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Evolution of Computational Thinking Contextualized in a Teacher-Student Collaborative Learning Environment.

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EVOLUTION OF COMPUTATIONAL THINKING CONTEXTUALIZED IN A TEACHR-STUDENT COLLABORATIVE LEARNING ENVIRONMENT.

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ABSTRACT

The discussion of Computational Thinking as a pedagogical concept is now essential as it has found itself integrated into the core science disciplines with its inclusion in all of the Next Generation Science Standards (NGSS, 2018). The need for a practical and functional definition for teacher practitioners is a driving point for many recent research endeavors. Across the United States school systems are currently seeking new methods for expanding their students' ability to analytically think and to employee real-world problem-solving strategies (Hopson, Simms, and Knezek, 2001). The need for STEM trained individuals crosses both the vocational certified and college degreed career spectrums.

This embedded multiple case study employed mixed methods data to gain insights into the pedagogical practices, curriculum, and teacher-student interactions that occurred in three teacher's lives. The study's teachers were all using LSU's Introduction to Computational Thinking (ICT) curriculum and the accompanying professional development program. The cases studied demonstrated that it was possible to train a teacher with no experience in computing to be a functional novice teacher. The three teachers demonstrated a pathway of professional growth that I classify as apprehension of the novelty, transitional growth with the content, and reinforced confidence from student interactions. The teachers were challenged by embracing new project/problem based pedagogical techniques and working in a virtual environment. Teacher success was reinforced through their ability to embrace reflective thinking practices with their students. The role of contextualization was examined as a critical factor in teacher professional evolution. The results have implications for future computing curriculum development and meaningful/ successful teacher training practices.

CHAPTER1
INTRODUCTION

In the past two decades the United States has devoted an increased amount of funding towards making technology instruction involving computational thinking an integral part of STEM instruction (Kuenzi, 2008; NGSS, 2018). The push to include these concepts and tools in the K-12 classroom instructional cycle is not clearly or uniformly defined (Akerson, Burgess, Gerber, Guo, Khan, & Newman, 2018). The discussion of Computational Thinking as a pedagogical concept is now essential as it has now found itself integrated into the core science disciplines with its inclusion in all of the Next Generation Science Standards (NGSS, 2018). The need for a practical and functional definition for teacher practitioners is a driving point for many recent research endeavors. In 2016 the research team of Weintrop, Beheshti, Horn, Orton, Jona, Trouille, and Wilensky clarified the definition of Computational Thinking to be "the form of a taxonomy consisting of four main categories: data practices, modeling and simulation practice, computational problem-solving practices, and systems thinking practices" (p. 127).

Traditionally computer technologies have been utilized in classrooms solely as a tool for instruction or as the means to achieve proficiency with software tools. Historically computers were relegated to the role of data gathering, data analyzation, or word processing tools for use in career and technical education electives. Early computer programming courses were attempted via the inclusion of programming languages, such as LOGO, Python, and Java Script. These early interventions consisted of short lessons with quantitative tests for the efficacy of learning outcomes for isolated specific skills (Papert, 1996; Ortiz & MacGregor, 1991; Papert, 1980). The earliest lessons to include programming were of a template nature. The early exercises were found to need refinement and further examination of the "students' interactions with the instructional and programming contexts, developmental transformations of their programming skills, and their background knowledge and reasoning abilities" (Pea & Kurland, p.137, 1984).A complex challenge for students lay in developing the understanding of computer programming language's usage to interact with the complex concepts involved in applied algorithmic thinking. Adding to the difficult task of training students to apply higher order thinking was the fact that many traditionally trained K-12 teachers lack any background knowledge or training in programming/ coding. When presented with the challenge of including coding in traditional core classroom the educational community must ask itself, what format should the inclusion of technology take?

In examining this question, one must consider the roles federal guidelines have on instruction. In recent years a renewed focus has been placed on the required K-12 science and mathematics courses to include more technology and computational thinking. The requirements occurred within the testing mandates of the No Child Left Behind Act of 2001 and Every Student Succeeds Act of 2015 (United States Department of Education, 2017). School districts across our nation must achieve funding through their standardized test scores (Kohn, 2002; Winfield, 2007). Districts were tasked with adding new skill sets to their classrooms and with testing students under strict framework. In 2015 the No Child left Behind Act was replaced by the Every Student Succeeds Act, ESSA. Under ESSA states were given some freedom to define what they wanted to assess and how they wanted to set accountability levels, but they were still needing to gain approval from the U.S. Department of Education. ESSA added many new challenges for states and began several debates as all stakeholders began to voice their concerns (Dreilinger, 2016). The most significant detail that changed under ESSA was in the establishment of Computer Science as a federally recognized core academic subject. In this study, the state department of education used this ESSA mandate as an impetus to redesign its career technical education and college preparatory curriculum pathways. The Louisiana State Department of Education noted that a desire by local industry for more STEM trained workers coupled with technological advances of the past 10 years produced a need for more students to be trained in analytical thinking.

Across the United States school systems are currently seeking new methods for expanding their students' ability to analytically think and to employee real-world problem-solving strategies (Hopson, Simms, and Knezek, 2001). The need for STEM trained individuals crosses both the vocational certified and college degreed career spectrums. The National Center for Women and Information Technology's 2011 report projected that individuals with a computer science-oriented degree would fill 77% of future job openings. In 2014 the Louisiana Workforce Commission predicted that the "computer and mathematical occupations" to be one with the largest areas for projected ten-year growth. The report anticipated a 36.6% increase in occupations by 2022. Despite these reports' predictions in 2014 only 61 students in Louisiana took the Advanced Placement (AP) Computer Science exam, six of which were African Americans (The College Board). This data represents only 0.3% of the total number of students taking AP tests in the state. The 2013 National Research Council report on *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century* lists 15 essential 21st Century Skills and Competencies for life and work. Over half of these skills are typically considered part of computational thinking (i.e. creativity, critical thinking, problem solving, communication, collaboration, information literacy, media literacy and digital citizenship). These skills are also noted as critical skills for students to master in other courses outside of just an elective Computer Science course (McPeck, 2016). Prensky (2008) claims that programming is the skill that will "above all others" allow a person to "bend digital technology to one's needs, purposes and will".

In a novel attempt at addressing these issues three entities, Louisiana State University (LSU) partnered with the Louisiana's Department of Education (LADOE) and the East Baton Rouge Parish Public School System (EBRPSS), developed a new series of courses dedicated to the exploration of computational thinking. The proposed courses are in four distinct areas biomedical technology, computer science, digital media, and engineering. The conceptual framework of computational thinking links all the four programs of study. The endeavor, known as the STEM Pathways, offers professional development trainings for teachers in either a three or six week program, an open sourced virtual curriculum, a mechanism for schools to earn extra points on their school accountability performance scores, and a funding source of career technical education funds paid by the state to the local districts. The partnership began at Lee Magnet High School (LMHS). LMHS is dedicated to the study of STEM and has operated continuously since 2013. The courses are centered on project-based learning and are intended for students of both the university-preparatory diploma track and vocational career high school graduation pathway. While serving on this grant team I was evaluating the implementation of multiple pathways, training, and helping in the development of relevant pedagogies. After IRB approval was attained informed consent was obtained from all districts, teachers, and students. The data was maintained under secure conditions. Before undertaking this dissertation, a separate IRB was attained, consents were secured, and all data was securely stored. Every effort was made to mask all participant identifiers and pseudonyms are used to protect individual identities.

This study evaluates the efficacy of training of the teachers and their understanding of the Introduction to Computational Thinking (ICT) Course. The ICT course is a primary course in all five pathways. This study designed to answer the research questions:

1. How does the contextualization of teaching the content with students interplay with the teacher's own self- reflections from their experiences, as student learners?

2. Why do certain individual teachers with limited to no background in computer science demonstrate an evolution in the proficiency of implementing the Introduction to Computational Thinking Curriculum?

3. What impact do teachers participating in the ICT professional development perceive and gain in terms of content knowledge, pedagogical techniques, collegial networks, and attitudinal views towards STEM?

A critical component of the ICT curriculum occurs within the two areas of computational problem-solving practice and systems thinking practices which employ higher order thinking. Higher order thinking is a term that has its roots in the philosophical (critical thinking) and psychological (evidence-based problem solving) concept of critical thinking. The application to critical thinking in educational pedagogy was first academically noted in the work of Robert Ennis and B.O. Smith in 1961. The earliest instances of critical thinking were centered on the individual student's analysis and judgment of information and the psychological problem-solving approach had long been the structured approach of the natural sciences (Lewis & Smith, 1993). In the years that followed Ennis and Smith's work critical thinking in educational pedagogy would evolve into the current conceptualization of higher order thinking. Lewis and Smith (1993) note higher order thinking solves the split between the disciplines of philosophy and psychology. They elaborate by noting further

> Higher order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations. (p. 136)

Student difficulties in the application of higher order thinking occur because it requires the usage of multiple reasoning skills, and the individual student's capacity to hold these skills in the "working memory" is exceeded (Sfard and Linchevski, 1994). Assessment of the student's ability to demonstrate higher order thinking is not easily undertaken (Heywood, 2000). To reduce the cognitive load, the curricula posits that code can be used for externalizing thought processes that otherwise would remain implicit. This externalizing of thought calls forth metacognitive processes that can lead to process/object reification, often taken to be the hallmark of abstract thinking (Piaget, 1951; Sfard, 2008). The STEM Pathway program posits that the use of computer coding will allow students to reify their thinking processes and ideas into a written and proof readable product. The curriculum employs many of the mathematical concepts from Algebra 1 and the use of simple functions to aid students in the creation of unique projects and to explore engineering principles. The curriculum is designed to employee a series of project-based, real world applications to increase student engagement with mathematics (Ricks, 2010).

This study was conducted over 2 calendar years from June of 2017 until June of 2019. The study was a framed within a mixed method multiple-case embedded case study design. Quantitative data was gathered using pre/posttests, attitudinal surveys, student work artifacts, teacher rubric grades, and teacher work artifacts. Interviews were conducted to probe teachers' actions and responses within a set protocol. Participants were observed in trainings and while teaching their students in the academic year. This study is working to construct a model for understanding how the ICT training and course teaching results in the teachers utilizing contextualization. The study explores a pedagogical methodology for developing practitioner/student self-awareness of computational thinking.

CHAPTER 2
LITERATURE REVIEW

Computational Thinking

The recent driving force behind the utilization of computational thinking in academic courses can be attributed to a report from the US Department of Labor. The report stated that 1.3 million jobs in 2022 will require the skills of programming, coding, and using computational thinking (Richards & Terkanian, 2013). In 2013 the k-12 Next Generation Science Standards (NGSS Lead States) saw the inclusion of computational thinking into all 9-12 science courses in the United States. As the framers of this Science Technology Engineering and Mathematics (STEM) program sought a central concept for the organization of their courses, they settled on computational thinking. The inclusion of the term computational thinking has historically proven troublesome for many educators, due to the fact it encompasses many diverse concepts and is not uniformly defined (Winthrop et al., 2015; National Research Council [NRC], 2010; Wing, 2006; Papert, 1996). Computational thinking has no one set pedagogical methodology at the time of this writing. To delve into computational thinking's meanings a brief exploration of its complex history in the literature is warranted.

The key pedagogical concepts and structures of algorithmic thinking were developed in the 1950s (Tedre & Denning, 2016). Algorithmic thinking was a guiding force in mathematics and would contribute greatly to the practice of computational thinking. Computational thinking's earliest pedagogical model was credited to Seymour Papert. In 1980 Papert first used the term computational thinking in the context of utilizing algorithmic thinking to solve complex math problems. The first endeavor to combine the programming language of LOGO with the computational pedagogy demonstrated a connection of mathematics, but also sparked the idea in its creators that programming added much more to the learner (Papert, 1980). Papert (1980) found "computer presence could contribute to mental processes not only instrumentally but in more essential, conceptual ways, influencing how people think even when they are far removed from physical contact with a computer" (p.4). The continued exploration of computational thinking led to the argument that learners should gradually be taught code literacy and programming (DiSessa, 2000; Hockly, 2012; Prensky, 2008; Rushkoff, 2012; Vee, 2013). DiSessa described computers as being the platform for a new literacy that would change how people approached thinking and learning. DiSessa described this new form as a type of two-way literacy. The learners would be both the creator and consumer of dynamic and interactive expressive forms of thought and knowledge under DiSessa's framework (2000). The concepts of computational thinking and the practice of programming start to become difficult to delineate at this point historically. Often computational thinking studies and discussions of it as a theory utilize programming as their context and lead readers to erroneously associate the two as one (Lu & Fletcher, 2009 ; Hambrusch, Hoffmann, Korb, Haugan, M, & Hosking, 2009.; Lee, Martin, Denner, Coulter, Allan, Erickson, Malyn-Smith, & Werner, 2011). Programming, Computer Science, and Computational Thinking are not the same conceptually. Programming served as a tool for introducing the concept of computational thinking, but it is by no means the restrictive discipline for computational thinking.

In 2006 computational thinking was reexamined and brought to a more public forefront in an article published by Jeanette Wing. The article was in the *Association for Computing Machinery* and it charged educators with making computational thinking a central part of every child's education. Wing (2006) argued that "Thinking like a computer scientist means more than being able to program a computer. It requires thinking at multiple levels of abstraction" (p.34). Wing's idea spurred many to revisit the problem-solving skill of abstraction. The philosophical concept of abstraction can be traced back to the inductive and deductive thinking practices of Thales (Long, 1999), but was formalized in Francis Bacon's *Novum Organum* (1878). Wing's use of the term abstraction evolved from the earlier philosophical underpinnings but was enhanced by those studying artificial intelligence and decision making (Li, Walsh, &Littman, 2006). The core concept of learner's working in the abstract domain of their own minds to solve problems presents many challenges for educators and researchers.

