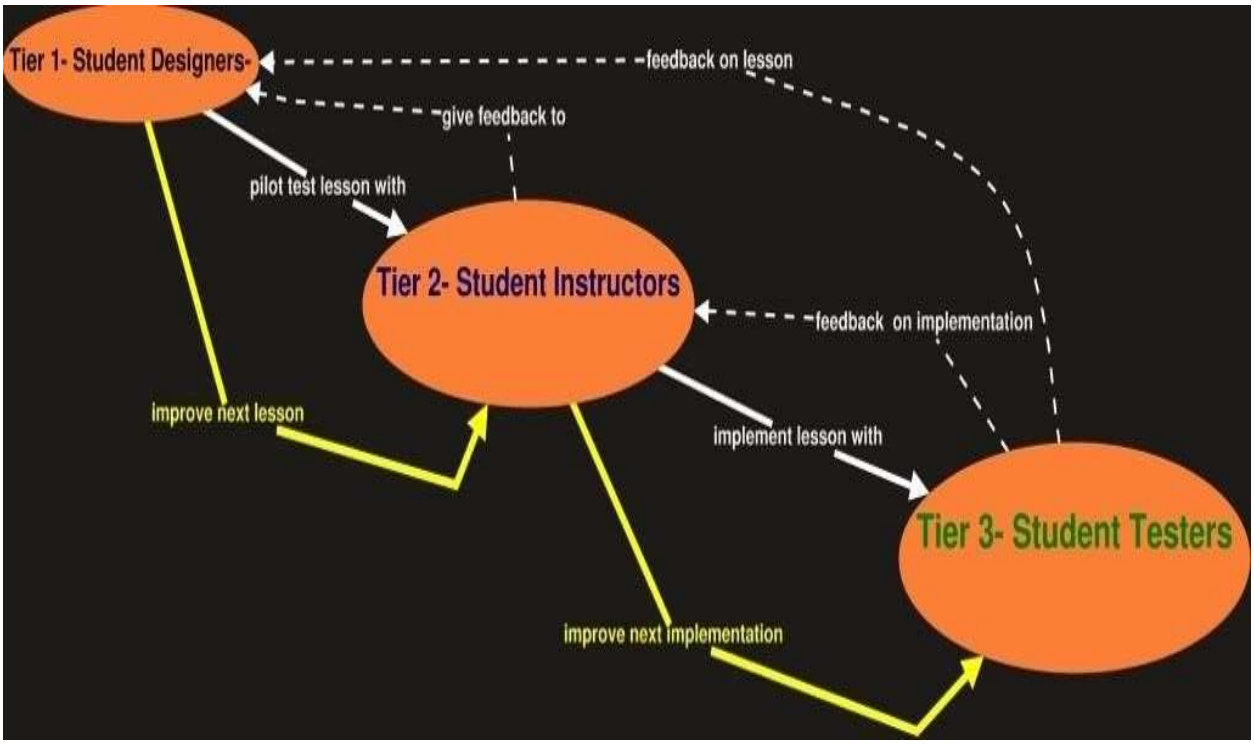

Figure 1. The Three-Tiered Transformative Teaching Classroom model (TTTC)- Student Roles, Version 3 (Latest Version)

Although it was never planned that we would teach a more TTTC based curriculum beyond the first few weeks, I had hoped there would be enough student interest to continue using it. I still held on to the possibility that their weekly exit memos would express desire for further exploration of the model. We had left the course planning open for this possibility. I did not, however, spend time preparing for this unexpected possibility. I wanted to avoid what I had felt was "wasted" course planning time in 4310 by assuming the undergraduates would want to use the TTTC for their own learning during the entire semester. Even though there was no

surprise in the lack of interest and the unwillingness to take a risk on implementing the model for their own classroom learning/working process, I still took it very personally. I had hoped that undergraduates preparing to become middle school science teachers would show a desire to use inquiry for learning how to teach.

An Epiphany

The process of building stories about both my practicums and fitting them into the narrative of my doctoral experience enabled me to deeply reflect on the development of the TTTC model. This resulted in the TTTC as a character of the narrative with its own storyline depicting the conception, birth, and growing life as this inquiry model. In doing so, I noticed that this separate storyline functioned as the central protagonist in the story of my first professorship practicum in which the model was pilot tested in the undergraduate classroom (4310). This brought me to an epiphany I had been blind to for so long, but Dr. Spector stated on many occasions; the model is not the driving force of, nor is it central to, my overall doctoral experience. Instead, the TTTC serves the same function as the CMAP software did in those first semesters of my program. It is a tool stimulating my growth as a doctoral learner. Up until this dissertation process using the new catalyst of narrative inquiry (writing to learn about my doctoral experience), I could only perceive the TTTC as a strategy facilitating growth in a classroom, or not. Dr. Spector had discussed with me that this perception of the model was obscuring my overall understanding of what my doctoral experience really was prior to the cycles of writing inquiring into my doctoral experience.

My epiphany was that truly central to my overall growth in the doctoral program was the conflict I experienced during the 4310 practicum. I realized all my narrative inquiries were either the stories leading up to this conflict or descending from it. It was the success in my 8th

grade classroom and then failure in testing the model in the 4310-undergraduate classroom, followed by the translation of these events into the ASTE conference research paper that really shaped all of what came afterwards. This brought me to identify the conflict as the critical event central to my entire doctoral experience.

The critical event controlled the way I tested the model for the next professorship practicum. It directed how I studied and built theory to support the model for presentation to my professional community. It also changed my perception of how the TTTC functions in my middle school classroom then and today. The epiphany I had about the critical event in my first practicum (4310) as the central point to my overall doctoral experience facilitated an inquiry into the on-going story of the TTTC beyond this narrative.

I was left with an important question after reflecting on the development of the visual interpretations translating the TTTC, as well as the evolving interpretations of the model in theory and practice within the university classroom and the middle school classroom leading up to and after the critical event: *"*Since the evolution of my model is not central to the narrative for this dissertation, then how can it fit into the overall story to improve the communication of my doctoral experience to the reader?"

Dr. Spector had to continually remind me that the purpose of building my narrative was not to tell the story of the TTTC. She explained to me that I should be using the narrative inquiry to capture my entire doctoral experience, not just the evolution of the TTTC. She did point out that since the emergence of the model played an influential part in my growth as a doctoral learner and professional teacher, any retelling of my doctoral experience would result in a storyline describing the development of the TTTC. However, the significance of the model's influence as a mechanism for me to learn and teach kept me blind to the key points of

my experience. This blindness had made me unaware that the conflict I faced in 4310 was also the critical event for my narrative. It was through my reflective process focusing on the evolution of the TTTC while writing this narrative that the critical event came into focus, so did the importance of the role of my co-mentor.

My scholarship was dependent on and lived entirely through the working relationship with my co-mentor. The dialogic interactions with my co-mentor served as the primary catalyst for my doctoral experience. It included, and was not limited to, our reflective practices discoursing about emerging doctoral coursework; collaboratively reflecting on testing ways for me to teach and learn; explaining to each other what it was I understood about an experience; and exchanging interpretations of events and development. Additionally, we built learning designs together, reflected on them, discussed the tests of the designs, the results of the tests, and how to revise the tests. We follow this process with summative reflections on the overall experiences from tests, sets of events, reflective writings of these experiences/events, and combining all these experiences. I got immediate feedback, either orally or in email, diagnosing my developmental stage based on how I expressed myself through the communication with my co-mentor about what I learned throughout my program, as well as how all of it was connected.

