11-20-2018

Teaching the Common Core State Standards (CCSS) using interdisciplinary units: A qualitative case study of how secondary core curriculum teachers implement the CCSS using interdisciplinary units (IUS)

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TEACHING THE COMMON CORE STATE STANDARDS (CCSS) USING INTERDISCIPLINARY UNITS: A QUALITATIVE CASE STUDY OF HOW SECONDARY CORE CURRICULUM TEACHERS IMPLEMENT THE CCSS USING INTERDISCIPLINARY UNITS (IUS)

by

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A Dissertation

Submitted to the
Department of Educational Services and Leadership
College of Education
In partial fulfillment of the requirement
For the degree of
Doctor of Education
at
Rowan University
November 13, 2018

Dissertation Chair: Carol Thompson, Ph.D.

Dedications

I would like to dedicate my dissertation and the entirety of this process to my Lord Jesus Christ and to my family. I would not have been able to accomplish any of this without my faith, my family's faith, and my family's support. My late husband was able to be my personal cheerleader and my counselor, and he provided a good living while I worked on this dissertation. He is no longer with us here on earth, but he is with us in spirit. Our son, John Phillip, is patient, and he understood when I had to work and could not be with him. John Phillip, you have been the reason for my persistence to the end of this dissertation.

To my sister, Joan, and my brother-in-law, Carl, who would not let me give up, even in the darkest period of my life when my husband left this earth. John Phillip and I would not have our strong faith, our home, and our hope for our futures if it had not been for your love and encouragement. You both have been loving and strict when I needed it, and you have become my family set of cheerleaders. To my nieces, Melissa, Nichol, and Lisa, and their families: I thank you for understanding when John Phillip and I had to be home so I could work and when we did not send you enough thank you notes. I am eternally grateful for everything you, my family, have done for me and John Phillip.

Acknowledgements

I am grateful to the educators and classmates who helped me and supported me as I grew to become a professional educator. I want to recognize the Glassboro evening cohort for the three years we worked together with cooperation, collaboration, and interactions to complete our studies. The knowledge and experiences of our professors and the knowledge and experiences of the professional members of our cohort helped me to fulfill a lifelong dream of earning the title of doctor. I especially want to recognize Kimberly, Laurie, Liz, and Helen who were by my side when my husband passed away. You became a set of my cohort cheerleaders as I shared my progress toward fulfilling my dream.

I would especially like to thank my dissertation chair Dr. Carol Thompson. Without your guidance, patience, understanding, and support, I would not have been able to create my topic, perform my research, and write my dissertation. You were understanding and patient waiting for me and my son to grieve our loss and encouraging when I was ready to finish this dissertation. Your suggestions and modified timelines took a lot of the stress out of the experience. Your knowledge and experience with how students learn provided me the clarity and organization that I needed.

Finally, I would like to thank Father Tom, who knew I had this dream and simply said there may be a way. I would also like to thank the current principal and teachers of the school where I conducted this study, for their encouragement and always letting me know they were there to help. The teachers and students in this study were honest and maintained high expectations of themselves and each other.

Abstract

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2018-2019
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Doctor of Education

The purpose of this qualitative case study was to explore how teachers understood and practiced using IUs to teach the core disciplines of the CCSS. The strategy of inquiry was a single case study in an urban high school where teachers of English, science, social studies, and math courses discussed IUs, and some teachers were observed using IUs. Data from public documents, teacher and student participant interviews, teacher classroom observations, a teacher survey, and field notes were analyzed and produced themes around the implementation of IUs.

The findings of this study indicate that teachers perceive how to conceptualize an IU, and some demonstrated incremental adjustments in their instructional practice. Students preferred learning frameworks based upon cognitive apprenticeship dimensions, and most teachers did not use the dimensions. Most teacher participants perceive that time to teach the standards and objectives in their discipline will be diminished by incorporating other disciplines. The teachers' instructional strategies revealed incremental steps toward using students' prior experiences, knowledge, and skills and revealed an unanticipated approach using cognitive apprenticeship and Vygotskian constructivism (Colllins & Kapur, 2006).

Table of Contents

Table of Contents (Continued)

Table of Contents (Continued)

Table Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

List of Figures

List of Tables

Chapter 1

Introduction

How should secondary core curriculum teachers teach the Common Core Curriculum? A major goal of the Common Core State Standards (CCSS) is the use of interdisciplinary teaching practices to help high school students improve comprehension in each discipline (Songer & Kali, 2006). However, the CCSS are a result of the top-down decisions made by the federal and state governments (Bolman & Deal, 2008), and they were adopted by the Wonder City Public School District Board of Education (WCPSDBOE) without teacher input. Teachers had little input at the national level as well, though they are critical personnel implementing the CCSS, and they did not have input into the developmental process of the adopted curriculum (Association for Supervision and Curriculum Development [ASCD], 2012). The WCPSDBOE voted to adopt and implement the CCSS in 2010, and the board members did not include teachers' suggestions.