A traditionalist curriculum theorist's approach to defining computational thinking would start by trying to define a series of qualities or attributes and then organizing them into essential ideas versus secondary ideas. When examining the various approaches to defining computational thinking's objectives the recommendations vary with three distinct organizations emerging to lead the field. The Computer Science Teachers Association (CSTA) defines computational thinking through a series of attitudes that they find essential to student understanding (Table 1) (ISTE & CSTA, 2018). The CSTA has argued that their standards are applicable to multiple subject areas but are highly based upon the practitioner understanding aspects of computer usage above that of a novice. The CSTA approach has been critiqued as having objectives that are too broad, too indistinct from other 21st century skills (i.e. media literacy), and too reliant on logical definitions as opposed to the pragmatic use of concept utilization (Voogt, Fisser, Good, Mishra, & Yadav, 2015). Dorn and Tew (2013) highlight the fact that "there is a lack of readily available, validated assessment instruments, educators typically create their own measurements, such as comparing responses to common course exam questions or designing surveys to evaluate student understanding of a particular topic" (p.60).

This prompted another approach at computational integration into a curriculum. The College Board and its Computer Science Principles course was established to address the accountability deficit (US College Board, 2018). In this approach standards (See Table 2) were developed for a stand-alone course through the collaborative discussion of professional societies, US College Board members, and the US National Science Foundation (Settle, Goldberg, & Barr, 2013). The AP Computer Science Principles course added the construct of thinking skills and creativity to the objectives they assessed (Dede, Mishra, & Voogt, 2013). The core argument for including creativity in this mix is that computing not only extends traditional forms of human expression, but also allows the creation of new forms of expression (The College Board, 2018). The inclusion of topics like creativity presented a new challenge to educators as they sought to establish criteria for evaluation that would avoid subjectivity. The final systematic objective approach occurred with the Next Generation Science Standards (NGSS, 2018). The NGSS standards use computational thinking with mathematics as a practice. Each of the strands connects computational thinking with mathematics, but in 61% of the standards mathematical models are the primary focus. The NGSS standards rely heavily upon the use of simulations to explore data interactions on computers and data mining. Sneider, Stephenson, Schafer, and Flick (2014) view data mining is different from simple data acquisition in three ways: "(1) Someone else has already acquired the data, (2) the data sets are very large, and (3) the primary focus is on obtaining insights from the existing data" (p. 12). The NGSS standards encourage a more practical utilization of computational thinking with connections to performance-based tasks.

Curriculum Design

Currently academia is not in consensus on a definition of what exactly computational thinking entails pedagogically or how to utilize it effectively in the K-12 setting (Lu & Fletcher, 2009; Tew & Dorn, 2013; Voogt, et al., 2015). The current endeavors to include computational thinking in K-12 educational curriculum fall under two main classifications. The first classification grouping relies upon direct integration of the concept in an established computer science course. The second classification grouping is more ambiguous as it relies on integrating computational thinking within a STEM core curriculum course. The computational thinking discipline is lacking a solitary vetted, validated, and user-friendly instrument to accurately assess computational thinking practices. Through a lengthy search of the current research the LSU concluded it would need to develop its own instruments for tracking computational thinking.

Academically, the concept of curriculum development describes how a curriculum is planned, implemented, evaluated, the key people involved, and the essential processes and procedures that will be needed (Ornstein and Hunkins, 2009). Curriculum models are tools for designers to systematically map student learning, but they can overlook the human attitudes of individual curiosity, personal values, and professional meanings. O'Neill (2010) cautioned that "they are not a recipe and should not be substitute for using your professional and personal judgment on what is a good approach to enhancing student learning" (p.1). This project's design team had a varied approach for both the design of their courses and the assessment of their students. The research team's models did not fully conform to a pre-described theoretical model. The research team did not employ a classically trained curriculum theorist in their efforts. Each of the writers was not formally trained in curriculum writing, but each did have experience teaching high school age students.

The primary curriculum writers selected an approach of designing the content to conform to a sequentially tiered set of elective courses. The elective courses were coordinated so that they would interconnect to form a high school graduation pathway that earned the student a certification. The writers each approached the process of writing curriculum using a constructivism approach with the lesson design being either problem based or project-based learning (Woods & Morgan, 2009). The focus of this study is on the Introduction to Computational Thinking (ICT) course due to its inclusion as a requirement for the initial stages of all four programs. The ICT curriculum was written primarily by a research associate with a master's degree in computer science. The writer had a background in research, two years of 9-12 teaching experience, and numerous experiences working with enrichment summer camps for middle to high school age students. ICT was designed to have a student-centered focus with a teaching method that required learners to engage problems, explore the topics through coding, and communicate with peers to solve the problem. The ICT curriculum has lessons that culminate in problems that require synthesis and analysis to create a solution. The problems are well designed and have multiple correct outcomes or solutions. The curriculum sets the teachers role as that of a guide with built in feedback check points.

The ICT curriculum was developed around the guiding principle of how students cognitively process information. The lesson designs utilized a series of threshold concepts that encapsulated key challenging, significant topics and skills (Land, Cousin, Meyer, & Davies, 2005). The task of using computational thinking within the discipline employed traditional and nontraditional approaches to assessment. The curriculum incorporated group learning and project-based assessments to track learning gains in lieu of standardized tests. The curriculum does not strictly adhere to either the technical/scientific (Tyler, 1949) or non-technical/non-scientific models (Hunkins & Ornstein, 2016) for its content relay to students. The main attributes of the curriculum model are outlined in Figure 1. The lead writer chose from the two models in an ala carte fashion. The writer's selections will be detailed more in the analysis and evaluation portion of this dissertation.

Table 1. STEM curriculum design model attributes from Wiggins, Wiggins, & McTighe, 2005.

Technical/ Scientific Curriculum Model	**Non- Technical/ Non- Scientific Curriculum Model**
Curriculum is a plan or blueprint	Questions assumptions of technical approach
Defined process to relay content is conveyed	Questions universality/objectivity
Means/ends analysis	Stresses personal, subjective aesthetic nature of curriculum
Emphasis on efficiency	Learner focused lessons
Incorporates backwards design model	Students are active participants

Reflection Learning

Reflection Learning is an essential component of both the student curriculum and the teacher training models developed by the program. In researching the practice of programming and coding education there is currently a void in writings on how best to utilize learner reflections (Boyle, Bradley, Chalk, Jones, & Pickard, 2003; Wang, Sy, Liu, & Piech, 2017). The concept of reflection is in itself, not clearly defined (Kember, Sinclair, & Wong, 2008). Reflection learning has been present in education since the days of ancient Greece and Rome (Chesters, 2012). The concept of reflective thinking was researched in the USA by John Dewey (1933). Dewey wrote of it as a thought process that education should strive to cultivate. Subsequently, discrete strands have emerged in the literature on how to accomplish this task (Moon, 2004). A key component to getting students to do any task lies in understanding that most students are inherently assessment driven in their motivation (Biggs, Kember, & Leung, 2001; Chirema, 2007; Thomas and Bain, 1984). It has been previously noted that students demonstrate a lack of content mastery in the absence of correction to their writings and by extension code scripts (Demaree, 2006).

The experiences of an individual learner are often the first foundation that he/she reflects upon (Boud, Keough, & Walker, 2013; Ferry and Gordon, 1998). When a practitioner begins to instruct and evaluate the students' work these individual observances must be closely analyzed and explored (Slezak, Underwood, & Moreno, 2018; Ruiz-Primo, Li, Ayala, & Shavelson, 2004). In the evaluation of reflection there is no set standardized system, but there are several guiding principles which can be of use to the practitioner (Dunn, Morgan, O'Reilly, & Parry, 2003; Lunsford and Mealear, 2004; Schoon and Cafolla, 2003). A key element in the analysis of reflection writing practices stems from "the functions of self-reflection, the relation between self-reflection and reflections about the intentions and beliefs of others, and to methods for studying reflective processes" (Von Wright, 1992). In their three-year study Baird, Fensham, Gunstone, and White found that collaboration fostered by reflection had the impact of challenging individual students to develop "pluralistic understandings" on scientific problem solving (1991). The ability of students to integrate concepts outside of singular experiences (i.e. classroom lectures) will be increased if students are challenged to write, peer communicate, and explain their understandings to others Lederman, Lederman, & Antink (2013).

A key component to addressing strongly held personal ideas and conceptions revolves around the development of new cognitive models for students through targeted teacher guidance (Luft and Dubois, 2017; Underwood, Slezak, Chastain, Moreno, & Browne, 2013). The lack of teacher guidance in reflective learning is also a source of potential misconceptions (Ferry and Ross-Gordon, 1998). If students are not provided regular feedback and given opportunities to have their misconceptions challenged, false understandings can take root (Kirschner, Sweller, & Clark, 2006). The framers of various curriculums focused on the inclusion of student reflection, via the process of having students write. The goal of this mechanism was to capture learner insights (Leung, Sweller, & Clark, 2003). One main argument expressed by Ferry and Gordon is that those using reflection will be more likely to exhibit a constructivist decision-making perspective while non-reflecting individuals will use an instrumental problem-solving approach (1998). The literature demonstrates that to further foster long term memory and the utilization of these reflections, misconceptions must be routinely addressed and challenged (Underwood, 2012; McIntosh and Draper, 2001; Mezirow, 1990). The ICT curriculum was developed to be an interactive series of exercises that requires its users to complete exercises and proceed to the next topic through structured instructor feedback. Two central components of the ICT curriculum's delivery were in having teachers master the content by completing its components and for the teachers to be able to provide reflective feedback to their students.

Professional Development

Teacher professional development has been a part of education in one form or another since the earliest days of the profession. Beginning in the 1950s the professional development model was centered on training teachers to do a specific curriculum or practice (Darling-Hammond & McLaughlin, 1995). As time passed and the policies of No Child Left Behind and ESSA were instituted more legal mandates and requirements were established on what was appropriate for practitioner training (No Child Left Behind Act, 2001; United States Department of Education; 2017). The newer additions to teacher training focused on an increased integration of technology, an emphasis on cross curricular connections to STEM, and a focus on. a learner centered model of instruction (Hawley & Valli, 2000; Weimer, 2002; Tondeur, van Braak, Ertmer, & Ottenbreit-Leftwich, 2017; Darling-Hammond, Hyler, & Gardner, 2017). Over several different studies it was noted that while roughly 69% of teachers reported participating or attending a form of professional development, the majority reported it as being ineffective in changing their practices or improving their approaches to the subject matter (Garet, Porter, Desimone, Birman, & Yoon, 2001; Desimone, Porter, Garet, Yoon, & Birman, 2002; Corcoran & Foley, 2003; Smith, Hofer, Gillespie, Solomon, & Rowe, 2003; Diaz-Maggioli, 2004; McDonald, 2012; Darling-Hammond, Hyler, & Gardner, 2017; Ryan, 2017). Foster, Lambert, and Kim's (2017) findings indicate that "the real issue is not that teachers are not provided with professional development, but that the typical modes of professional development are ineffective at changing teacher practices and/or student learning" (p.181). The professional development models demonstrate that the common support factors for teacher growth consisted of an appropriate program of professional development, teacher understanding of the elements of the curriculum innovation, teacher engagement at a cognitive level, and successful experiences in implementing the new approaches (Peers, Diezmann, & Watters, 2003; Varma, Husic, & Linn, 2008; Desimone, 2009; Davis, Beyer, Forbes, & Stevens, 2011; Patton, Parker, & Tannehill, 2015). Darling-Hammond, Hyler, and Gardner noted that to aid a novice teacher in fully grasping the new content the practitioner must develop a deeper understanding of the content through active engagement with the concepts (2017). After a review of 35 studies Darling-Hammond, Hyler, and Gardner. (2017) concluded that there are 7 attributes to highly effective professional development to be "1. Is content focused 2. Incorporates active learning utilizing adult learning theory 3. Supports collaboration, typically in job-embedded contexts 4. Uses models and modeling of effective practice 5. Provides coaching and expert support 6. Offers opportunities for feedback and refection 7. Is of sustained duration" (p.4).

The STEM Pathway's project began in 2015 as a limited pilot at STEM, public, urban magnet high school. The initial two years of the project had each of the writers embedded as a teacher at the school. The job embedded writing approach was used to help create a functioning curriculum and to provide each writer with a first-hand experience of teaching it. The actual training of teachers from additional schools to redeliver the curriculums first occurred in the spring of 2017. One critical issue faced by the STEM Pathways team lay in how to prepare and train teachers in the pedagogical mindset of computational thinking. At the time of this dissertation there were no models of computational pedagogy to follow. The majority of the literature focused in on the attributes of computational thinking. The team reviewed the current literature on computational thinking and identified three crucial questions for the structuring their trainings.: 1) How exactly is computational thinking related to critical thinking in algorithmic problem solving in the core disciplines of math and science?, 2) To what extent is computer programming involved in pedagogical practices utilizing computational thinking?, and 3)Does computational thinking require the usage of a computer?

To better understand the nature of the professional development it is essential to address some unique aspects of the ICT curriculum. The ICT curriculum is open sourced and held virtually on a server. It is not printed or bound with the traditional resources of in print textbooks. The lessons and exercises are broken up into tier tasks with limited readings. The curriculum lacks a hard copy textbook and at the time of the initial training did not have an instructor's guide. To train the teachers in the curriculum it was decided that the teachers would work through all exercises as in the role of students. According to the curriculum designers the training provides teachers with chances to choose their learning opportunities based on interest and their own classroom experiences/needs on some of the lessons. The teachers utilize refection and inquiry to learn and development new ideas on computational thinking. All throughout the six weeks the teachers are challenged to link their own personal learning with experiences that will be utilized during the school year as resources for teaching. The curriculum is divided into sequential lessons that require the user to link conceptual skills in a scaffold to produce a project at the close of each unit.