In the Fall semester of 2020, I enrolled in my last formal course titled, Teaching and Learning in the Content Area, with a professor other than my co-mentor. All my classmates were well along in their doctoral programs in different content areas. Much of the print material and class discussion addressed the dysfunction of schooling in general and the need for change in the various discipline areas. The essence of the issues was familiar to me, and I felt very confident in this course. In fact, I had to monitor myself to ensure I did not monopolize discussion time. The

issues were like change issues I studied in the history and philosophy of science education and in the various change agent courses I took with Dr. Spector. It seems I may be able to apply the TTTC and my change agent knowledge more generally than I ever anticipated.

The Epilogue

This epilog focuses on the role of co-mentoring in facilitating meaningful learning throughout my doctoral experience. It is separated into two sections evaluating, reflecting on and reflexivity on, Dr. Spector's role as my co-mentor. These data emerged during my study of the narrative as it was being built for this dissertation. A continuous comparative analysis generated narrative and narrative inquiry evaluating the meaning of my doctoral experience during this dissertation process. This stimulated me to critically think, or construct meaning to explain my doctoral experience. Continuous dialogue with Dr. Spector about her co-mentoring role in my doctoral experience resulted in an awareness that I had been using her as a sounding board to help me figure out what I really wanted to say. It also led to emergent hypotheses in the conclusion section that are grounded in the data about co-mentoring.

The significance of co-mentoring appeared to be a recurring discussion in emails, on the phone, and face-to-face between Dr. Spector and myself throughout the dissertation process. I selected two pieces of data to share from the study of the narrative that show the impact of, and essence of co-mentoring as a significant finding.

Reflexivity on Co-Mentoring

The text below is reflexive data collected during the construction of the narratives for my autoethnography. This data includes the time and context in which the data was collected, as well as its original content. Grammatical editing has been used to help better translate the original content to the reader. The text is not edited for proper line spacing or correct paragraph

formatting intentionally to preserve the original writing style I used at the time it was composed. The text below (adapted from my original email to Dr. Spector) is presented as such, to express (to the reader) the emotional recall that stimulated my emerging reflexive thoughts. Additional reasoning for this formatting is to embody the raw nature of my data (email text structure), which is distinctive from the formality of this dissertation, and convey an authentic context that initially influenced this email. The dotted lines added serve as physical indicators of original email content and context.

Email Sent Tuesday May 25, 2021- Summer Term -Dissertation writings

Sender: Alton Declaire (myself)

Recipient: Dr. Spector (Co-mentor/Major Professor/Doctoral and Dissertation Supervisor)

So, I researched our emails between each other. I saw a presentation I made for your Reading Course, (... I took to get my teaching certificate) and what immediately struck me was how you included me in the decision making of when I should do my presentation. This is why I named the document Shared Governance because of how involved your classroom was even before I was your doc student.

Then I stumbled upon a thread of emails with my ideas for a PhD program that I could work on with you as a doc student.

I am going to review them again. I cut out unnecessary emails in between all my rants, but what caught my attention was your responses to my ideas and how you continued to take away my fear and anxiety, and it is evident how I respond to your "safety net".

This security combined with your active responses and questioning to my rants and idea brain dumps I feel created a "snowball" effect in my thought process. It gave me a sense of freedom and safety to think of new ideas and approaches to my education.

You continually encouraged me to come up with ideas and be an equal part of the decision-making process. I find this recurring theme in the way you share power with your students (me in particular), unlike the way I share power with my students....in these emails it is evident that you share governance in "what" I learn.

I share governance with my students in "how" they learn.

I have been missing the "what", with my students, and for me this may be correlated with my transformation as first a learner.

I lacked confidence in "how" I thought. I had to change "how" I learned before I could ever be confident in deciding "what" I want to learn.

I am a direct product of an authoritative educational system.

You presented me with the next step: "What" do you want to learn? The effect of this can be seen in my emails where I digress in brain dumps. Entering the PhD program under your guidance clearly motivated me, and I do recall having a huge sense of autonomy and choice in the idea that a PhD must be creatively intelligent in order to discover something new in their field. After examining our communications through these early emails with each other, I now know that these brain dumps were an early sign of my learner transformation into taking charge of "what" I think.

This may seem normal for any educated person, but the gap between undergraduate senior work and graduate work is huge. And this gap between the next two levels is even wider.

What I am getting to is that I had to experience as a learner the confidence and safety to take risks and decide "what" it is I wanted to learn, before I could provide this experience for my students, in the role of a teacher.

I saw the importance of shared governance in the "what" this past year of teaching, as using the TTTC was no longer my motivation to start my year of practice, as it has been for so many years. This year after being transformed as a learner (from the time I have spent with you) who takes charge of "what they learn", I was ready to do the same for my students as a teacher.

The notion of shared governance for "what" my students learn never crossed my mind until this year.

I understand that the circumstances are also a factor of these years controlled by the uncertainty of COVID. However, as you have stated before, as an emerging theoretical model, the TTTC provides the mechanism in which to change "what" we learn through the transformation of the classroom into a supporting community of practice. Emancipating the power struggle that takes place in formal education by providing a continuous building process/practice for students to collectively help each other learn through the advancement of improving the way they teach, thus learning how to learn together.

I would infer the model takes care of the "how", so the learners can focus on "what" they want to think....

This may be similar to the ‘function then structure idea’ that seems very persistent in the holistic paradigm of education.

The TTTC is a structure (model), but in a learning community it meets the functional practicality of the learning process however it needs to. It is malleable and designed to be

flexible to facilitate an emergent design process supporting a grounded theory approach to teaching and learning science. It is a constructivist community learning model for an open-inquiry practice-theory-practice cycle. The underlying principle it is structured allows for the flexibility of the model to re-invite itself continuously, thus evolving based on emerging needs within the community of practice that functions within. The structure (content) of the learning process is the "what". Maybe for me as a learner and as a teacher changing "what" I think follows changing "how" I think. The how is the functional part for me.

Reflecting on Co-Mentoring

Dr. Spector asked me a question about a particular narrative inquiry I had written. It reflected on the professional writing process I went through when synthesizing the research, we had collaborated on about the TTTC. That summer of 2019 was a transitional time in my doctoral experience, like the current shift I am experiencing now with this dissertation. My doctoral research as a process was moving towards research as a product in the form of a research paper for presentation at a professional conference, ASTE.

In the summer of 2021, I emotionally recalled this important doctoral learning experience in transition from research as a process to research as a product. After reading the narrative inquiry reflection on this learning experience, Dr. Spector informed me there were many points bouncing all over the place in the piece. She asked me to clarify a pattern she thought might be in my chaotic writing. She noted the text seemed to iteratively describe a role for her co-mentoring in facilitating the transition of my experience from learning as a research process to product. She requested I write out the key points I was trying to illustrate in that reflective inquiry. My response was the email below in which I identified the consistent impact of the dialogic

interaction with my co-mentor. I now realize my key points were all addressing the consideration she gave to my occupational well-being and its effect. It was written toward the end of writing my narrative for this dissertation.

The reflective data seen below was collected during the construction of the narratives for my autoethnography. This data includes the time and context in which the data was collected, as well as its original content. Grammatical editing has been used to help better translate the original content to the reader. The text is not edited for proper line spacing or correct paragraph formatting aiming to preserve the original writing style I used at the time it was composed. The text below (adapted from my original email to Dr. Spector) is purposely presented as such, inconsistent and separate from traditional formatting used throughout this dissertation. Choosing to use non-traditional formatting is intended to simulate (for the reader) the genuine nature of my original experience collecting the data (composing the email). By leaving the format unedited, I aim to convey the emotional recall that initially generated my reflective thought processes used to build the email. Using the original format preserves the genuine context that generated the content of this email, which then stimulated the extension of it seen in Co-mentoring characteristic table composed for and presented in this dissertation (see Table 2). The added dotted lines serve as physical indicators of original email content and context.