Furthermore, the Partnership for Assessment of Readiness for College and Careers (PARCC) assessments are required for graduation in 2019, and they reference interdisciplinary topics in the algebra I, geometry, and algebra II tests (Clark, 2015a, para. 2; New Jersey Department of Education [NJDOE], 2017). The PARCC results are part of a teacher's evaluation score (NJDOE, 2017), and teachers may encounter stress and teach to the test as a result. Additionally, the emphasis on testing may influence the kind of instruction teachers choose (Stotsky, 2016). This qualitative exploratory case study discovered how secondary teachers in math, science, English Language Arts (ELA), and social studies at one school teach the CCSS in their field using interdisciplinary units to prepare students for standardized math tests required for graduation.

The Problem

A chief issue for student progress in mathematics is retention of concepts over time (Kagan, 1992; Ogbu, 1992; Thomspon, 1984). This problem continues to occur despite the adoption of the CCSS, and it may negatively affect students because the PARCC assessments are required for graduation in 2019 (Goyl, 2009). A possible cause of this problem may be the lack of cross-curricular teaching practices. Beane (1995) explains teaching a separate-subject curriculum has taught us the purpose of education is to master a collection of facts, rules, and skills in a subject area, rather than understanding the purpose of education to be learning how those elements could be part of solving real problems. Teachers contribute to a separate-subject organization by identifying themselves as math, science, social studies, or English teachers (Beane, 1995, p. 619). Importantly, the study indicates that students' preferred learning structures and teachers' teaching structures were not compatible to each other. Students' preferred learning structures included components of cognitive apprenticeship dimensions and Vygotskian constructivism. The NCTM principles, teaching IUs, Vygotskian constructivism, and some components of cognitive apprenticeship were not included in some teachers' teaching structures.

Furthermore, parents and other adults are hesitant to accept curriculum changes that are different from what they experienced in school (Beane, 1995, p. 619). This is the same attitude some parents demonstrate to me, a secondary math teacher, more than two decades after Beane's (1995) observations. I continue teaching secondary math courses with over 25 years' experience, and I have discovered that some parents are not willing to accept major changes to math curriculum or teacher practices that differ from their experiences.

There is a lack of research regarding secondary teachers teaching the CCSS using interdisciplinary units. Obtaining the perceptions of secondary teachers and discovering how they use interdisciplinary units to implement the CCSS can provide valuable information for improving teaching models, evaluating programs, and developing interventions at Wonder High School (WHS) (Baxter & Jack, 2008). A qualitative case study that investigates teaching the CCSS using interdisciplinary units provided favorable conditions for practicing interdisciplinary units. Barriers to their use were also discovered in both teacher and student data. Additionally, the study may enhance positive parental involvement with teachers, students, and the community. Parents and community members may be positive resources for students and teachers in processing cross-curricular topics (Chevalier, 2012; Crowley, Pierroux, & Knutson, 2014). Furthermore, the CCSS refer to cross-curricular topics (Common Core State Standards Initiative [CCSSI], 2017).

The CCSS promote problem solving techniques both inside and outside of the classroom (CCSSI, 2018), and the standards in each core discipline are interconnected (Lee, Quinn, & Valdés, 2013). For example, history, science, and language arts are all incorporated in the Common Core State Standards in Mathematics (CCSSM) (CCSSI, 2017, 2018; Eilers & D'Amico, 2012). Students may make connections using prior knowledge, experiences, and personal interests, and this process may enhance their critical thinking skills and problem-solving techniques (Dewey, 1902). These skills may be demonstrated to a high degree throughout their high school experiences (Anyon, 1980; Hillman, 2014; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006). Moreover, the learning sciences is an interdisciplinary field that studies how best to promote learning across academics. Interdisciplinary concepts and the connections students make based upon prior experiences and knowledge are crucial elements in learning (Jacobs, 1989).

Teachers need increased professional development (PD) to learn how to teach the CCSS. The current lack of training has created a situation that negatively impacts student learning. Coordinated type of teaching, teachers collaborating on concepts from disciplines, was new to some core curriculum teachers at the secondary level and presented a challenge for them (Porter, Fusarelli, & Fusarelli, 2015). Teachers encountered problems while they simultaneously implemented the CCSS with their normal lessons because of a lack of motivation, difficulty researching and incorporating appropriate resources in new lesson plans, and the need to design specific preparations for the PARCC assessments.