This six-week approach would change the teachers into active learners, as opposed to the passive recipients of knowledge (Polly & Hannafin, 2011; Lieberman, 1995). The teachers are only given sample correct answers once they complete a task. The main goal of the training was designed to provide teachers with what John Dewey described as a “meaningful experience” that would foster understanding through linking the concepts taught to prior personal experiences in problem solving (1938). As the individual teacher encounters the new materials they are challenged with discrepancies, data, and the experience of being a true novice learner. The insights offered to the teachers in these opportunities will provide the teachers with insights into the mental struggles their students may encounter. By engaging the practitioners in dialogue, self-examination, and reflection the focus will shift from what content the teacher teaches to how the learner learns the content (Gutiérrez & Cerecer, 2014).

Contextualization

The challenge for most teachers in delivering a new lesson is the incorporation of the training into a realistic setting with a diverse set of students (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2009). Joyce and Showers (2002) found that for a teacher to become an effective instructor of new content in the classroom they need persistence, understanding of how to transfer of training, and the ability to use peers productively. The experiences that the teachers have during their professional development are key to their construction of teaching and learning models. As the teacher progresses through the six weeks of professional development they develop a brief familiarity with the ICT materials. The training provides content and context, but it does not provide meaningful experience with students. Through the utilization of Giamellaro's definition of contextualization a new robust understanding of situated cognition is evident (2017). Giamellaro (2017) sees contextualization as "a construct that (a) indicates curricular intention, cognitive process, and learning outcomes; (b) is a measurable variable that can be correlated to measures of learning; (c) is broadly applicable and thus represents a comparison variable across diverse scenarios; and (d) represents an important link between existing theory and practice" (p.1).

Contextualization does not occur in a single step but rather through a distinct spectrum of experiences. The continuity of experiences that an individual perceives and reflects upon is situated within the context of the learner's actions and accomplishments. Contextual learning is based on the constructivist and constructionist approaches to teaching and learning (Piaget, 1971; Papert, 1980, Borko & Putnam, 1998; Brown 1998; Dirkx, Amey, and Haston 1999). Constructivist learning theory is based upon individuals learning by constructing meaning through interacting with and interpreting their environments (Brown 1998). The meaning of what individuals learn is coupled with their life experiences and personal contexts; it is constructed by the learners, not by the teachers; and learning is anchored in the context of real-life situations and problems (Lave, 1988, Dirkx et.al., 1999). Constructivism challenges the technical-rational approach to education by redefining the relationship between the knower and what is known, including what is most worth knowing and who decides (Dirkx et al., 1999).

Constructivism was taken to a new direction by Seymour Papert with his theory in 1980. Sabelli (2008) notes that Papert defined constructionism in a proposal titled *Constructionism: A New Opportunity for Elementary Science Education* as:

> The word constructionism is a mnemonic for two aspects of the theory of science education underlying this project. From constructivist theories of psychology, we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that

> learning is most effective when part of an activity the learner experiences as constructing a meaningful product. (p.194)

Constructionist theory contributed much to the pedagogical method of problem-based learning and was instrumental in the creation of programming languages, such as LOGO (Barrows, 1996, Papert, 1971). Through the merging of the two lenses, of constructionist and constructivism, I propose that it is possible to examine the transference of knowledge from teacher to students. John Dewey made a distinction between the broad, continuous nature of experience and the having of a more compartmentalized experience (Dewey, 1938; Pugh, 2011). Dewey noted that the larger experience (learning a lesson on a specific coding principle) was not a critical to the learning process as the occurrence of specific personally identifiable event (the struggle one faces mastering a certain aspect of the lesson) (Dewey, 1938; Simpson, 2011; Roth & Jornet, 2014). It is in fact the identifiable experiences that allow researchers to see insight into the individual's cognitive connection between learning and the actual events in the real world (Dewey, 1910; 1938). The learner instills experiences with associations only after the fact of their occurrence (Roth & Jornet, 2014). Following the line of reasoning argued by Dewey it is clear that experiences occur "in the material world as well as in the reflective and cognitive constructions of the mind" (Giamellaro, 2017, p.5). Dewey's interplay between external and internal is also paralleled and expanded in Vygotsky's conceptualization of experience as integrating the material, practical, intellectual, and affective (Roth & Jornet, 2014; Vygotsky, 1978). Giamellaro (2017) conjectures that "contextualization can be seen as the transactional bridge between external and internal experience, the mechanism that connects the material and temporal world to the world of ideas through an experience or through a series of identifiable experiences" (p.5). Through the use of the concept of contextualization student/teacher interactions, evidence from artifacts, interview data, and a comparison of the teacher's efforts in the summer trainings cross referenced with their students' efforts in the school year a clearer picture of how the teacher accesses their personal context and understanding will become evident (Lave, 1988; Gumperz, 1992; Cordova &Lepper, 1996; Borko & Putnam, 1998; Ferry & Ross-Gordon, 1998). This evidence is fully explored through a systemic case study of three individuals.

Rationale for a Mixed Methods Case Study

Mixed methods research seeks to combine quantitative and qualitative methods to be both confirmatory and exploratory in its methodology. The epistemology of mixed methods research emerged from dialectical pragmatism. The mixed methods researcher combines statistical trends with stories and personal experiences of the people involved (Johnson & Onwuegbuzie, 2004; Collins, Onwuegbuzie, & Jiao, 2007). The ontological basis of the mixed methods paradigm is pluralism. Researchers arrive at truth via an appreciation of the objective, subjective, and intersubjective realities of their topics. The interrelations between the topics and the people lead to true understanding (Tashakkori & Teddlie, 1998). The axiological assumptions of mixed methods research are in the combined need to confirm and explore the values of people through a fusion of qualitative statistics and quantitative relativism. Methodologically the mixed methods research paradigm occurs through the careful triangulation of the qualitative and quantitative methodologies (Olsen, 2004). Greene (2006) notes four domains: (a) philosophical assumptions and stances, (b) inquiry logics, (c) guidelines for practice, and (d) sociopolitical commitments which must be addressed prior to a study's inception. Once addressed a procedural design must be established. Creswell notes 3 primary procedural designs: convergent, explanatory sequential, and the exploratory sequential (2015). One of the difficulties facing mixed methods researchers is in “multiple validities legitimation” (Johnson, Onwuegbuzie, & Turner, p.128, 2007). According Johnson et. al., 2007, researchers should attempt the difficult task of designing and conducting studies that are based on consideration of the types of validity presented in the qualitative research literature, the quantitative research literature, and the mixed methods research literature.

The ICT course’s professional development relied heavily upon the teacher learning the material as a student first. The training model allowed for empirical data to be gathered from the teacher during their training and throughout the following school year. The ICT servers recorded all the work done by the teachers, their students, and any graded feedback/ reflections that the teacher shared with their students. By conducting qualitative interviews with the teachers, I was able to capture their personal thoughts and experiences as they encountered novel content, pedagogical practices, and through merged their practices with students’ efforts via the lens of contextualization. Before starting this project, it became evident that an explanatory case study would prove most useful.

Yin (2018) notes that an explanatory case study is most useful when 1) the primary research questions focus on the “how” and “why”, 2) the events being studied are not well controlled by the researcher, and 3) the focus of the phenomenon is contemporary or novel. The training for ICT is less than five years old and the number of trained teachers in ICT still numbers less than fifty. Within the limited number of trained teachers only a few have demonstrated a “novice level” of proficiency (Alegre, 2019). The case study approach was selected to grant deeper insight into the actions and practices of three teachers. The case study approach also provides important insights into the teachers’ thought processes as they reflect on student interactions (Bassey, 1999).

CHAPTER 3
METHODOLOGY

This chapter begins by providing clarity on the rationale for utilizing an embedded multiple-case study design with three case units for my methodology. The case study used mixed-method data collection. This is followed by an explanation of my research design, including a description and rationale for the participants/locations selected. The three primary research questions, the propositions, and the theoretical perspectives that guided this case study are then expanded upon. This methodology also details the data collection strategies and analyses that were employed.

Research Design

The project emerged from my work with the STEM Pathway's project in its early stages of 2017. While serving as the project's evaluator I uncovered that there were varying degrees of success in the participant's ability to teach and to demonstrate deeper understandings of the ICT curriculum in the summer sessions. To my peaked interest the teachers all appeared to show gains in these areas once they were actually teaching the content to their students. The first step in this study's design was in developing the contextualization theory of change. The theory of study, contextualization, is framed on the idea that the interaction of the teacher with the students, the process of conjecture and refutation in student interactions, and the open-ended nature of the student task promoted a novel type of professional development and growth for the teachers.

Contextualization of curriculum has been recognized as a meaningful tool to aiding novice students learn how to code (Apiola, Tedre, & Oroma, 2011). One primary tool for capturing these teachers' experiences would be to plan and execute interviews. These were a tool to gather feedback on the teachers' experiences because as Dewey noted in 1938, "every experience is a moving force. Its value can be judged only on the ground of what it moves toward and into"(p.38). Traditionally contextualization has been studied in education from the context of new language acquisition because the inclusion of culture, cultural traditions, and experiences aid students in learning and understanding situational context (Hassan, 2014). This sociological lens became a model for understanding the internalization of the teacher's understanding of ICT's content occurs with their students. It is important to note that I am not approaching ICT or programming as a linguistical language, but a phenomenon that is multifaceted and therefore requiring a new model to understand it. The model construction and refinement occurred through the close examination of the thematically coded participant responses and a reexamination of the contextualization theory's application to the empirical coursework data represented. Because contextualization is a specific process situated within experience, it can also be seen as leaving a cognitive residue, detectable as manifestations of individual or group outcomes responding to the inputs of the learning and recall experiences. Causal chains and sub-models were examined for each teacher and validated when more than three similar occurrences were noted between individuals. The difficulty of this method lay in identifying rival explanations and vetting each. The model is limited by the number of respondents. It is strengthened by the homogeneity of the participant teachers' novice status and the academic/ socioeconomic status of the students they teach. Careful attention was paid to intervening variables and notations were made when unique scenarios, such as the role of school based administrative policies on the teacher's performance.

The ICT course writers created a mixed-method research design, for their grant study, with an appropriate collection protocol to capture teacher and student interactions and inputs. Each summer the ICT teachers must complete several common assignments and assessments before they teach the course, in the following fall. The teachers each take a pre/post attitude survey on math and computing use. The teachers also take a content exam. During the course of the six-week training the teachers are interviewed with a set protocol at the start, mid, and completion of the training. Throughout the school year the teachers meet monthly to discuss issues that they have with teaching the ICT class, sharing student work, provide lesson feedback, and to review up-coming lessons. Each of these Saturday sessions was attended by me and scripting was taken. Each of the teachers was observed teaching a lesson in their own classrooms during the academic year. To coordinate the teacher's data with their students the teachers gave the pre/post attitude survey on math and computing use and the content exam. Data Analysis will begin by first examining each case individually for constructs, themes, and discernable patterns. A cross case analysis will then occur to see what is or is not concurrent. The findings will be employed to modify the contextualization theory for teacher training and utilized to make future recommendations to the program.

Participants and Research Site Descriptors

The three teachers selected had some common features that made them ideal for this study. All three individuals were novices with no background in coding, none had taught a computer science course before, all were certified to teach in a core academic discipline, all were teaching their school's first computer science course, and all had attended 95% of the required trainings. The three selected teachers each demonstrated statistically significant gains in content knowledge by the conclusion of their training. The three teachers' students also demonstrated high content gains by the conclusion of the ICT course in both years one and two.

The three case study teachers are from three unique school districts. Each school is described briefly, and a pseudonym has been assigned to it. Site A is a rural public school with grades 4-12. It has an open enrollment and is a majority African American school. Site A became a STEM magnet school in 2015. Students who attend must maintain a 2.75 GPA, a clean behavior record, and a preset level on their state test scores. The ICT course is the first computer science class the school has ever offered. The school enrolls 300 students in 9-12. Through a classification that is new to the state the school is classified as a program and not a separate school. The result of this classification is that all student test data is accounted for with the districts two lower preforming high schools. Techer A was a certified elementary- middle school mathematics teacher who had just moved to the area from another state. Teacher A had previously taught for four years. Teacher A had only taught 6-8th grade prior to teaching ICT to high schoolers.

Site B is a high ranked public school in a rural district. The school is the only public high school in the district and has no entrance requirements. The school is attended by a majority of Caucasian students. The school has won many awards and offers many college and vocational certification programs. The school is a 9-12 school. The school has 622 students enrolled with 10% being classified as special education and 50% being classified as economically disadvantaged. Teacher B was entering the second year of teaching ROTC and a pre-law elective course. Teacher B was seeking certification in an alternative certification teacher program after a career of military service. Teacher B had recently completed an MBA program and was originally hired by his school to teach social studies electives. Teacher B was sent by the district to add an elective for the school's students.

Site C is touted by their district as being their "flagship" school. The school contains grades 8-12 and is classified as rural. The school has 785 students with 10% being in special education programs and 78% being classified as economically disadvantaged. The average ACT score is a 16.9. The school has an enrollment with 49% being African American/Black and 49% being Caucasian. Teacher C had been a Biology teacher for 8 years. Teacher C was also certified to teach art in grades K-12. Teacher C was sent by the district to help earn extra funding for the school.

Research Questions and Propositions

This study was conducted over 2 calendar years from June of 2017 until June of 2019. The study was a framed within multiple-case study design. I began by first establishing a theoretical framework from the existing literature which guided the collection of my data and its analysis: 1) Computational thinking is a methodology of problem solving that employs higher order thinking and is novel to most 9-12 teachers, 2) The professional development for ICT may provide the teacher with content knowledge and impact the teacher's desire to perform certain practices with their students, 3) The design elements and messages of the professional development can have a positive impact on teachers' practices, and 4) The actual performance of teaching ICT may be differently impacted by the contextualization of their interactions with students at their school sites. These propositional statements were the parameters utilized in the development of my three primary research questions:

1. How does the contextualization of teaching the content with students interplay with the teacher's own self- reflections from their experiences, as student learners?
2. Why do certain individual teachers with limited to no background in computer science demonstrate an evolution in the proficiency of implementing the Introduction to Computational Thinking Curriculum?
3. What impact do teachers participating in the ICT professional development perceive and gain in terms of content knowledge, pedagogical techniques, collegial networks, and attitudinal views towards STEM?