-- Email sent: Thursday December 2, 2021.

Sender: Alton DeClaire

Recipient: Dr Spector (Co-mentor/Major Professor/Doctoral and Dissertation Supervisor)

Key Points I was trying to make

-Co-mentor reflecting with me to make sense of why TTTC model failed in when tested in undergraduate setting by shifting my focus from what didn't work to what did work and flourished in middle school setting

-Emancipation of power relationship results in a negotiation of a horizontal relationship---this is a result of student granting access to the teacher into the student's world of exploration in the constructivist classroom of learning, instead of the other way around.

-Co-mentor always attending to my needs as student in comprehensive manner, never forgetting the dual or triple learning roles/practices effecting my process to advance

1. practicum science teacher educator role practice (4310, 4320)
2. doctoral science education student learning from science teaching experiences
3. doctoral science education student learning from science teacher educator experiences

-Co-mentor is sensitive to the values of certain roles over others, decision/reflecting processes will circle towards roles more important to student's development, even if student is unaware

--Co-mentor facilitates progress by reducing overall time of needed for growth of student (provides support and advice on easier ways to get to the same point) -is able to do this because teacher has studied student and student has studied themselves

--Co-mentor is always adapting and adjusting the direction of course learning to address needs personal to learner -the art of discernment by co-mentor understanding the emotional impact of failed model attempt would only distract progress for me if summer research focused on the reasons why it failed

---Co-mentor is unbreakable to adversity, opposition circumstance, and unexpected outcomes to keep using emergent design and shared governance to decide the direction of the learning - strong constructivist belief

--Co-mentor is able to look beyond emotional impact, and use her expertise of field, experience of profession, her past student experiences, and her growing knowledge of the learner, the emerging learning experience, and her position in the emerging process to provide appropriate support for advancement through dilemmas

----Co-mentor removes barriers of progress,

Examples of this is the way Dr. Spector removed me obstacles, prepared me for my unknowing future, and helped me avoid pitfalls by finding them before I even knew they were there.

**In Table 2, I identified and organized the characteristics (dispositions, beliefs, and actions) of a co-mentor that I found to be useful for advancement during my doctoral experience. They are supported and support extant literature (Thompson, 2017; Ford & Ford, 2020; Harvey, 2011). These characteristics contributed to me building and maintaining trust in our relationship. This suggests how a supervising professor can establish a successful co-mentoring relationship with a doctoral student.*

Table 4. Characteristics of a Doctoral Science Education Co-Mentor

Co-Mentor Expressed Beliefs	**Co-Mentor Dispositions & Skills**	**Co-Mentor Supportive Actions**
Priorities	*Character Traits*	*Encouragement*
showing empathy with a student's situation and notes when she has experienced similar situations	needs and interests from decoding verbal messages, and interpreting non-verbal cues, such as facial expressions and physical posture	points out to student where student expresses the same idea at different levels of complexity in successive writings
making it obvious that the co-mentor finds what student has to say interesting	using the extant literature that is needed to explain the student's situation	paraphrases and summarizes explicit and implicit meaning of experience based on student translation to co-mentor
how an idea is important, even though it is not obvious now how student will be able to use it	to find when to supply relevant literature at the time student expresses a need, "just on time delivery	making it clear the doctoral experience is not just academic taking place in a vacuum
faith in the process an attitude of success (in contrast to weed out)	requires ongoing student reflection, metacognitive, and reflexive writing	in the remembrance of ideas, student shares at earlier times (whether from other course material or student's own comments) and asks how those ideas relate to the current experience student is describing
learning from student's sharing	through asking open-ended and learner centered questions at appropriate times	models and explains how to do reflection, metacognitive, and reflexive writing
making student feel as important co-mentor		
Dialogic Interaction	*Identifying Student's*	*Helping Student Identify*
engaging with student in persistent reflexive dialog about all program courses and experiences	expressed and unexpressed needs	alternatives to achieve overall goal
cautious to not interrupt the flow of student's ideas no matter how long student talks	zone of proximal development	what is influencing student's perceptual screen being used to interpret a piece of data or an experience
providing language for multiple options to express student's ideas	inherent qualities advantageous to self-efficacy development	how to regulate and modify their own thinking
mediates learning through language	relevant additional learning opportunities for experiences	what student is doing intuitively and not recognizing as important
Safe Reflexive Space	*Creative Exploration*	*Emergent Design*
full investment in mitigating problem/issue student in passionate about	sacrifices expedience of getting task done to accommodate student's emotional needs being expressed	providing a sense of security and adventure
reassurance to student that it is ok to be confused, make mistakes, and share those with an expert	ensuring all aspects of the position paper on doctoral education from the Association for Science Education (ASTE) are met	finding ways to circumvent obstacles
		uses flexible work design
		by giving nonjudgmental /non-evaluative informative, and useful feedback

CHAPTER 6: SUMMARY AND DISCUSSION ON FOUR AREAS OF IMPACT

The original research question was, "What is the impact of the learning experience in a science education doctoral program on a middle school science teacher's professional practice?" The impact of my doctoral learning experiences on my professional practice became evident in four areas: practice as a learner; practice as a middle school science teacher; practice as a novice science teacher educator (teaching and researching); and practice as a professional from Public Health advocating public school change for awareness and improvement of teacher well-being.

Impact of Doctoral Program in Science Education on my Practice as a Learner

I no longer approach learning as a passive act dependent on authority. I no longer believe I must memorize relevant vocabulary before I can make sense of a learning opportunity. Instead, I approach learning as an active process in which I build knowledge, in any subject, by having an experience (a learning opportunity) and inquiring into the experience, then examining and exploring multiple facets of it. I speculate about various paths to make sense of the experience. I use writing as a mechanism to learn and make a habit of investigating the roots of words to better understand their meanings. I write what I think I know about the experience, ask myself questions about what I think I know, and seek to fill any gaps. I investigate the extant literature to find multiple perspectives and evidence to support or negate my speculations. I test my sensemaking ideas (understandings) by engaging in dialogic interaction (discussion) with others (especially my co-mentor). Dialogic interactions when examining my written reflections provide me with creative exchanges of perceptions and ideas from which my meaningful explanations

emerge, as well as new explorations. I reflect on the input I receive and re-evaluate the sense I am making until I am satisfied. This is an iterative process.

When my ongoing iterative process was applied to doing course assignments, I looked at assignments as being open-ended vehicles to collect data and did not do them just to get something done to meet someone else's criteria, or rubric as I did in the past. I did them until I felt competent. I have become an autonomous learner who engages in metacognition consistently. I approach different silos of knowledge asking how they are connected, always looking for the networks that connect people, things, and ideas. My inquiry processes acknowledge cause and effect are not linear in most of life. I now give intentional consideration and acceptance to the idea that my life is all connected, and one part influences the other.

A constellation of factors came together to generate my learning practice. They include, but are not limited to, having (a) shared governance (emancipation of vertical hierarchy), (b) continuous communication, (c) consistent emotional support, (d) safe spaces for dialogic interactions, (e) freedom to make choices, (f) time to be iterative, (g) opportunity to explore before I explain a phenomenon, (h) a series of continuous meaningful experiences, and (i) connection to a scholarly community. These factors contributed to developing my voice and self-efficacy, both of which further empowered my practice as a learner.