Data Collection Procedures

Data was gathered over a two-year period through a series of instruments designed by the ICT provider, work product artifacts, over 30 hours of qualitative interviews, 8 hours of classroom observations, summer training observations, and individual participant interviews in two phases. Data were gathered from 360 students and 3 teachers and was organized using a data base and a uniquely designed program for the ICT curriculum work product gathering. The ICT work product gathering server tracks user logins, holds submitted coding project work for each student/teacher, and the feedback shared by the teacher with the student. The project proceeded with two phases.

Phase One

This phase's data collection followed a cycle that began in the summer of 2017's professional development. The teachers were administered a pre/post-test on content designed by the curriculum writer, a pre/post Computer Attitudes Survey created and validated by Dorn and Tew (2015), a pre/post Attitudes Towards Mathematics Survey by Tapia (1996), a professional development survey that was administered biweekly, three focus group interviews were administered, and all teacher work products with coding were logged. The 2017 cohort was also open to observation each day. The entire summer was observed and scripted by me. The scripting employed analytic memoing (Miles, Huberman, & Sadaña, 2014). The summer professional development data was collected again in the summer of 2018 using this same formula except I was not able to script each day's lesson.

Phase Two

As the 2027 school year began the data collection was now centered on the teachers and their students. The students were administered a pre/post-test on content designed by the pathway's curriculum writer, a pre/post Computer Attitudes Survey created and validated by Dorn and Tew (2015), a pre/post Attitudes Towards Mathematics Survey by Tapia (1996), two focus group interviews were randomly conducted at 50% of the school sites in 2017, and all student work artifacts using code were logged. The same student procedures were followed for 2018. Phase two was designed to investigate and probe teacher responses from the summer trainings, observations, and interviews conducted during the research grant.

Phase two's teacher data was compiled from observations of the 3 participant teachers teaching two lessons, with a total of one observation each semester. The observational visits were recorded and held on random dates. The teachers were also observed and interviewed at monthly four-hour professional development sessions. The professional development sessions were utilized by the STEM Pathways team to retrain, gather feedback on the pilot implementation of the ICT course, trouble shoot issues that the teachers had, and to review grading procedures/gain insights on grading. The teachers were asked to maintain lesson reflection journals for what did/did not work in the execution of lessons. The materials and lessons that the teachers utilized to supplement lessons were also recorded by the pathways team. The same data collection procedures were also utilized in 2018.

Instruments

The students and teachers participating in this study interacted and were assessed with content through the LSU STEM Pathway's project-based curriculum: An Introduction to Computational Thinking (ICT). ICT is an open sourced web-based program that collects data on a server at LSU and logs all coding done by the users. They also took the Computer Attitudes Survey created and validated by Dorn and Tew (2015), an Attitudes Towards Mathematics Survey by Tapia (1996), and a course content specific multiple-choice exam created by LSU.

LSU's research team created a multiple-choice computing quiz over a two-year period with multiple field tests for validation involving high school aged students. This quiz was vetted with 120 ninth grade students. It is composed of twenty-four multiple choice questions and is unique to the coding language and program employed by our team. The quiz is a mix of content specific questions, designed to ascertain the students' understanding of the programing commands, and structure and application-based questions. The instrument includes questions in four areas: variables, expressions and functions (6 questions), CodeWorld specifics (7 questions), mathematical modeling (5 questions) and logic and programming (6 questions). A sample question set from this quiz is included in Appendix A. LSU's team is currently refining the development and establishing full validation for our quiz, which will be the focus of future research endeavors (Underwood, Alegre, & Moreno, 2018).

An LSU created professional development survey and monthly lesson reflection log were also collected by the STEM Pathway's instructors. During the two-year study twenty-four interviews were conducted with the teachers. Sixteen of these interviews were group interviews recorded and conducted by the LSU STEM Pathway's team. Eight interviews were recorded and conducted for clarification and exploration of topics germane to this study. There were two scheduled classroom observations made with each teacher using the Reformed Teaching Observation Protocol (RTOP) by Piburn and Sawada, 2000. RTOP was selected because it was criterion referenced, validated at all secondary levels of instruction, and its emphasis on teachers utilizing techniques that promote student engagement with higher order abstract conceptual thinking.

The interview protocol for the research grant consisted of a general summer intake group interview, a mid- summer training interview, and an individual summer training interview. The grant interviews are outlined in Appendix C. The interviews were conducted by me. The three teachers for the dissertation case study were individually interviewed twice more using the protocol in Appendix D. The interviews were all conducted and recorded in normal instructional settings. The interviews were transcribed and analyzed using software.

Data Analysis

The pre/post-test on content designed by the pathway's curriculum writer, the pre/post Computer Attitudes Survey created and validated by Dorn and Tew (2015), and the pre/post Attitudes Towards Mathematics Survey by Tapia (1996) were scored and analyzed using their respective instrumentation keys. The data from the pre/post content test of each teacher was compared to that of their students to examine correlations and quantitative transfer of ICT content knowledge. Correlations were also sought between the attitudinal survey data of the teachers and their students. Patterns and trends were noted when they became apparent.

The recorded focus groups and personal interviews were transcribed and analyzed using Nvivo and then causation coding to establish trends (Miles, Huberman, & Sadaña, 2014). The coding was used to establish patterns and a content-analytic summary table. The reflection journal entries were examined using this methodology. The qualitative data was triangulated to see areas of convergence and divergence amongst the teachers. The student interview data was next compared to the teacher data points closest to the lesson observed (i.e. student interviews on lesson 12 were compared to the data amiable for the teachers on or near lesson 12).

As I conducted the data analysis I relied upon Strauss and Corbin's constant comparative method (1998). This method involves systematically comparing new data with emerging themes and sub-groupings. Through this iterative process of interpreting data in which categories may emerge, alter, and be subsumed over time. Creswell and Creswell (2017) state that this practice has its foundation in grounded theory and describe it as:

> The researcher begins with open coding, coding the data for its major categories of information. From this coding axial coding emerges. These categories relate to and surround the core phenomenon in a visual model called the axial coding paradigm. The final step, then, is selective coding, in which the researcher takes the model and develops propositions that interrelate the categories in this model or assembles a story that describes the inter-relationships of the categories of this model (p.65).

It was through this process that the model in figure one emerged. In an initial effort to answer the study's research questions I looked for statements that either supported or refuted the four propositions I made. With the addition of newly coded interviews a refinement and modification of the coding was merited. In total I coded the eight teacher individual interviews, the three teachers' responses within the twenty group interviews, the written feedback shared in their reflections on the lessons, and the statements that they made during Saturday sessions. A thorough process of coding, examining the data for commonalities, searching for additional evidence by triangulating coded data with relevant empirical data, an examination of alternative propositions, and cross-checking emerging themes occurred as demonstrated in table two. The final ideas to emerge were utilized in the responses to my research questions and incorporated into the discussion of future implications.

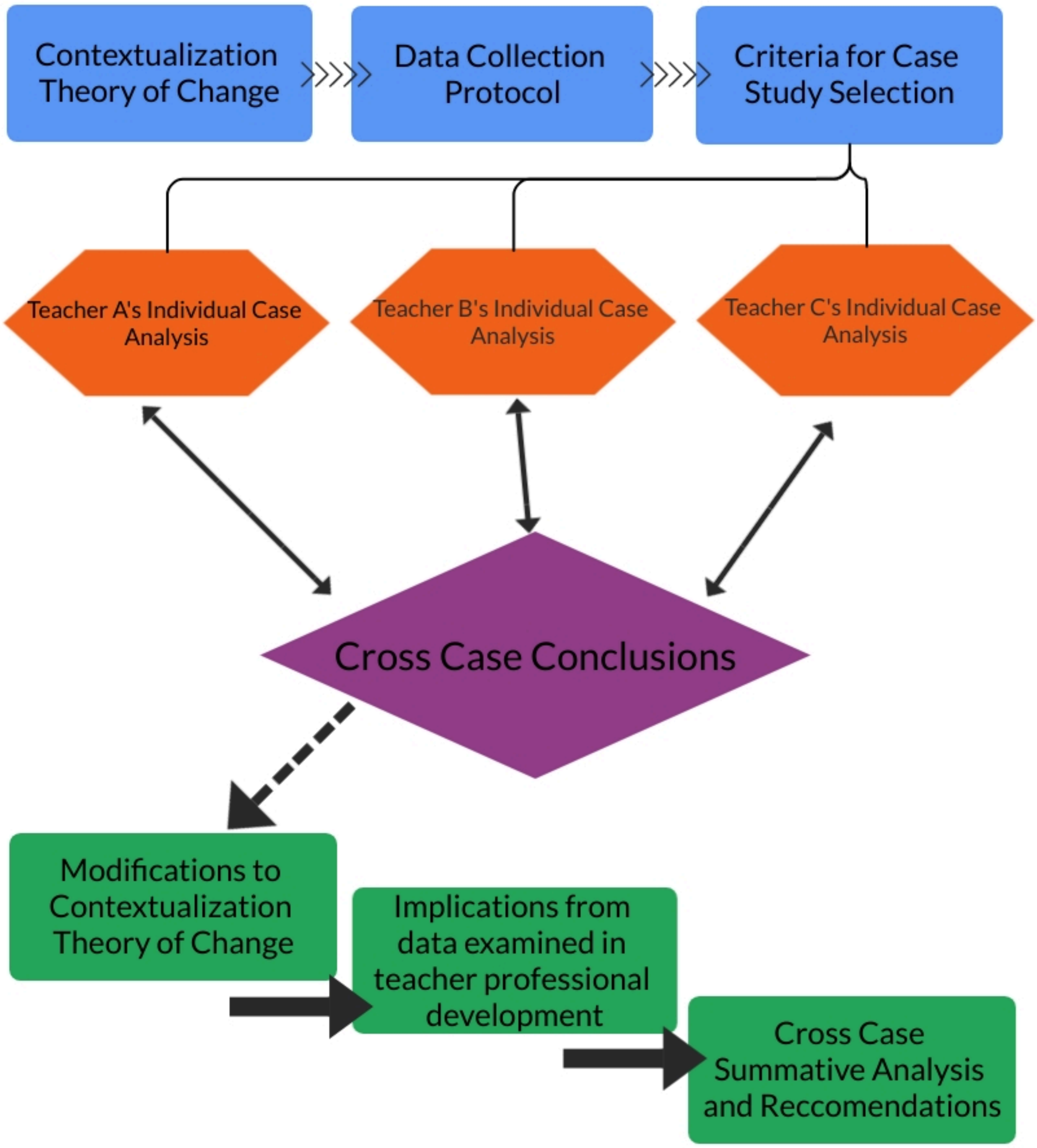

Figure 1. This is the initial axial coding paradigm model developed.

Table 2. Coding patterns that emerged as the interview data was analyzed.

Initial Code	Category	Research Question Addressed
• All were non-experienced in computer science/coding at the start of the study	Concerns from lack of personal experience/ knowledge	RQ 2 & RQ 3
• All expressed great reluctance to teach a course devoid of a textbook or hard copy resources		
• Each expressed initial discomfort in applying mathematics to problem solving		
• All made the statements initially questioning if a 9th grader could do ICT	Teacher perception of student knowledge	RQ1
• All demonstrated gains in content at the conclusion of their summer trainings	Teacher content and perceptual gains	RQ 2 & RQ 3
• All demonstrated positive attitudinal shifts at the conclusion of their summer trainings		
• By the second Saturday session of year one all three were engaging with sharing "best practices" with their peers and in suggesting "changes" to the curriculum of ICT	Impact of interaction with students and teaching ICT curriculum	RQ 1
• By the third month of teaching the ICT course all reported increases in self-confidence in teaching and higher levels teacher/student enjoyment during interviews		
• All three teachers maintained active attendance in year two trainings and demonstrated the same gains in student outcomes in ICT	Cohort and Peer Interaction Impact	RQ3

Table 2 (continued)

Initial Code	Category	Research Question Addressed
• By the end of the first year of teaching ICT all three teachers were advocating for more ICT sections and an expansion of computer science at their schools	Perceived value of ICT due to experience, data, and desire to learn more	RQ1, RQ2, &, RQ3
• All three teachers' students had significant statistical gains in content mastery, as supported by the quantitative data that the course curriculum tracked.		
• All three teachers returned to be trained in an additional computer science class		

CHAPTER 4
RESULTS

This chapter is designed to demonstrate how the quantative and qualitative data was connected. The findings relevant to each research question is presented. The data is utilized to also explain an apparent evolution of teacher competency and engagement that was common in all three cases. The chapter concludes with a review of some of the limitations of this study.

Engaging in Contextualization

By the conclusion of the six-week summer training session the three teachers all had top scores on the ICT content exam, self-reported high levels of confidence in being prepared to teach the class and were all focused on getting the school year started. The teachers had all participated in the role of students who each had to master the content, but they had yet to approach the ICT content from the professional role of the teacher. From the constructivist's view the context that would occur for the teacher role would be vastly different from that of a learner. The personal, cognitive content would be shaped by their interactions with their students (Cobb, 1986; Clark, 1998; Nilsson, 2007; Skott, 2009). At least three types of cognitive contexts may be fruitful to refer to when analyzing teachers' contextualizations (Halldén, 1999). First, there is the conceptual context denoting personal constructions of concepts embedded in a summer training. Second, there is the situational context, which refers to interpretations made in the interaction between the individual and their students, including interpretations of figurative material, possible actions, and directly observable sensations. The third is the cultural context, referring to constructions of discursive rules, conventions, and patterns of behavior that are exhibited with cohort peers and classroom teaching (Nilsson & Ryve, 2010).

The data gathered demonstrated that the teachers left the summer training possessing content knowledge, a physical curriculum to teach, and pedagogical techniques yet they were not truly prepared to apply it to teaching the ICT class. The teachers needed a context of student interaction to frame their new knowledge within. The characteristics of the students' cognitive abilities, intrinsic motivation, learning styles, and ability to process the content would factor greatly in how the individual teachers succeeded. Teachers were not fully prepared to deal with all of the possible student misconceptions and therefore needed to use self-reflection, peer collaborations, or instructor interactions to offer viable alternative explanations to those provided in their training. The observational data and interviews also supported the fact that a teacher with the limited content training, who utilized the pedagogical training could succeed. The teachers did not have to be "experts" provided they supplied the appropriate questions and investigations to scaffold student independent explorations (Appleton, 1995). One area of contextualization that is unique to the teaching of a computer science course arises from the teachers need to assess and evaluate online resources and technical materials. As students learn to code and explore the web the teachers reported they often were required to do research of their own to assure that quality resources were being located by the students. The three teachers reported that they felt like co-learners with their students due to this phenomenon. The contextual role of a teacher was altered for the teacher as they had to accept new techniques and exhibit flexibility in grading student solutions. The rigidity of one correct answer, one way of solving a problem, and one source of information were not the normal for teachers in ICT.

Evolution of Teacher Proficiency

During the qualitative coding process the provisional coding methodology approach was taken with each teacher to investigate the second proposed research question. In order to explore common factors that would yield greater specificity memos were employed (Gordon-Finlayson, 2010; Yazen, 2015; Yin, 2017). The memos were groupable into a pattern that was apprehension of the novelty, transitional growth with the content, and reinforced confidence from student interactions.

The apprehension to novelty was very evident in the remarks that the teachers made after only the first week of training. The three teachers each agreed with their cohort peers that the material "looked too difficult for a 9th grader". In the initial group interview Teacher A expressed fear of the computer usage itself. When following up with Teacher A they freely admitted that they were "not used to using the computer besides Microsoft applications and Googling stuff." In the initial group interview Teacher B stated that they were a parent of a child entering 9th grade and stated sarcastically "it will be a fun experiment to make her do this". The teacher cohort all were perplexed and frustrated that the content was all virtual. Teacher C was reluctant to "not have worksheets or a textbook". The three teachers continued to demonstrate apprehension throughout the summer training despite being three of the teachers with higher percentages of completed work.

One area that the three teachers each commented upon during their training was an uncertainty in the ICT course's professional development. The novelty of a learner centered approach to content exploration was readily accepted by Teachers B and C. They both made similar comments that they could see value in "students struggling a bit with the content." Teacher A was not comfortable with asking direct questions and not being provided with an immediate response. Teacher A commented "The instructor says "I don't know" a lot. Is he supposed to say this? I mean I know he is modeling teaching practices, but I just can't see myself saying this to students." The pedagogical techniques introduced were a topic that the cohort all accepted, but continually voiced reservations about. An example of this phenomenon was when an interviewer asked if the cohort was opposed to group work no one responded affirmatively.

Yet later in the individual interviews several private contradictory concerns emerged. Teacher C noted that "telling students to pair code, work on code at home, and collaborate sounds great but I know they are going to cheat. <sighs> I am seeing some parent conferences and some serious issues with grading [in the future]." Teacher B was "pretty sure that the groups will have to be monitored and I think that it will be tough." The pedagogical concept of group work appeared to not trouble the teachers as much as the idea of how the new ICT course would look with the technique.

As the summer training progressed the three selected teacher each began to express less stress over the novelty of the ICT curriculum. The tone of the cohort group interviews became filled with less negative comments as a whole. The progression of the content and its mastery tended to dominate more of the teacher's thoughts. Teachers B and C articulated a sense of ownership for the curriculum. In the scripting of the summer training these two individuals began to shift their questions from general topical questions to things like "I am trying to visualize this in my school…", "I just want to make sure that I am ready to share this…", "I like the way this ties in math…, "I can't wait to show this to Mr.X he's going to love its connections to Physics…", and "I know that I am going to wow my kids…". Teacher A demonstrated less confidence than their peers, but it is notable that this was Teacher A's first few months in a new state, anticipating an unknown new school/student group, and preparation to teach 9th grade. In individual interviews it was clear that Teacher A had many issues that were causing stress and self-doubt in their abilities. At the conclusion of the six-week summer training the three teachers all scored well on their content exams, as discussed later in this analysis, and self-reported on the exit surveys a feeling of confidence in teaching ICT. For the purposes of the proposed training model this was the first evidence of transitional personal growth by the teachers with the content.

Each teacher in LSU STEM Pathways' training program was required to attend a monthly Saturday session either in person or via Skype. These sessions provided the content trainers with an opportunity to interact, retrain, and address misconceptions for the teachers. As the project evaluator I was permitted to sit in these sessions and script the interactions. The teachers were also asked to maintain lesson reflections on the successes, errors, suggestions, and personal questions they had for each lesson. The written reflection activity was not always completed by all of the teachers, consequently some of the reflection data was gathered orally at these Saturday sessions.

In the transitional personal growth stage the data demonstrated some common themes. The first noticeable theme was the continuation of ownership practices by the teachers. In their 2001 work Kirk and MacDonald contend that the greater the "voice" a teacher has in speaking on and about the curriculum the higher the rate of implementation. As the curriculum team worked with the teacher cohorts on the Saturday sessions the three teachers began to express more of their feedback and have discussions on the curriculum. The teachers' discussions were groupable into five categories: 1) pedagogy, 2) content explanation, 3) teaching practices, 4) difficulties specific to school sites, 5) new ideas or additions that were teacher generated. On the October Saturday session the first major moment of teacher leadership occurred when the content writer asked each teacher to share what they were doing, and a discussion began on geometry that was needed to help in making a lesson on quilt patterns. Teacher A commented that there was a need "to review basic formulas for circles, squares, etc. because my ninth graders are lost". While this idea was agreed upon Teacher B began to detail how they redirected students to earlier lesson design elements. Another cohort member asked A to demonstrate the practice. As teacher A took over the leader role the entire group followed and began to rely less on the instructor for guidance. This was the first of many occasions where the demonstration of ownership led to new content being generated. The body language and facial expressions of those present showed pleasure and joy as they added pieces to the "new lesson". The exploration of the ideas was now in the teacher's hands. In the following Saturdays the practice of the teacher's critiquing and adding material to the lessons became common place.

On an individual level the transitional personal growth was different for each of the three profiled subjects. Teacher B was the first to emerge as a leader. One contributing factor to this emergence was the teacher's past as a military officer and the fact that they were usually the first to complete a task (Jenne, 1997). Teacher B was also a parent of two and tended to take a more guiding role in the small group interactions and instructional setting. Teacher B was often looked to for leadership when the teacher cohort assembled. Teacher B was also the first to mention that "my kids lead me and often help me to see what is needed". B was often sharing stories of how the "kids I teach discover so many cool things" that he was making his own collection of their "short cuts and ideas". Teacher B was often the first teacher to contact the content writer with new information throughout the year.

Teacher C tended to be more reserved and direct in their comments. Teacher C was a parent of two and was less of a guide, but more of a cautious warning to the group. When working on cohort tasks C would often remind the others of the "rules" or "guidelines" when they strayed. Teacher C was more likely to come to the Saturday sessions with lesson reflections completed in advance. When the other teachers began to discuss the lesson C was always prepared to offer insights. Teacher C was the first to share the idea of student flex time. C had created an arrangement with their students so that once every two weeks they had. An independent workday where they could listen to music, spread out into various locations in the room, bring a snack, work with peer review groups, and/or watch sports on a PC as they worked. Teacher C's personal growth was also demonstrated as they admitted frequently "I learned this from one of my students' code…."

Teacher A had the slowest personal growth phase of the three. Teacher A had many novel changes in their personal and professional life to adjust to. Teacher A expressed a frustration that "I just don't seem to be keeping up. I know I can do this, and it is not hard….I just need time." As the semester progressed A was also hindered by a school administrator who wanted the students to "always have fun" and "make good grades". The ICT course was a challenge for some of Teacher A's students which led to homework. Teacher A had to call upon the curriculum team for support twice in their first semester due to pressure from the administrator. Teacher A worked virtually with the content writer and their cohort to address these issues. The compromise that was reached for Teacher A and their administrator was a slower progression through the curriculum. It is important to note that the students in Teacher A's classes were not expressing displeasure and had a reasonable grade distribution. Teacher A and their administrator agreed there were no parent complaints, it was only the administrator's perspective that was a factor. Teacher A's self-confidence received a boost when their students projects were shared at the third Saturday session. It was at this session that the teacher was able to see that their students were on par if not, in some cases, more complex in their work. It was at this session that they first began to actively trouble shoot another peer's problem. Teacher C shared in individual interviews that seeing their student's work being equal helped to "make me feel like I am doing this, I am ok, and I know what I'm doing is right." Teacher A's confidence was very connected to their participation in cohort collaborations.

The final phase of the proposed model of progression centers on the teachers having reinforcement of their confidence from their interactions with students. The most fascinating aspect of the teacher data came from their interactions with the students. As the school year unfolded the teachers were all tasked with the normal teacher duties of teaching, grading, and managing their classrooms. When initially interviewed all three of the teachers in this study approached these duties, in the context of ICT, with great anxiety. All three teachers had misgivings on not teaching with a lecture centered approach and having times where there would be multiple methodologies to solving problems. As the summer training finished attitudes had improved, yet it was clear they each had some private concerns. At the middle of the first semester individual check-in the three teachers' responses were completely reversed.

In the December interview each teacher shared success stories from their classrooms. When asked: What do you think has made teaching this class enjoyable and why they responded:

> Teacher A: You know I think it was the kids' reaction to this. I doubted they would like it as much as they did. They seemed to put such creative spins on things. I was always challenged to help them keep up with what they were wanting to do. The first time I had to really try to figure out what a student did {that was not on my answer guide} I was nervous, but then I was like wow, you really worked hard on this and you know what you are right! Even my weakest kids started to be inspired by the ideas that were shared as a class. I even got inspired by them {the kids} to make warm-ups that were on neat aspects of what some of them {the kids} were making.

> Teacher B: Well, I'd have to say my students' ideas. The work they create is so awesome. Like this one guy who started out with making Super Mario. It was a simple project but he just kept coding he added more things and eventually was asking me how to animate it. Now keep in mind this was like in October so I was like well (HaHa) let me call the course writer. I had to do the phone call thing a few times and then the writer sort of prompted me to explore what I knew. I found myself challenged by my kids' work and started asking them to show me things. It was weird. My class became a new sort of resource.

> Teacher C: For me it was probably having the freedom to see my students explore and create. I teach a state standardized test class, so it was nice to just work through the material and get to encourage them. I liked the fact that the

> material was setup (differentiated) so that my top students would be able to work ahead. I also found it great to see that my students could teach me new things. It was really fun to have the top students teach the class with the smart board new ideas. I think my class culture grew as even some of my lower students were able to share insights. I enjoyed letting them struggle as a team and only giving hints. I can't believe I was once skeptical about not knowing all the things to say or do for every situation.

While each of these responses focused on different examples it was clear that the teachers placed a high value on their interactions with the students. It was also thematically apparent that the project-based nature of the lessons had become a key aspect to the teaching of ICT. The teachers all expressed that the class became more enjoyable after having to help students solve open ended problems. The comments also suggested that the teachers were reflecting on their students' perceptions of the "teacher role". The "teacher role" was no longer the gate keeper of all knowledge, but rather the facilitator. The teachers each commented on the creativity that they saw in their students. As the teachers had more interactions, daily grading of coded work, they were also provided insight into the students' abilities beyond those of a traditional course. The teachers were experiencing a greater investment in the class. This investment is further supported by the teacher self-reflection logs that follows.

The self-reflection log was a virtual document that the teachers were requested to fill out after they had taught each lesson. A sample of the self-reflection document is in Appendix B. Only one of the three teachers, Teacher C, completed 90% of the reflection logs prior to the Saturday sessions. When group interviewed about this phenomenon the teacher cohort reported that they were often occupied with other teacher tasks and responsibilities. As a result of this the instructor choose to have teachers complete the reflections at the close of the Saturday sessions. The reflection feedback gained was often brief and tended to focus on the content more than the teacher's views of the pedagogical practices or student knowledge gained.

After reading through the three teachers' reflections a few recurring trends were noted. The teachers reported utilizing some form of group work for 30% of their reflections. When used the teachers all reported a positive view of how the lesson was received. The teachers all reported concerns on monitoring work equity in group sessions and the difficulty of students who copied their peers code. Recommendations were made by the teachers to add more professional development activities on this and ways to group students. When the scripted summer training was examined there was only two dedicated hours that could be designated group work/ peer project rubric instruction.

The second most noticeable trend was in the teachers' frequency to suggest changes to the curriculum. As the teachers worked their way through semester one very few changes were requested. Most of the first semester changes dealt with formatting, the addition of an example, or the identification of differentiated topics for students to explore versus required lesson topics. When the teachers reached the January lessons the feedback became more prescriptive and centered on content. The teachers' all expressed frustration over the increase in mathematical based lessons that were not as engaging as those in first semester. Teachers A and C both reported "math burn-out" and "math test prep anxiety" as factors in their students' completion of work and motivation. Teacher C recounted in an interview

> I remember one time in second semester I had a really good student come in, sit down, and sort of just stare at the computer. I asked her what was wrong, and she said "I just can't do more math. All we are doing is the same thing as my math [Algebra 1] class. I need a break miss." And you know I got that, so we sort of did a fun day. When I wrote my reflection I told the writer I'm not trying to be negative, but we have to ease up on the kids.