Practicing learning in the context of the preceding factors during my doctoral experience led to my awareness that I am the creator of my knowledge. It is not discovered or imposed by nature or an instructor (Phillips, 1995). It is emergent, with my own inquiry as the generator of my understanding. The more intellectual risks I took, the more understanding I developed. Dialogic interactions with my co-mentor, an expert, and non-experts enabled me to articulate the knowledge I was creating and to feel confident in my developing voice. My constructed

knowledge became more sophisticated as my ability to articulate thoughts improved. The expert provided a safe dialogic space for me to take intellectual risks and to exercise my voice through exploration of both the way in which I build understanding and how I communicate my understanding. The expert stimulated the critical thinking process by providing a more experienced perspective on the way I communicate (voice) and what I am communicating (knowledge). The non-experts provided additional perspectives that also stimulated critical thinking fostering re-evaluation of how I translated my knowledge and the significance of the content (the so what?).

Impact of Doctoral Program in Science Education on my Practice as a Middle School Teacher

The TTTC changed incrementally throughout my doctoral studies and as an outcome from my doctoral studies. Here is an example of a change I made in the model in response to a specific doctoral experience: The product for a course in which I was enrolled with Dr. Spector in the summer of 2019 was to be a research paper presented at the national meeting of the Association for Science Teacher Education (ASTE) five months later. The paper was to introduce the TTTC model to the science education community. I had to clarify and articulate in detail the way the TTTC worked to complete this task.

Most of what I did in my classroom emerged spontaneously in response to my needs and those of my students. I was too busy teaching to document my actions and those of my students until I was required to do so during my doctoral work. The research, writing, and literature search I did during the summer of 2019 provided a mechanism, process, and language to clarify, in a coherent communication, what the TTTC model was and how it related to extant literature.

Having completed this task, I was able to build a word wall (see Figure B1) in my classroom before the school year started in the fall (2019) showing the elements of the TTTC I had identified during the summer, including the addition of students writing weekly reflexive journals. The classroom word wall contained science content words from the district curriculum maps such as photosynthesis, cellular respiration, etc. in prior years. Now the word wall provided a teaching compass for me to refer to all year long. It helped me continually communicate the processes happening in the classroom to the students. In essence, it made visible what was previously invisible, the shift in paradigms from dominant paradigm teaching to holistic paradigm learning.

Most of my students became aware they were learning how to learn together as a community. The more we studied the model, the more I was able to holistically examine the impact constructivist teaching had on the learning environment. This was evident in their collaborative differentiated practices, which were all socially dependent on a shared belief system that assumed learning was not an isolated activity nor individual pursuit. The awareness of these changes became evident even to members not in groups that were consciously taking on transformative classroom roles ('Designer' and 'Instructor' groups). The 'Tester' group, most students, began experiencing transformation in learning from only learning scientific principles, mostly by memorizing, to constructing meaning by learning how to learn. Their understanding of the nature of science shifted from a collection of labels and facts to science being an inquiry tool leading to autonomy. Additionally, the 'Testers' increased their feedback to the products and processes they experienced, because they understood the value of their responses to the work their peers designed in the classroom. In this way, they took on more responsibility for their own

learning and unified the community. The communication bridges critical to the success of the TTTC were crystalized. Student learning and the model were transformed.

I immediately adapted and tested a new action or interaction in my eighth-grade classes every time I realized something I experienced had transformative value for me during the three years in my doctoral program. I discussed each venture into something new with Dr. Spector as I implemented it. This enabled me to evaluate and refine it on the spot, thereby establishing a practice-research-practice cycle.

Here are samples of other visible ways my doctoral studies directly impacted my actions in my middle school classroom: I introduced them to, and encouraged them to, use CMAPS as an ongoing tool to foster inquiry. I began requiring weekly reflexive journaling in my classes. I shared governance with my students about what they learned in addition to how they learned. I consciously adopted the practice of making decisions for my students based on what they indicated was in their personal and academic best interest, because of the way decisions for adapting my doctoral experience were always made to serve my personal and professional best interests. This meant I shifted the usual classroom procedure from students studying the teacher to me, the teacher, studying the students. I implemented the actions of a co-mentor. I am reminded of the adage, "Teachers teach the way they were taught."

Impact of Doctoral Program in Science Education on my Practice as a Novice Teacher Educator

My practice as a novice teacher educator includes teaching undergraduate preservice teachers and conducting research. These two dimensions of a teacher educator's job were tied together for me by using a continuous practice-research-practice cycle. I innovated when

teaching. I researched what happened because of my innovation. I revised my innovation and researched the revision.

My newly acquired understanding of the culture of higher education impacted both my teaching and my research. My expectations about practice in higher education culture were unrealistic. All I had to compare this practice to was what I observed as a higher education student, what I had seen on T.V., in the movies, in social media, and what I knew about the teaching as a middle school teacher. I experienced culture shock on a variety of levels.

For example, a common perception I share with all middle school teachers is we are teaching human beings who do not wish to learn the subject being taught. Higher education teachers are teaching those who want to learn what is being taught. I experienced the opposite as a novice teacher educator with preservice undergraduate science students. I found out that there is a culture clash between those teaching science education, most of whom were trained as scientists in addition to their training as educators, and preservice students learning science education who have not had any experience in a teaching occupation (Spector & Strong, 2001).

Another startling realization was the power relationship between students in a class and the teacher. The university treats students as customers. Professors in a College of Education have to keep the customer majoring in science education satisfied. The students' end of semester teacher evaluations can destroy a new professor's career. Middle school students do not have this power over their teachers. Now I understand that as a novice science teacher educator I must walk a very delicate tightrope between my principles of pedagogy and what makes the students comfortable as consumers.

Now knowing about the culture of undergraduate preservice science teachers, I realize I must deliberately facilitate trust building activities, enact strategies to mitigate their grade

emphasis, and be explicit that the important part of science is the inquiry process itself. I must study the students and continuously adapt instruction in response to their needs. I will use my skills as a change agent to encourage these students to shift their paradigms. My experience resonates with Jablon's 2002 study in which he calls for science education doctoral students to have experience teaching undergraduates and focus on being change leaders.

Some of the teaching strategies I will use follow: Explicitly discuss the contrast in paradigms in science education and the manifestations of the paradigms, structure an entire course as an inquire, create canvas pages to facilitate inquiry, build in self-evaluation procedures to help mitigate their grade fears, and build in as many features of the TTTC as possible.

My research expertise came from my Masters of Epidemiology degree using quantitative measurements in statistical software. I managed, organized, and analyzed large sets of medical data prior to my doctoral studies. I had heard that emergent design qualitative research techniques existed that could help me explain what, why, and how learning occurs in my classroom. I wanted to learn to do this kind of research for my doctoral work. I had no idea of the reams of paper I would be writing to do this research. I was terribly averse to writing! Knowing this, Dr. Spector encouraged me to write streams of consciousness. She was explicit that she wanted to know what I was thinking, and I should not let writing style inhibit me. Fortunately, the reflections she required me to do for my courses led to such exciting dialogic interactions that I got immersed in the writing process without realizing it. I was exhilarated by the revelations I was finding in my writings by the time I came to writing this dissertation. Now I am addicted to writing reflections about almost every aspect of my career.

Even in what physically appeared to be the isolated process of writing research data and analysis for this dissertation, I always knew that Dr. Spector and my committee were on the other

end waiting to read what I had to say. Not only was it important to me that I knew someone was going to be reading what I wrote when I practiced the isolated experiences of qualitative research writing, it was even more important that I knew the experts on the other end of it thought my overall collection of ideas had value.

I learned the value of an outside critical friend in a qualitative study when Dr. Cyndy Leard, a science education consultant, reviewed versions of my research at key junctures in my writing. She provided a perspective from the stance of a professional audience who knew nothing about my work. Her insight generating questions revealed gaps in my story. They were often things I took for granted, not understanding their importance to a reader with a fresh perspective.