The teachers all commented on the need for scaffolding between the introduction of a concept and its practice. The lesson structure was in the words of Teacher B "missing the transition from the basic introduction of a topic to the included math and activity." The teachers also all expressed a desire to do animations. In the summer training animations were mentioned for the second semester but did not appear until near the semester's end. Teachers A and B both wanted more "fun, engaging, and video game-like" activities. Teachers A and C expressed concern that the dryness of the activities would lead to students not wanting to take a second course in the STEM Pathway.

When interviewed the content writer acknowledged that the second semester was an area of research-based uncertainty. The writer was unsure of where the ICT class would end due to testing, what level of mathematical ability the students could do by the year's end, and what skills the students would need for the second course in the STEM Pathway. The ICT curriculum was in its early stages of development and was still in a beta testing phase. The writer acknowledged that many of the frustrations the teacher voiced were to be expected due to the novelty of the ICT curriculum. The research into what was needed for students to complete the course was still occurring during the years of this research study (F. Alegre, personal communication, May 10 2019).

The self-reflections also told a story of erratic class schedules, access to laptops, and the reassignment of teacher duties for all three teachers. The ICT class is an elective 9-12 course. The principals of the Teachers A and C choose to remove them from their teaching duties to proctor state mandated testing for two weeks. During the testing weeks the teachers did not see their classes and their classes had no computer access. The state uses computers to test on and needed the computers. Teacher B had a computer lab and was displaced for two weeks. While Teacher B was not given a testing duty assignment he had not computers to teach with. The disruption of the teaching routine was noted by the teachers and was a factor that caused varying levels of reteaching to occur. All three teachers noted that an offline mechanism to teach ICT was needed for testing time. Each of the teachers reported that they felt the process of teaching slow for the final month. An example of this challenge came from Teacher

> At my school testing was sort of the end for my kids. They all acted like the year was done. I'm not from here and was surprised by this attitude shift. I mean they just stopped working. I asked my colleagues for what to do and they said "Let them [the kids] have fun!" I know we did not finish the curriculum, but I tried my best.

Addressing Variations in Teacher Proficiency

One major component of question three's response lies in the fact that there are often many personal issues that impact a teacher's life. For this particular study the teachers were all at different school districts, dealing with different administrative expectations, in different stages of their professional careers, and all were facing unique personal/home scenarios. Accepting the prior factors as prima facia factors it is clear that the common attributes of attending the same training, using the same curriculum, and teaching student populations that were similar in demographic and socio-economic status were commonalities. ICT was developed by its writers to teach novice instructors and students the fundamentals of coding. The curriculum is one that requires project-based teaching skills that were not familiar to the teachers at the start of their trainings. The data gathered demonstrated that the evolution of the teacher's proficiency was connected to four factors: 1) student interactions, 2) mathematical comfort/knowledge, 3) determination or persistence to succeed, and 4) self-confidence.

The teachers studied all had to actually teach the ICT curriculum to increase their proficiency in the four previously identified factors. The teachers all began the trainings with a pedagogical philosophical view aligned to quantative attainment of knowledge and prepared formulaic curriculum that required a mere presentation to students (Horn & Raymond, 2007). The teachers had to be trained and practice implementing experiential, project-based learning within a virtual space. The practices and structure of the classroom had to be adapted in new ways. The culture of the classroom space required the teachers to foster closer relationships with their students. These relationships could be strengthened, as demonstrated by these teachers, through feedback, group work, collaborative coding, accepting peer feedback, and by the teacher taking on a new role as a facilitator of knowledge. It is within these contextualized interactions that the three teachers studied began to demonstrate success on factors one and four. Unlike other courses that the teachers had taught they all reported that this class fostered a higher degree of student engagement.

The two individualistic factors that appear to have a great impact on the teachers' success were their personal mathematical comfort/knowledge and determination or persistence to succeed. The summer training data and teacher observations demonstrated the mathematical knowledge of the teachers coming into the training was a factor in their speed in grasping concepts. Teacher A's lack of high school math training was a source of anxiety and it persisted through the first year of their teaching. The math involved in ICT was restricted to Algebra 1 and Geometry, but for Teacher A it "was not hard so much as an area of uncertainty for me." The ICT course works heavily with linear equations and algorithms. After Teacher A received some additional tutoring they reported more confidence in their skills. Teacher A sought additional resources on their own without being prompted by the LSU instructors. All three of the studied teachers demonstrated a determination or persistence to succeed with teaching ICT. The three individuals used a combined grouping of 128 statements about this. They all were tracked during the summer training via logins to work on examples and class assignments for longer than their peers. The three teachers were also the most engaged of their cohort in virtual and in person conversations. The conversations that they had were mostly centered on issues, challenges, and difficulties with teaching the content. All three teachers requested feedback from the LSU

Pathway's evaluation team. Their request was unique because only five out of the sixteen teacher cohort did this.

The data gathered also supports a model that shows as each of the first three factors increased so too did the teacher's self-confidence. Lawrence has noted that teacher self-confidence is directly related to the teacher's ability to be flexible, personalize their teaching to the students, setting clear and attainable expectations, and productively managing stress (1999). The teachers studied all exhibited a reluctance to Lawrence's idea of flexibility in their initial interviews. There is not enough background data to comment on the teachers' prior experience with Lawrence's ideas of personalizing their teaching to the students, setting clear and attainable expectations, and productively managing stress however these were all evidenced in the study's data. An additional source of improved self-confidence can be seen in the teachers' mastery and application of the content with their students. (Swackhamer, Koellner, Basile, & Kimbrough, 2009; Appleton, 1995)

The observational data was next analyzed to identify the areas of strength and weakness for the individual teachers. The RTOP scoring mechanism assigns a teacher a score for twenty-five attributes on a scale of 0-4. The highest attainable score on the rubric is a 100. The rubric is broken into six distinct domains. The teachers' observational summary scores are displayed on table 4. According to Piburn and Sawada, 2000, the closer a teacher's score is to a 100 the greater the likelihood that they are employing student centered teaching, higher order thinking prompts, and the employment of what is now commonly referred to as 21st century teaching skills.

Table 4. Reformed Teaching Observation Protocol (RTOP) by Piburn and Sawada, 2000 teacher observation scores.

Teacher	Observation Score 1	Observation Score 2	Average of the 2 Scores
A	86	92	89
B	84	87	86
C	93	95	94

The three teachers all demonstrated exceptionally high scores that were very close to each other. An in-depth analysis of the teacher's strengths demonstrated that they all had a perfect score on both observations for 40% of the rubric. Table 5 demonstrates that the strengths were heavily clustered within the areas of the RTOP protocol that emphasized student teacher relationships, content knowledge (both procedural and proposition), and classroom culture. The structure of the ICT class lessons, and scripted summer teacher trainings coupled with the pedagogical techniques taught in the summer trainings offered support to why the RTOP domains were prevalent.

The ICT course framework is virtually hosted and is centered around programming skill development (LSU Pathways, 2020). The summer training model was based upon placing the teacher in the role of a student learner. During the summer training the instructor went to great lengths to emphasize both before and after each main lesson the objectives. The lessons are constructed in a tiered learning model. Each exercise includes foundational concepts that are linked to the next. The teachers were practicing of Dewey's learning through experience model (1938). The instructor modeled the practices of having the students work, explore, collaborate, and engage each other to build knowledge. During the summer training an emphasis was placed on the shift from "a teacher centered classroom to a learner centered classroom" (Alegre observation, June 4, 2018). The teachers were presented with guest speakers, model lessons, and examples of project-based lessons.

During the academic year all three of the teachers in this study followed the lesson delivery format that was similar to those scripted in their summer training. The teachers concluded each lesson with an exit exercise or question that was designed to assess their students' understanding on the topic. The teachers all self-reported using project-based learning strategies in their daily lessons. Validation for the teachers' reports was witnessed in the school site observations. One common technique that all three teachers employed was having students work in small groups to "debug" and proof-read their peer's code. The students were all observed to be interacting in respectful ways and in each of the three teachers' classrooms there were some sets of posted rules on group interactions posted. On each of the observational visits it was noted that only after the students had struggled a by with obtaining an answer or resolution to their problem would they contact the teacher. In teacher B and C's classroom the teacher never directly answered the student, but rather followed a Socratic pathway to help guide the student. In teacher A's classroom the students were allowed to "ask another group" before being Socraticly guided. One common technique that was modeled in the summer training employed the use of a projector or Smart Board to show student work and to gain peer critique. This practice was observed in each scholastic year observation. The 9^{th} grade students displayed no visible signs of shyness or reluctance to face their peers with problems. In each observed instance the students all worked on helping their comrade and comments were presented in a professional way. The ease of use coupled with the student behaviors suggest that this is indeed a common practice for learning. The culture of the classrooms I observed was strikingly similar despite being in different geographic and socioeconomic settings. Many research studies have demonstrated that through the establishment of a classroom culture of support learning may be facilitated with greater ease (Brown, 2003; Cavanagh & Waugh, 2004). Supovitz and Turner's 2000 study pinpoints that "the quantity of professional development in which teachers participate is strongly linked with both inquiry-based teaching practice and investigative classroom culture", p.976. ICT's six weeks of summer training and monthly Saturday sessions clearly are impacting the teachers' practices and the evolution of their classroom cultures.

Table 5. The categories from Reformed Teaching Observation Protocol (RTOP) by Piburn and Sawada, 2000. These were categories where the teachers scored a 4 on all observations.

Attribute of RTOP Protocol	Average Score
4) The lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	4.0
6) The lesson involved the fundamental concepts of the subject.	4.0
10) Connections with other content disciplines and/or real-world phenomena were explored and valued.	4.0
12) Students made predictions, estimations and/or hypotheses and devised a means for testing them.	4.0
16) Students were involved in the communication of their ideas to others using a variety of means and media.	4.0
19) Student questions and comments often determined the focus and direction of classroom discourse.	4.0
20) There was a climate of respect for what others had to say.	4.0
21) Active participation of students was encouraged and valued.	4.0
23) In general the teacher was patient with students.	4.0
24) The teacher acted as a resource person, working to support and enhance student investigations.	4.0
25) The metaphor "teacher as listener" was very characteristic of this classroom.	4.0

There were only three attributes that had an average score of less than a 3. Two of the three attributes were located within the content domain and were directly connected to the teacher's own personal understanding and comfort with the content. Attribute seven focused on a lesson that promoted strongly coherent conceptual understandings. The teachers observed often were working within the parameters of their scripted lesson plans and when deviations or unknown factors appeared the teachers would revert to the script. Attribute eight noted the teacher has a solid grasp of the subject matter content inherent to the lesson. Some examples of these deficiencies are noted below.

Example 1:

Student: Ok so is this supposed to be something we calculate or just guess at?

Teacher A: Well, let's look back at the example we did earlier….

Student: No I get that. I mean what about the exercise we did yesterday?

Teacher A: OK, don't worry about that now let's focus on today's example.

Example 2:

Teacher B: I'm going to just run you through this part by looking at my code. Don't worry if you don't understand this part. (Teacher proceeds to go through 3 example screens of code then scrolls back to the top). So we can all copy this part then you can work on the easier parts.

The third attribute with a deficient score, number eighteen, dealt with there being "a high proportion of student talk and a significant amount of it occurring between and amongst students". The probing of this in teacher interviews appears to have be attributable to the structure of the classroom design/management systems used and the school's administrative expectations of classroom teaching. When the teachers stated that the students had collaborative time they would converse, but if it was deemed work time the classroom was more independent work centered. Windschtil noted in 1999 that often students require training to function with peers who have different learning/thinking styles, are prone to distraction, have varying work ethics, and the basics of communication. Upon probing the efforts to build these classroom culture aspects all three teachers acknowledged that they had not considered using a norms of communication lesson. Teacher B noted in an interview "The kids are really just focused at first on just getting the work done. They don't really worry about their peers until I make them stop. I found that if I make them submit as a group early on they tend to improve.” Teachers A and C acknowledged that they were actively working to change this culture, but it was endemic to their schools as a whole and they had not made the progress they liked. The challenge of teaching in a constructivist class setting has also been something that can run afoul of the administration’s expectations of learning (Schofield, 1995). Teacher B related “At first my administration said I was not teaching. They thought that the kids were being too independent and just following the lessons online. I had to get them to visit four times before they recognized it was a “new way” for a “new subject”!”

ICT’s Impact on Teachers

The perceived impact on the teachers studied is approached with multiple tiers of data. The attitude surveys and interviews demonstrated that the teachers all saw great value in the practices of having their students engage with mathematics and applying it to real-world activities. The teachers’ feedback on the ICT curricula’s project-based learning approach reflected a clear recognition of the opportunities for students to engage with mathematics in applied settings. The teachers’ perceptions of the ICT course demonstrated an evolution of usefulness as they transitioned from novice users in training to practicing teachers. Pedagogically the RTOP observations demonstrated a strong shift into the teachers all embracing the 21^{st} century skills and pedagogical components associated with them. The three teachers all developed classroom cultures that were student centered and employed less lecture and more student guided exploration of the content.

The teachers’ reflection logs, Saturday sessions, interviews, and virtual communications show that they gained new content and pedagogical insights from interacting with their cohort members. The three teachers studied went on to mentor other teachers in future years and all became advocates for more computer science in their schools. All of the studied teachers demonstrated high gains in content knowledge via their post training exams, data gathered on content during the classroom observations, and commented interview remarks.

The ICT curriculum design exploits the parallelism between math and coding as much as possible. Students are encouraged to think mathematically while they look at code and perceive the code as an extension of the regular math they know. ICT's implementation utilizes a web-based educational programming environment called CodeWorld. This system makes it easy for students to transition between the code and the math concepts because both its syntax and semantics follow closely the syntax and semantics of the corresponding mathematical concepts. This systemic feature helped us spend very little time actually teaching the programming language itself, so that we could focus on applications from the beginning. Despite having very few syntactic features, Haskell, the language used by CodeWorld, is a very high-level language that has more of a pseudo-code feel than actual code (Underwood et al., 2018).

The Computer Attitudes Survey by Dorn and Tew (2015), the Attitudes Towards Mathematics Survey by Tapia (1996), and the course content specific multiple-choice exam created by LSU were each analyzed via their respective keys. The analysis of the findings is represented in tables 6,7, 8, and Figure 1. The Computer Attitudes Survey demonstrated a positive gain of 50% in teachers B and C. It is not surprising that both of these teachers expressed a great deal of comfort in using computers and with the course format throughout the two-year study process. Both teachers B and C were also returning to school sites where they had been teaching for over two years. Both teachers B and C self-reported having no fears that their students could "do this work". Teacher A demonstrated a drop in her favorable attitude as the summer training concluded. During the individual interview Teacher A conveyed a sense of trepidation at the more difficult mathematics involved within the last unit. Teacher A had only an elementary math background and was personally concerned that the students at the school site might not be ready for the addition of computer science to math. Teacher A was aware of the school's low performance scores in math and had yet to teach or meet the students. In the personal and group interviews that would follow the summer training the teacher's perceived anxiety did decrease and the teacher self-reported not being sure why "I had been so worried".

Table 6. Data from three distinct testing points during the summer training institute for the three teachers using the Computer Attitudes Survey by Dorn and Tew (2015).

Teacher	Pre	Mid	Post	Positive Gain
A	80%	92%	86%	30%
B	80%	84%	90%	50%
C	84%	92%	92%	50%
Cohort Average	73%	88%	90%	17%

The Attitudes Towards Mathematics Survey results showed a great deal of variance between the three teachers. The attitude survey has its questions divided into four factors: self-confidence using math, the personal value one sees in math, the enjoyment one gets from doing or using math, and the motivation one feels to solve or do math. The teachers' data was analyzed in total and for the factors. Teacher C was the only teacher to demonstrate a positive overall gain in their views towards math. Teacher C's responses indicated that they were at ease using math and placed personal value on it. Teacher C's background within teaching the natural sciences and art may have contributed to this view. In personal interviews Teacher C articulated that often "I feel like I need to bring math into my classes. My students are often weak, and it just seems natural that I teach it." Teacher C also submitted three lesson reflections that proposed the inclusion of a simpler mathematical explanation for the topics covered in ICT lessons.

Teacher A’s data was reflexive of the previously expressed concerns in the Computer Science Survey. Teacher A’s math attitude survey data showed that while motivation to do math and the recognized value of math were important to them, the teacher still had issues with self-confidence and math enjoyment. The structure of the ICT’s curriculum employees basic Algebra 1 and requires the user to apply functions to solve problems. The work that Teacher A submitted to the ICT servers demonstrated that the time to complete the assignments in unit 3-5 was lengthier. Teacher A communicated frequently in the scripted class sessions that the work was “not hard, but it makes me think.” Teacher A communicated in three separate interviews that the struggles they were having were due to “just not seeing the math connections, until the instructor shows me.” Teacher A acknowledge during an interview that they had not taught any math above that of grade 8 before. Teacher B’s slight attitudinal shift was not as clearly identifiable in interviews. Teacher B had a strong background in business with an MBA. The teacher never expressed frustration with the math in ICT and self-reported that they enjoyed the challenges it presented. One area that may have been a source for the decrease in Teacher B’s motivation/enjoyment can be witnessed in the problem-solving approach that they initially used. Teacher B’s early coding exercises demonstrate a brute force approach. The brute force style does not include any shortcuts to improve performance, but instead relies on sheer computing power or trying all possibilities until the solution to a problem is found (Paar & Pelzl, 2009). Teacher B did evolve their coding approach as their knowledge grew, but at the start of the course training they acknowledged “spending 4-6 hours trying to make things work.” The simplification of exercises and the use of algorithms took longer to become a norm for this teacher. It is conceivable that the brute force technique may be a factor in his reduced motivation/enjoyment of the mathematics.

Table 7. Data from pre/post testing points during the summer training institute for the three teachers using the Attitudes Towards Mathematics Survey by Tapia (1996).

Teacher	Pre	Post	Gain
A	71%	70%	-1%
B	97.5%	96%	-1.5%
C	93%	96%	+3%
Cohort Average	91%	89%	-2%

Table 8. Data from pre/post testing points during the summer training institute for the three teachers using the Attitudes Towards Mathematics Survey by Tapia (1996). This data is divided into the instruments prescribed four factors.

Teacher	Self-confidence	Value	Enjoyment	Motivation
A	68%	100%	78%	100%
B	100%	100%	94%	83%
C	97%	100%	100%	100%
Cohort Average	82%	87%	84%	85%

All three of the teachers in this study showed gains of 38-40%. To provide a comparison sample the teachers in this case study's data is presented in figure 1 with those of their sixteen-teacher cohort. The computing knowledge test captured normalized gain growth in all of the participants with an overall average growth of 29%. This instrument was previously vetted with 120 nine-grade students in the spring of 2017. The nine-grade students were exposed to the same concepts and a similar curriculum to that of this study. Their gains were comparable to those of the teachers, albeit with lower absolute scores (Underwood et al., 2018). Fig. 2 demonstrates the growth of the teachers during the summer professional development. The initial average score was 51% and it increased to 80% at the end of the training. The smallest amount of individual gain was 22%. Fig. 3 displays the pre- and post-test results for the four categories included in the test: variables, expressions and functions, CodeWorld specifics, mathematical modeling, and logic and programming for all of the teachers in the training cohort. The data is presented for all members of the cohort because the three teachers in this case study all made high levels gains. The inclusion of the additional teachers makes for a more complete representation of the knowledge gain spread and reinforces why the three selected teachers are deemed high performers. All of the teachers gained knowledge in all four categories with their greatest area of gain being within CodeWorld specifics. The media post-test results were all above the 75% percent of correct answers. In examining the free response sections of the post professional development survey all of the teachers, in this case study, expressed their desire to teach more computer science courses. In their discussion of what that they learned about computer science they shared things like: “I have more knowledge about coding and HTML”, “I have gained knowledge on how to teach a computer science class”, and “I am learning something new in a field that I love. This will help me to teach new horizons to students”.

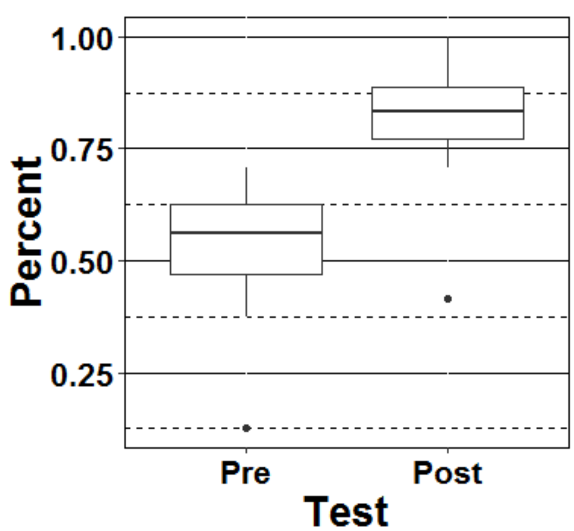

Figure 2. Boxplots comparing the results of the 24-question pre- and post-test on computing knowledge for the 16 teachers trained in the summer professional development. Boxes stretch from the 25th percentile to the 75th percentile of the distribution. Medians were 56% and 83% of correct answers for the pre- and post-test, respectively. The outlier corresponds to a teacher whose score increased from 3/24 to 10/24 correct answers and was not included in this study.

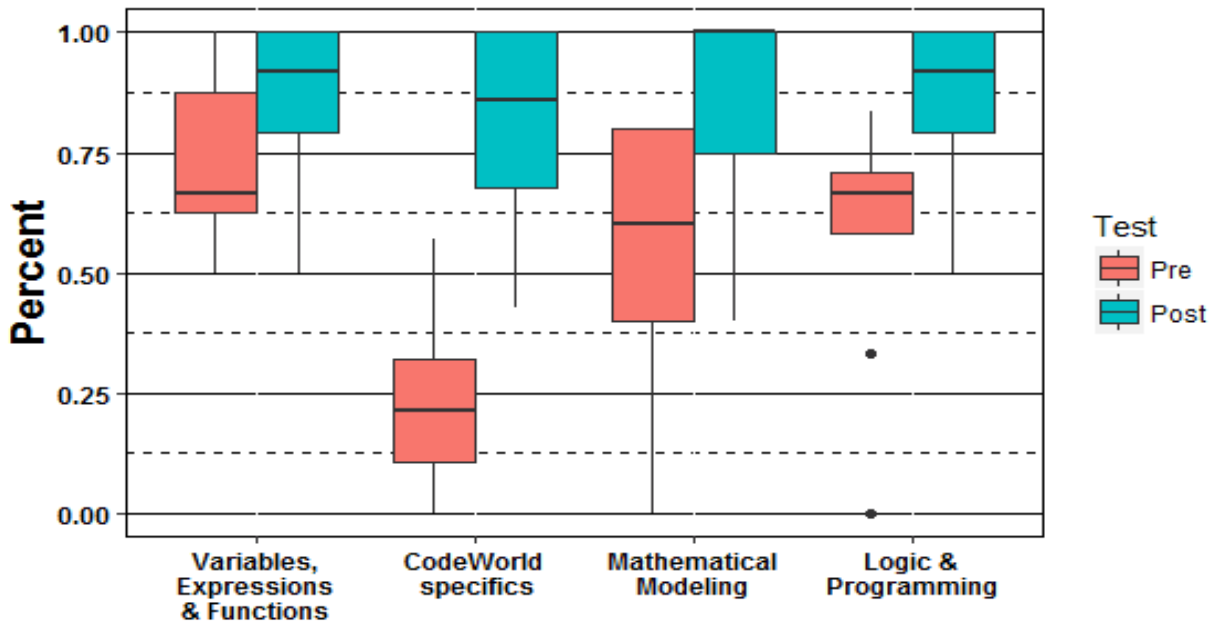

Figure 3. Boxplots comparing results of the computing knowledge test by categories for all 16 teachers in the training cohort: variables, expressions and functions, CodeWorld specifics, modeling, and logic and programming. Boxes stretch from the 25th percentile to the 75th percentile of the distribution.

As the first year of teaching drew to its close another interesting development would occur for all three teachers. Each of the teachers would agree to not only return to LSU's Summer Institute to take a course, but also to serve in a teaching/course developer role. The teachers had evolved from total novices to novice practitioners in a year long journey. Each teacher faced unique challenges; however each also had several common attributes of success. The teachers all adapted to use the project-based teaching model, formed classroom cultures that embraced the ICT curriculum, challenged themselves with the content's structure, interacted with their teacher cohort, and continued to explore professional development opportunities after their initial training. The teachers demonstrated an openness to the process of computational thinking and in their conversations, classroom observations, and teaching practices exhibited its impact on themselves.

Study Limitations

The major limitation of this study was in the ability to observe the teachers and students interacting without being a variable. I was limited in my ability to access each teacher and often would have to schedule my visits in advance. It is possible that my scheduled interviews may have led to some coaching about student behaviors during my visit or to the teacher preparing for the lesson presentation a bit more than normal. The interview process was an area of concern. Despite my reassurances and the structure of the pathway's program having group interviews it is plausible that some respondents tried to talk to their strengths or attempt to reply with a favorable response. Finally, I was limited in the analysis of the self-reflections by the teachers' willingness to complete them. The self-reflections often varied in length and may have occurred days after an actual lesson was taught.

Due to the fact that time was a factor I was forced to sacrifice breadth for depth. I used sampling criteria to focus on three teachers who demonstrated success and were making accomplishments in ICT with their students. This case study was confined to three teachers and was limited in the depth of interview exploration of data due to time constraints. The case study did focus on three of the more successful members of the training cohort in order to establish commonalities and attributes that led to this success. It should be noted that a converse study could have occurred on attributes of those less successful. A limitation that was unique to this area was in the degree of access that was sharable for student data. Due to the timing of this study it was not possible to gain access to the student data in detail.

CHAPTER 5
CONCLUSIONS

This chapter initially reviews a summation of the study's major findings. Next I have connected these findings to the broader theoretical frameworks mentioned in my literature review. I proceed to offer suggestions for the improvement of computing science education, developed within the broader context of current educational research. I conclude this chapter with some possibilities for continued exploration in the areas of CS teacher training and lesson development utilizing computational thinking.

Summation of Findings

The study's data demonstrates that the LSU STEM Pathway's six-week training model does promote an emergence of the teacher's confidence, ability to use project-based learning, and Computer Science content gains. The six-week training experience was strengthened by the cohort structure that allowed for the trainee teachers to have collegial contacts outside of the training and on the Saturday sessions. The data suggested that while the teachers left the summer training with a gain of knowledge and skills they did not demonstrate mastery until they applied this with students.

Through the contextualization of the interactions with students the teachers were challenged to explain and reevaluate their own understandings. As the teachers engaged in a form of computational thinking about their students' difficulties a variety of ownership and deeper curriculum engagement practices emerged. The teachers were encouraged by the content writer to add, edit, and generate new scaffolding lessons to enrich the curriculum. The teachers began to give more attention to their classroom culture and progress towards their roles as leaders/co-learners in their classes. Due to the professional flexibility these teachers exhibited they were some of the most successful members of their cohort. The three teachers studied all showed statistically significant gains in their use of the content and its pedagogical practices. The three teachers all returned to receive additional course trainings and participated in further LSU STEM Pathway courses.