The fact that the ideas for practices emerging from my research could be tested immediately in my classroom and generated more questions to investigate was incredibly motivating. It led me into a practice -research- practice cycle that is self-perpetuating. This cycle is consistent with the development of a scholar called for by Huber and Hutchings in 2005 and Walker, et. al., in 2008. I expect I will be continuing this cycle long after my dissertation is accepted. Additionally, I cannot resist reading articles about reflexive practice and other aspects of emergent qualitative research. I look forward to one day being able to teach a course on qualitative research in a higher education institution.

I was surprised to realize that teaching and research in higher education are constrained to a large extent by the institution functioning in the dominant paradigm in many ways similar to constraints I experienced as a middle school teacher. I experienced those constraints of living in a dominant paradigm while I attempted to teach preservice teachers in the holistic paradigm as a novice teacher educator. I now perceive the occupational well-being of a K-12 teacher and that

of a higher education professor share many features due to the entire education enterprise not being conducive to functioning in the holistic paradigm.

Impact of Doctoral Program in Science Education on a Professional from Public Health

The well-being of individuals while engaging in their occupations is an important domain for professionals in public health (Thorpe et.al., 2008). I have become committed to the practice of improving the well-being of teachers because of my doctoral experiences in science education. The shift from the dominant paradigm to the holistic paradigm in science education, towards which I have been working, can result in school environments conducive to a culture that fosters teachers' well-being. I will combine insights I gained about factors influencing my well-being as a learner and teacher in this study, and my emergent skills as a change agent to influence education institutions by developing innovative ways to support teacher well-being.

I experienced culture shock as a professional from public health when I moved into the culture of teaching in a middle school and the university. Public health is community-based and requires professionals to work together (Community focus for public health recommended, 2015). This results in a community of practice that relies on critical conversations among individual professionals working together. By contrast, teaching is individuated and isolating (Ostovar-Nameghi & Sheikhalma, 2016). Currently, most institutions are not structured to support interactions among the professionals within them. I experienced severe stress during my early years as a professional teacher. I did not recognize it was a cultural issue until reflecting during my doctoral studies.

My original intention of how the TTTC model functioned for me prior to entering the doctoral program emerged out of occupational dysfunction (being individuated and isolated) in

the teaching profession. I had never experienced a job as isolating as teaching. My first job working in construction relied on working in a crew doing different tasks that were all part of a shared job. Safety of yourself and those you worked with was the number one priority. It was a very dangerous job. There was an outspoken understanding of cooperative safety that unified the crew working the job. In my next job, I worked as an entry-level fast-food worker. I was fast tracked into management within a year. I quickly learned making profit was the bottom-line focus of the job. Controlling costs was my number one responsibility. A huge area of cost was labor. I had to take on multiple jobs to cut labor costs, because I was on a salary. Despite the overworked pressure in that career, looking back on it now, I had time each day to engage in dialog with other managers working in the restaurant. The job itself required a cooperative environment of multiple people working together. Even when I was the only manager on duty, I still was dependent on the work of other people. Communication was a critical work factor.

Moving into my next career as an EMT before teaching, I was taught that safety of a worker is the number priority. If the worker is not well, they cannot do their job well. It was stressed that all healthcare workers not only rely on interaction with each other to physically do their jobs safely and well, they need to reflect with each other about their job in order to keep doing their job. Sustainability in the career, progress in the profession, and avoidance of emotional breakdown and physical burnout depended on the professionals interacting with other professionals intellectually and emotionally about their job (Henckes & Nurok 2015).

The early version of the TTTC model was an outcry for professional interaction. Bringing the model to the doctoral program provided me with interaction. Dr. Spector pointed out early in our study of the TTTC model in my middle school classroom that a core function of it was supporting a community of practice. She explained that this characteristic was apparent,

because no matter what group role a student was in, each group was responsible for different parts of one collective classroom product, one goal. Thus, they were interdependent.

In our discussion about why the TTTC worked in the middle school and not with the undergraduate preservice teachers, we concluded there is a lack of support needed to easily shift from individual to cooperative working procedures in a dominant paradigm learning environment. My principal supported my efforts with TTTC, which was unusual in the dominant paradigm of a middle school. Dr. Spector also noted the element of time. The undergraduates were only brought together to exercise cooperative work on one product, once a week, for a fifteen-week semester. Students in my middle school classroom worked together five days a week. This frequency supported the necessary change in learning habits from individual work to collaborative collective work projects.

A collaborative work environment was the essential characteristic lacking in my occupation as middle school teacher. Integrating this quality into my occupational work practices (even when I was unaware of it) not only enabled me to full fill numerous teacher tasks, but it also provided a supportive work environment I relied on my entire working life.

Dialogic interactions with Dr. Spector throughout my entire doctoral experience (even in preparation for my first semester) subconsciously reminded me of the professional connection I had been missing since I became a teacher. It wasn't until our summative discussions reflecting on paradoxes and changes COVID forced on teaching practices that I began to focus on how growth and well-being were unsupported in my profession. This included a realization in the lack of support from all stakeholders involved in the teaching practice. At that time, Dr. Spector pointed out the unexpected connection of my previous graduate work in Public Health with my new doctoral work in Education.

As a professional from public health, I became intensely aware of the absence of strategies and an infrastructure to ensure the well-being of teachers. This was highlighted and exacerbated by the pandemic. I began advocating for teacher well-being by writing daily posts on the teachers' union web page. I helped bring clarity to the lack of structural support and what the various dimensions of the struggle were. These generated numerous responses rallying teachers to use the opportunity to voice their frustrations. Many teachers thanked me for helping them put their stressful experiences into a broader perspective. Using my lens as a former public health professional combined with my newly acquired change agent skills and insider's view of schooling will help me work toward systemic changes to improve teacher well-being.

This study is supported by, supports, and expands, the following extant domains of literature: Occupational Health, Implementation Science, Constructivism, Science Education, and Writing to Learn.

Occupational health literature includes ways to promote physical and psychological well-being of workers in all occupations (Thorpe, Griffiths, Jewell, & Adshead, 2008). The nature of the dialogic interaction between the doctoral supervisor and the doctoral student herein provides insight to the way occupational well-being can be promoted and maintained in a higher education institution, thereby adding a new example to the occupational health literature. Need for attending to doctoral students' well-being was highlighted by Pyhältö et al. in 2012.

Explanation to the role of co-mentor adds a new strategy to expand Implementation Science literature. Implementing innovations commonly requires individuals to make changes in their beliefs and actions (Halle, Metz, & Martinez-Beck, 2013). Enacting the role of co-mentor as described is a way to induce such changes.

It is important to recognize that constructivist learning is necessary in higher education (Entwistle et al., 1993; Jonassen et al., 1993), as well as in K-12 schooling. Teachers teach the way they were taught was confirmed by the Salish Project (2013). It is, therefore, necessary for supervising professors to teach doctoral students how to be teacher educators of constructivist learning experiences. This study is an example of constructivist teaching in higher education for which there is a paucity of literature (O, C.K. 2020).

Insights a reader may derive from the process that facilitated my shift in paradigms from the didactic mechanistic, reductionist paradigm of science teaching to the holistic, inquiry, constructivist, practice-based paradigm of science learning can provide guidance to enable other science educators to help students shift paradigms for learning science consistent with national standards. Further, doctoral supervisors modeling the holistic paradigm by executing a co-mentoring role have potential to increase retention of doctoral students in science education programs. This co-mentoring role also has potential to mitigate the problem Walker, et.al. in 2008 identified as the need to retain doctoral students generally in many disciplines.

There has been a trend in the 'Writing to Learn' literature to make it discipline specific (Bazerman, et.al., 2005). The undergraduate science education discipline has not enthusiastically embraced the practice (Reynolds, et. al., 20121). There is, therefore, limited literature. This current study expands the limited literature base. It has potential to help science teacher educators understand the way writing can contribute to cognitive development, including critical thinking in science teaching and be used as fodder for dialogic interaction fostering meaningful understanding of science.

CHAPTER 7: CONCLUSION

My learning journey has been a process of transformation for me both intellectually and psychologically. I documented my perceptions of events and my emotional responses to events as they occurred. I then used metacognitive and reflexive processes to reflect (revisit and record my constructed understandings) on my past and present experiences.

The impact has resulted in; the improvement of my occupational satisfaction, a determination to be a change agent in science education, an illustration of an emergent constructivist process of co-mentorship for educating doctoral students, and an original teaching model (TTTC) for middle school science with potential to be used in a various learning context.

Important belief and attitudinal transformations I experienced were from a) hating and fearing formal schooling to enthusiastically embracing it; (b) being an ineffective learner to a self-efficacious, productive, effective lifelong learner; (c) being insecure and reluctant to share my thoughts to being comfortable articulating details of intellectual meaning making and being expressive of my emotions; (d) disliking writing used as an observational report of past experience to being exhilarated by writing to learn (make sense of my world) used as an immersive participatory experience in cultural inquiry (ethnography); (e) accepting and functioning in the didactic, mechanistic, reductionist paradigm to being committed to, and functioning in the holistic, inquiry, constructivist, practice- based paradigm.

Three phenomena that became obvious in this study follow: (a) Emergent design allows form to follow function in design of a doctoral program, similar to the way form follows function in all of nature; (b) The co-mentor is a facilitator of constructivist learning and teaching; and (c)

Dialogic interaction is essential to constructing meaning and relationships, and persistent dialogic interaction is critical to successful co-mentoring. The keys to my successful learning during my doctoral experience were co-mentoring (as described herein) and faith in emergent design for research, learning, and teaching. This study provides 'how to' strategies for the work of Sverdlik, et al., (2018) indicating the relationship with the supervisor is the most influential external factor in the success of a doctoral student. The list below are the emergent hypotheses from my study:

1. To the extent a supervising professor serves as co-mentor (as described herein) to a doctoral student, the student's well-being will be enhanced.
2. To the extent a co-mentor adheres to emergent design constructivist principles in learning and teaching throughout a program, the doctoral student's learning will be expedited.
3. To the extent a doctoral student's well-being is increased, the student's willingness to take intellectual risks increases, and in-depth meaning will be constructed.
4. To the extent a doctoral student's depth of meaning increases, creative products will emerge.

The creative product in this study is labeled the Three-Tiered Transformative Classroom (TTTC). This model (TTTC) emerged from my need as a beginning science teacher and was elaborated and refined throughout the three years of my doctoral work in a co-mentor relationship. TTTC served as a living laboratory during the three years of doctoral study. TTTC was evaluated positively by internal and external evaluators during its pilot test in a middle school science classroom. TTTC can be used by a variety of audiences, middle school through

undergraduate school and in-service teacher education facilitating a constructivist classroom consistent with the Next Generation Science Standards and society's holistic paradigm.

This study illustrates benefits of education consistent with the holistic paradigm underlying today's society and development of a practice-research/ theory-practice cycle useful to university science teacher educators. These were derived from the processes and pathways I, a doctoral student, used to make sense of the learning opportunities afforded me and features of my experience that led to my well-being and maintaining my enthusiasm despite the significant life challenges I encountered and the tedious parts of the doctoral process.

Recommendations

As a result of experiencing a co-mentoring relationship during my doctoral program, I believe the following recommendations will benefit the science education enterprise:

The statements that follow should be added to current literature in my field (science education) identifying the contradictions between Next Generation Science Standards and the reality of teaching in classrooms unsupportive of these standards. Supported by the work from Spector & Ball (2014) which uses the perspective of the K-12 science teacher to highlight the distinctions between the dominant paradigm and the holistic paradigm in science classrooms, my suggested contributions to the literature highlight these differences and can be included in this extensive list. Using the holistic science teacher (paradigm) as the answer to dominant paradigm conundrums, this list (2014) is organized as a series of opposing answers to the two teaching paradigms suggesting that most science classrooms do not support the inclusion of NGSS classroom practices. Therefore, a paradigm shift in how we teach K-12 science is critical for the future of science education. To accomplish this type of radical change in such a vast field, the extant literature must provide a variety of teacher skill sets, models, and classroom examples

describing “how we teach science differently” in the holistic paradigm. My suggested additions (listed below) to this body of work (2014) are a response to these needed descriptors of the atypical (holistic paradigm) science teaching classroom:

- Mechanistic Classroom (Dominant Paradigm)
    1. The student studies the teacher to emulate the teacher's thinking.
    2. When a student can mimic the teacher, the teacher moves on
- Constructivist Classroom (Holistic Paradigm)
    1. The teacher studies the student to diagnose the student's needs.
    2. Teacher designs interventions to meet the student’s needs before moving.

The following statements should be added to the Association of Science Teacher Educators’ position statement (2021) delineating characteristics educators of effective science education doctoral programs:

1. Doctoral supervisors should enact the role of co-mentor with doctoral students.
2. Doctoral students should identify an issue about which they are passionate upon entry into a doctoral program and use that to guide decisions for doctoral programs.

In addition to these general suggestions, pre-, and in-service science teacher education should consider using the TTTC model to facilitate constructivist classroom teaching.

Future Studies

The future study will be an inquiry into my intellectual and emotional (psychological) transformation during the ten months writing this dissertation. It contrasts with this current dissertation exploring the transformative process during my three years of study in the science education doctoral program. My new endeavor will address four questions: (a) What happened to my learning during the process of writing my dissertation? This will describe the content of

the experience. (b) How did it happen? This will describe the process of the experience. (c) Why did the experience happen the way it did? This will explain the premise of the experience, and (d) How did the process of telling the story change me? This will describe the transformation I experienced psychologically, including my emotions. The data for this study will be the four hundred pages I wrote documenting the way my thinking and feeling changed with each cycle of writing. All of it influenced by research papers I read about reflexivity, narrative inquiry, and ethnography during the ten months of writing this current dissertation.

The study is expected to provide insights derived while crafting this current dissertation that can shed light on layers of complexity and distinguish steps useful in transformative learning. Further, this next study will document the way writing can be used to enhance a researcher's well-being. Finally, it is expected to provide insight to the way a researcher becomes empowered as a critical thinker through the qualitative research process. The latter will be useful in preparation of future qualitative researchers.

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APPENDIX A: COURSE PROJECTS MAPS FROM 'THE EXPOSITION'