Connections to Theories

My literature review demonstrated that the utilization of computational Thinking in the K-12 setting has many different possibilities for application (Tedre &Denning, 2016; Wing 2016; Voogt et al, 2015). The ICT curriculum's approach is unique in that it attempts to join the mental constructs of abstraction, problem decomposition, application, and synthesis to prompt the leaner to initiate Computational Thinking. The curriculum is specifically designed to maximize learner gains with scaffolded threshold concepts that encapsulate key challenging, significant skills. The learner, be they teacher or student, is guided through the exercises with mini assessments that require self-introspection of previous work (Demaree, 2006; Biggs et al., 2001). Through the instructor providing feedback misconceptions can be addressed.

The ICT professional development is well aligned to Darling-Hammond, Hyler, and Gardner's (2017) seven attributes of highly effective professional development. The training 1) remained centered on training the teachers to use and understand the content, 2) incorporated active learning utilizing adult learning theory to engage the teachers as learners, 3) prompted collaboration between teachers, 4) modeled effective teaching practice, 5) provided one-on-one coaching and expert support as needed, 6) offered opportunities for teachers to provide feedback and engage in self-refection, and 7) was sustained for the duration of one full academic year after the summer training session concluded. The six-week training session required the teachers to undertake active learning roles (Polly & Hannafin, 2011; Lieberman, 1995). The training sessions also focused heavily on John Dewey's (1938) concept of learning through meaningful experiences and problem/project-based learning (Woods & Morgan, 2009).

I think an unintended consequence of the formatting of the content and its professional development structure was the evolution of the contextualization component. Having just attained the knowledge and pedagogical skills the teachers set about the task of dissemination. ICT was not a scripted curriculum. In order for the teacher to become an effective instructor of new content in the classroom they needed persistence, an understanding of how to transfer the training into their classroom, and the ability to network with their cohort members/LSU instructors productively (Joyce and Showers, 2002). The data demonstrated that the experiences that the teachers had during their professional development were key to their construction of teaching and learning models. When the teachers were tasked with teaching ICT for the first time the successful application and usage of contextualization became essential.

This case study represents Giamellaro's (2017) four components. The teachers were tasked with relating the course learning outcomes to their students via a variety of techniques. The success of each technique varied by the classroom composition. As the concepts were tested the teachers had to rely not only on their training, but also the teacher's ability to adapt/reflect on what was presented. In a sense both the teachers and their students were applying constructivist learning. The teachers were tasked with making in-roads into what their students thought and how best to guide their students. The students were exploring the content and as the data demonstrated, finding solutions and problem-solving strategies that were novel. It was not surprising that constructivism emerged in the teaching process due to its aforementioned connections to the creation of programming languages (Barrows, 1996; Papert, 1971). The distinct spectrum of experiences offered by ICT's curriculum coupled with the opened ended nature of mental model construction led the case study teachers to innovations that were not taught to them. The continuity of experiences that the individual teachers perceived and reflected upon daily were situated within the context of the students' actions and accomplishments. The teachers in this case study were exemplars of the emerging processes needed to become novices in the principles and theories that entail Computational Thinking.

Improving CS Education

In the pre-service teaching programs, there are few universities that require a K-12 educator to work with coding, computing, or any trainings beyond the physical utilization of technology to teach (i.e. Google Classroom). The lack of dedicated study and grade level appropriate pedagogy is problematic. Teachers who are not properly trained cannot be expected to execute curriculum that requires content understanding. Computer science at the secondary level, as studied here, is a discipline that requires time and practice to master. A major difficulty with recruiting computer science majors to teach K-12 is the limited salary and prestige that come with the position. At the undergraduate level a job in the discipline of programming is far more appealing.

There is a need to set an attainable mechanism for teachers who are in the classroom to alternatively certify and be trained in computer science. Many states have no certification process in place without having the teacher return to a university and take the equivalent of a minor in computer science. In states that have a more defined process the guidelines are either 1) mandated by a score on the ETS corporation's Praxis Computer Science Exam, 2) a state regulated micro-credentialing program, and/or 3) a one-week training by the College Board in Advanced Placement course work. All of the aforementioned programs vary in what they emphasize as demonstrated by Appendices A-C. The need for a testable accountability and compliance with standards has thus far been limited to the courses defined by the Advanced Placement Program/ College Board.

With computing science crossing into all the natural sciences, mathematics, business, and education it would appear evident that now is the time for scholarly collaboration. It would behoove academia to look at mechanisms to introduce introductory computing into many major's required courses. Historically the academy has upheld the requirements of the humanities for all learners. Colleges typically require literature, art/music appreciation, a natural science, and a foreign language for most graduates. In our modern society, where everyone interacts with technology daily, why are we not exposing our minds to understanding computing? Socially, economically, and educationally it would be a prudent move.

With an increased exposure to the problem-solving approaches used in computational thinking our society's collective pool of understanding would evolve. The idea of computer science as an isolated profession is slowly dissipating. With computer programming becoming integral to careers a move towards teaching its precepts to college students would start the process of preparing citizens to better disseminate knowledge to others. The statistics on females and minorities who understanding computing would also increase. From an educational employment standpoint it would elevate the common pool of knowledge that employers could pull from and therefore add to the pool of potential teachers for K-12.

Future Research and Concluding Remarks

How do we teach computing to in service teachers? How can we foster computational thinking in K-16 learners? What role should higher educational institutions and industry play in designing the undiscovered country that is modern computing education? Who determines the standards and designs the accountability mechanism for this discipline in the K-12 setting? These questions are highly debated in the current literature and by experts in many disciplines. Because computing is not confined to just one field each has its own views. No one is disputing the role computers play in our modern society, but everyone agrees that some formal training is needed for our learners. Currently there are many different curriculums being developed, employed, and researched. It is still very early in the history of CS education and it is difficult to parse out which model is becoming most used. I believe that research studies are merited into the value of the material learned and the skills acquired by the learner. The automation of processes by technology is increasing, but often the user's understanding of how/why these workings occurs is not. I feel strongly that a curriculum that lacks a development of problem-solving skills is lacking in utility. I endeavor to continue the study of viable mechanisms to build learning scaffolds to help all learners develop a deeper understanding of computing.

Currently I am working with a five-million-dollar grant to study the impact of ICT on math scores for students in Algebra 1. The grant is funded by the US DOE and NSF. The grant promotes equity, access, and a model for a computing pathway starting in grade 7 and going through grade 12. The program is partnered with four districts to help offer classes to both college bound and noncollege bound students. My research was not only key in helping attain these grants but was also utilized in redesigning the professional development for the program. The value of the data generated by this study has already been proven and I look forward to building future research to explore new bifurcations as they occur.

APPENDIX A.
ICT CONTENT EXAM SAMPLE QUESTIONS

Q22. Consider the following code:
boxes = 5
dollarsPerBox = 7
totalCost(number,price) = number * price

What would be the value of totalCost(boxes,dollarsPerBox)?

a) number * price
b) (boxes, dollarsPerBox)
c) 5 * 7
d) 5
e) 7 f) None of the above

Q23. In coding, a definition is:

a) A function with arguments
b) A command for the computer to do something
c) A line with an equal sign
d) An explanation of something
e) A code

Q24. Consider the following code:
bar(length) = solidRectangle(1,length)
star(piece) = piece & rotated(piece,45)
& rotated(piece,90) & rotated(piece,135)
small = 5
The value star(bar(small)) is the same as:

a) star
b) solidRectangle(small)
& rotated(solidRectangle(small),45)
& rotated(solidRectangle(small),90)
& rotated(solidRectangle(small),135)

c) bar(5)
& rotated(bar(5),45)
& rotated(bar(5),90)
& rotated(bar(5),135)

d) star(5)

e) bar(5)

APPENDIX B.
A SAMPLE TEACHER SELF-REFLECTION LOG

Self-Reflection

Date:	Teacher:
Lesson:	Number of days taught:

1. What was your pedagogical or teaching method for this lesson? How did it work?

2. If student pairs or groups were used, describe how:

3. What supplemental materials or topics did you use? Why?

4. Were there any student misconceptions you had to correct in this lesson? If so please describe them.

5. Do you have suggestions on ways to improve this lesson? Please describe/explain.

6. How do you feel about the student's knowledge gain for this lesson? Why?

APPENDIX C.
LSU PATHWAY'S RESEARCH GRANT INTERVIEW PROTOCOL

All interviews started with:

Good morning/ afternoon). My name is John Underwood. Thank you for coming today. The purpose of today's interview is to get your perceptions of your experiences with the ICT training and its staff so far. There are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel. Your responses will be anonymously shared with our staff, but I will be the only one to know who actually said what.

If it is okay with you, I will be tape-recording our conversation. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a report which will contain all students' comments without any reference to individuals. Is this ok?

If you do not want to answer a question or would like to stop participating in the interview please know that this is ok.

A. Initial Intake Interview Questions:

1. How was the training you are about to take described to you?

2. Are their any topics you are excited to explore? Why?

3. Are there any topics that you are concerned about? Why?

4. What do you want to gain from this training? Why?

5. What do you think might be some obstacles in teaching ICT? Why?

6. Any questions for me? Any issues or concerns?

B. Mid-Summer Questions:

1. How do you think the training is going so far? Why do you think that?

2. How would you describe the amount of effort needed to do: (additional probes may be used depending on responses)

   a) the classwork
   b) the homework
   c) the group work
   d) the lesson reflections

3. What have you liked most about the training? Why?

4. What have you liked least about the training? Why?

5. How has (staff member) been as an instructor? Why?

6. Any questions for me? Any issues or concerns?

C. Individual Exit Interview Questions:

**For the exit interviews I was joined by a staff member who had not taught the teachers but was an expert in computer science. They added probes into the technical aspects of lessons and supplemented prompts as we discussed a selected piece of work the teacher had completed over the summer. The project was the same for all teachers.

1. Thinking back on the six weeks what do you think is your greatest accomplishment and why?

2. Looking ahead to the coming school year, what concerns do you have about teaching ICT and why?

3. How has this training impacted or not impacted the way you will teach? Why?

4. Describe one resource you gained from this training and what makes it so useful to you?

   This portion is unique to each teacher. The researchers would look at the vocabulary each respondent choose in their assignment and probe any unfamiliar words for clarity.

5. How did you define Independent Variable?

6. Why did you use the word ________ in your definition?

7. Looking at question ____ you misidentified the degrees of freedom used. Given this new knowledge and being able to view your response what are your thought?

8. Why do you now think this?

9. Looking at your responses you identified the relationship between degrees of freedom and time as:_____________________________. Why did you think this?

10. Any questions for us? Any issues or concerns?

APPENDIX D.
DISSERTATION INTERVIEW PROTOCOL

Each of the individual interviews was targeted to the respondent's responses from prior contacts. I am including as a sample one of them.

All interviews started with:

Good morning/ afternoon). As you know, I'm John Underwood. Thank you for coming today and for helping me with my dissertation. The purpose of today's interview is to get your perceptions of your experiences with the ICT training, the course materials, your experiences teaching the class, and to follow up on some of the ideas you have previously shared. There are no right or wrong or desirable or undesirable answers. I would like you to feel comfortable with saying what you really think and how you really feel. Your responses will be anonymously shared in my dissertation, but I will be the only one to know who actually said what.

If it is okay with you, I will be tape-recording our conversation. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a report which will contain all comments without any reference to individuals to share with my advisors as I work on my dissertation. Is this ok?

If you do not want to answer a question or would like to stop participating in the interview please know that this is ok.

1. If I were to walk into your classroom during an ICT lesson what do you think I would notice about how you teach it compared to another class you have?

- Probes will be used to gain specifics on student teacher interactions, think pair share, problem-based design of lesson

2. A few of the teachers trained felt that there was a great deal of mathematics involved with ICT. What has been your experience with the math in ICT?

- Probes will be used to address teacher's perceptions of difficulty for self/students, to clarify any vague terms or feeling

3. Can you describe any lessons that you have made to supplement what is in the ICT curriculum?

4. What aspects of teaching ICT do you like the least? Why?

5. When I observed you teaching I noticed you were having the students explore the possible solutions that each group presented. Why did you do this?

- Probe to see what the teacher thinks about "only having 1 correct answer"

6. How often do you talk with other cohort members? ICT Staff? Online Resources?

- Probes will be used to address teacher's responses and to clarify any vague terms or feeling

7. Pretend I am a new teacher who is considering taking the summer training. I have no experience in coding, computer science, and I am certified in the same subject area that you are. What would you say to me? Please be frank and honest.

APPENDIX E.
IRB APPROVAL #E12115

ACTION ON EXEMPTION APPROVAL REQUEST

LSU

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu
lsu.edu/research

TO: Kim MacGregor
Education

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: February 24, 2020

RE: **IRB#** E12115

TITLE: Contexualization of Computational Thinking by Novice Teachers in the 9-12 Setting A Dose Study

New Protocol/Modification/Continuation: New Protocol

Review Date: 2/12/2020

Approved X **Disapproved** ______

Approval Date: 2/20/2020 **Approval Expiration Date:** 2/19/2023

Exemption Category/Paragraph: 1

Signed Consent Waived?: No

Re-review frequency: Three Years

LSU Proposal Number (if applicable):

By: Dennis Landin, Chairman _DLandin_

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation. The data from IRB# E10522 cannot be used until the modification for re-consenting is approved.**

* *All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

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VITA

John Arthur Underwood was born in Rome, Georgia. Starting at age 15 he worked as an Emergency Room Tech throughout high school and during his first two college breaks. In his undergraduate years he served as the program manager for the Boston University Community Service Center's First Year Student Outreach Program. John was a supervisor for a full time staff of 15 college students, 500 peer counselors, and 4,000 freshmen. John joined Teach For America after graduating and came to Louisiana. John has taught grades 8-12 for 16.5 years in public schools. He has served as a SACS CASI chairman, school accreditation team member, school improvement team member, student interventionist, guidance counselor, an administrative assistant principal of curriculum, and created an online high school credit recovery program. John has been active in education and plans to continue this work.