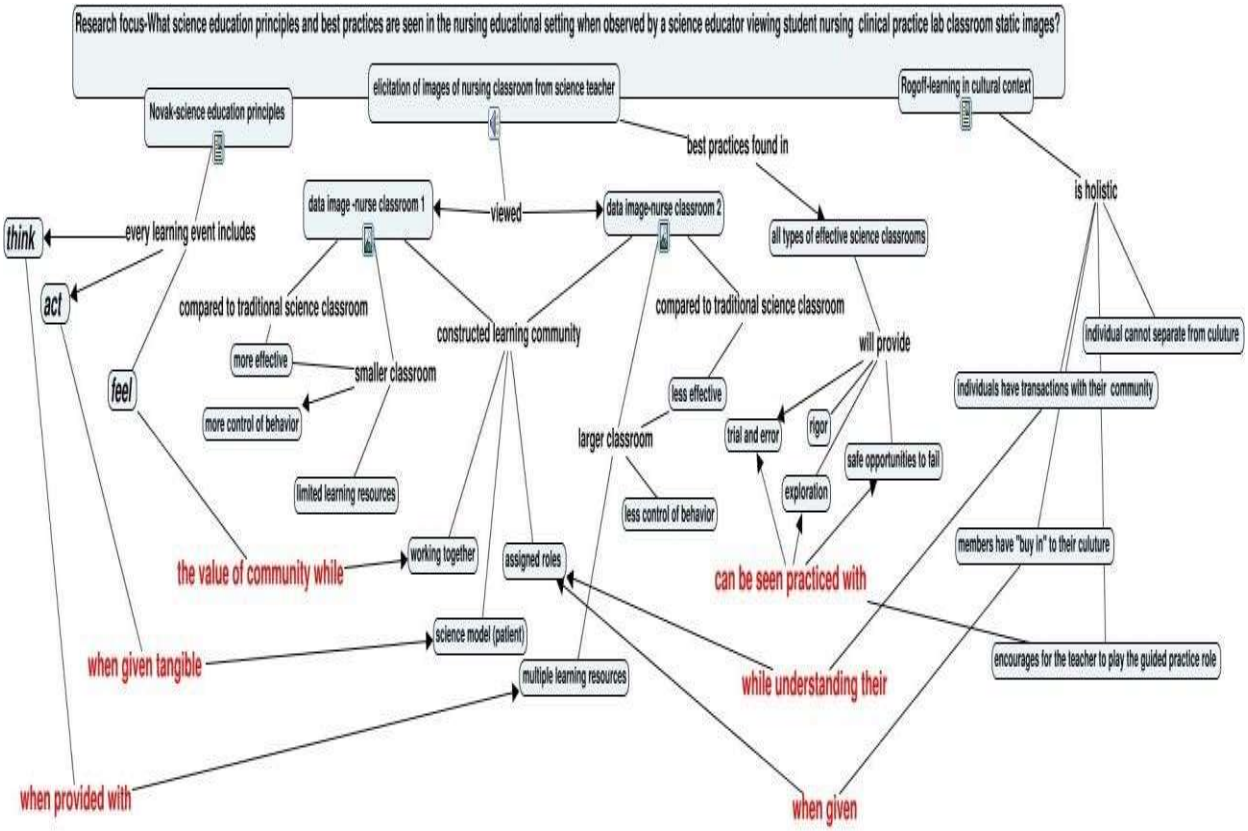

Figure A1. Visual Methods Course Nurse Project

**Constructed and presented in the middle of June 2018. Designed for navigation through course paper assignment only. First integration of map into my coursework. Here in Appendix A, all the maps collectively serve as a visual narrative interpreting the collective semester story called 'The Exposition'. Because they each were built for the same purposes, their legibility was not intended for translation in a textual document, such as this.*

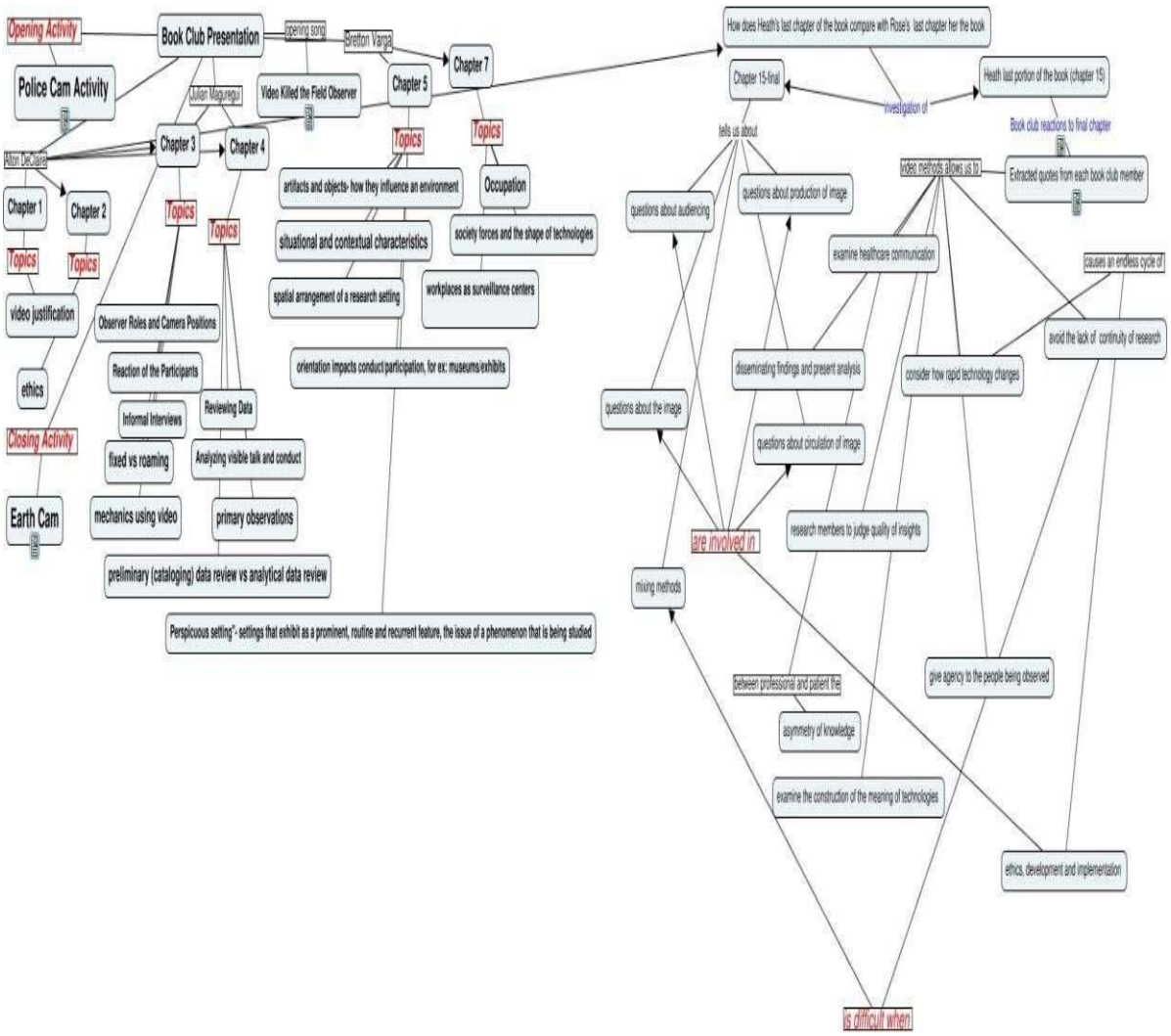

Figure A2. Visual Methods Course Final Group Project Map

Constructed and presented towards the middle of July 2018.** Designed for classroom presentation only. Although Figures A1- A2 are not legible in the format of this paper, their visual placement in this dissertation is not intended for individual artifact analysis. They function in adjacent to corresponding course experiences in which they were derived from, thus serve as visual translators of my first semester in the doctoral program.*

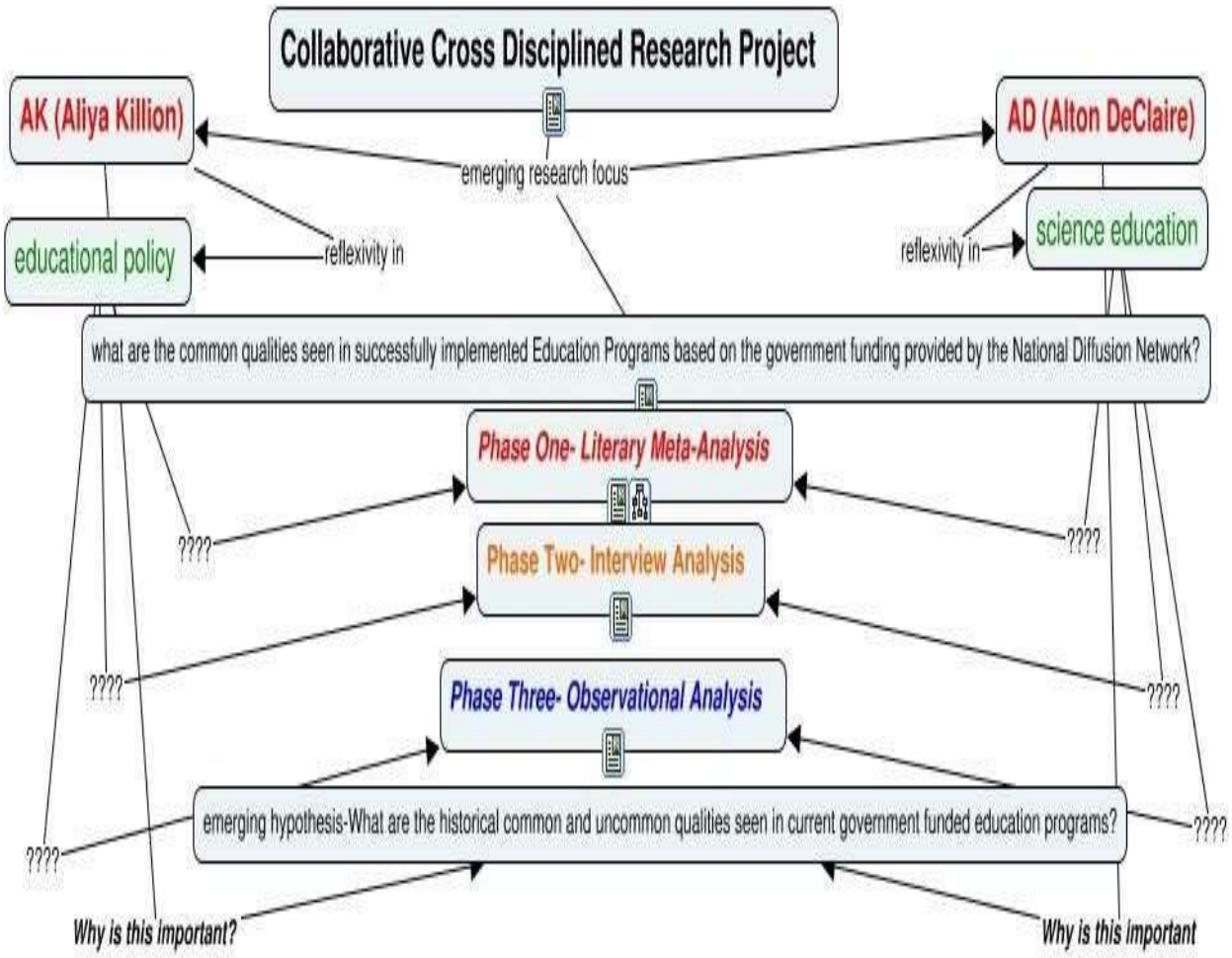

Figure A3. Qualitative Research Course Final Group Project Map

**Constructed and presented in the last class of my first semester (Summer 2018). Designed for organization and direction of group project, classroom presentation, and integrated into corresponding final course paper as an illustration of the research. This map represents the ending event of my first semester, as well as a visual conclusion to my first concept map collection designed and used for course explorations. The construction of these maps (Figures A1-A3) served as central story features for Narrative I 'The Exposition' in this dissertation. The nature surrounding their integration into meeting coursework needs provided social value which I shared and contributed culturally during my first semester course experiences.*

APPENDIX B: MIDDLE SCHOOL CLASSROOM IMPACT FROM THE RESOLVE

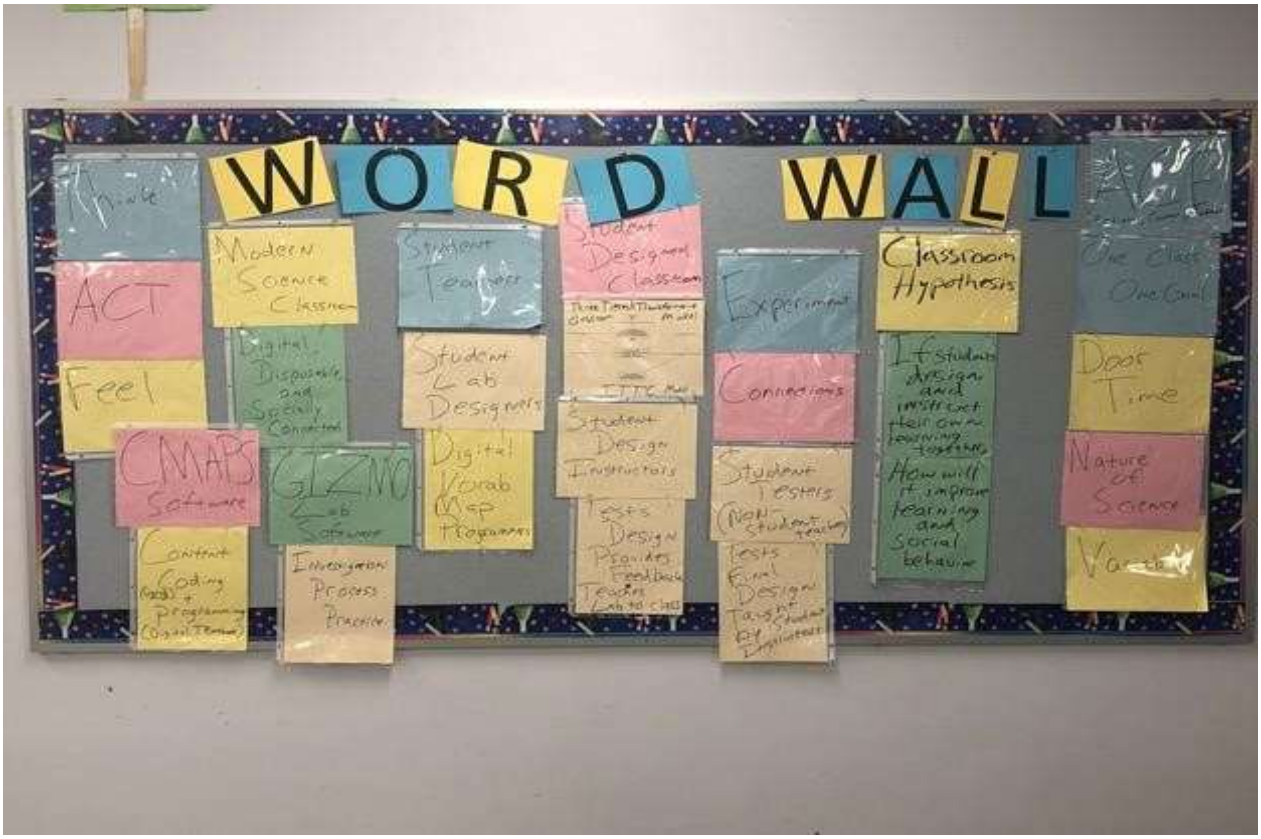

Figure B1. Middle School Classroom Word Wall

** Constructed start of August 2019 during pre-planning for middle school teaching year 20192020. The design and production of this wall followed my Summer 2019 doctoral semester work. This work resulted in the ASTE paper highlighting my use of the TTTC model in my middle school classroom the previous teaching year (2018-2019). This photograph was taken before any of the 8th graders I would teach that year entered the classroom. After the word wall was constructed, the photograph was taken and sent immediately to my co-mentor (Dr. Spector).*