Furthermore, classroom teachers are not the only educators with demanding responsibilities. Educators at the federal, state, and local levels confront considerable challenges in their efforts toward successful implementation of the CCSS. Odden (1991) stated that educators at all levels lack the competence and determination to implement newly created governmental programs. Because political pressures mandate quick results, there are no sufficient, successful, and continuous implementations of the CCSS at all educational levels (Fixsen, Naoom, Blase, Friedman, & Wallace, 2005). This is also a reason for unsuccessful implementation of the CCSS throughout all educational levels

(Porter et al., 2015). Teachers encounter a variety of challenges daily and teaching an adopted and written curriculum is one of them.

Research on students' math retention indicated that there are three issues that have together created or affected the problem of math retention for secondary students, and teachers must overcome them to teach the CCSS (ASCD, 2012). First, the political decision-making process used to implement the CCSS will not significantly affect student learning without teachers raising their expectations of themselves and their students (NJDOE, 2017; Bolman & Deal, 2008; Northouse, 2012). Classroom teachers are the most important group in implementing the CCSS (ASCD, 2012). Second, successful implementation depends upon the motivation of educators (NJDOE, 2017), but educators lack available, appropriate resources (ASCD, 2012). Third, the PARCC assessments require changes that affect students, teachers, and decisions made by districts as they implement the CCSS (Porter, McMaken, Hwang, & Yang, 2011). These three issues affected teachers because they are the educators who teach the curriculum. In addition, there is a concern among educators because part of their annual evaluation is based upon student test scores (NJDOE, 2017).

State Departments of Education adopt policies passed by the appropriate governmental bodies. The departments of education put the policies into code. This has the effect of law. The local school boards, district administrators, principals, and classroom teachers determine the degree of use, implementation, and incorporation of educational policies and any mandated state or federal requirements (Anderson, 2011; Fowler, 2013). The federal government attached funding to adopt the CCSS by awarding states that promised to adopt the standards by 2009 in their Race to the Top (RTTT) application (ASCD, 2012; White House, Office of the Press Secretary, 2009). Furthermore, the federal government increased its role in education by creating mandatory content in ELA and mathematics for students in kindergarten through twelfth grade (CCSSI, 2017; Fowler, 2013; White House, Office of the Press Secretary, 2009).

The second issue, which involves teachers' motivation and the availability of appropriate resources, is also impacted by the top-down decision-making at the federal, state, and local levels (ASCD, 2012). Not being involved in the decision-making process may create frustration and perceived helplessness in teachers (Bolman & Deal, 2008; Northouse, 2012). Indeed, teachers are the key educators to implement changes in adopted curriculum. The process of teaching the CCSS requires appropriate staff development, such as sample lesson plans and coaching from experienced math teachers. As the ASCD (2012) stated, the most important efforts at the school and district levels are "ensuring that classroom teachers have the time, tools, and support to make the standards come alive in the classroom" (p. 28). For example, approximately 76% of school districts in 2014 reported a major challenge to full implementation of the CCSS was funding for technology (Kober & Rentner, 2011). Additionally, PARCC assessments affect local decisions, and result in changes that impact teachers and students (Porter et al., 2011).

Politically driven federal and state decisions determined the local WCPSDBOE decisions (Anderson, 2011; Fowler, 2013). The WCPSDBOE made the decision to implement the CCSS and use the PARCC assessments because WCPSD is a Title I district. According to the 2016 New Jersey School Performance Report, Wonder High School (WHS) is in a peer group of 31 other schools within the state with similar characteristics because 68.6% of the student population is in the free/reduced lunch program, 0.6% are limited English proficient, and 21.4% are students with disabilities. Financially, WCPSD is a Title I district with approximately $1.3 million from federal aid for the 2016-2017 year.

In addition, teacher assessment is affected by being based on student retention of standards, the third issue of standardized testing. Importantly, the PARCC (2015) and its coordinating online resources mandate interdisciplinary units by incorporating literacy, science, and social studies in high school math assessments. In 2012, The WCPSDBOE appropriated funds to purchase applicable high school math teaching resources from Pearson that have the standards printed on the first page of each lesson of the online text (ASCD, 2012; Pearson, 2012). This is an improvement for math teachers at WHS because they align their lesson plans to the appropriate math standards, and Pearson provides some practical internet resources. For example, practice problems in the middle and at the end of a chapter are online, and students use menus and some math symbols like those required on the PARCC practice online tests. The problem teachers encountered in the WCPSD is student retention of mathematical concepts, and this is embedded in the aforementioned larger issues that surround the adoption of the CCSS.

History of CCSS

Federal funding from Race to the Top for states to adopt the CCSS was provided if they used PARCC or the Smarter Balanced Assessment Consortium (SBAC) for student assessments (Harwarth, 2015; Ujifusa, 2015; White House, Office of the Press Secretary, 2009). The CCSS were developed in 2009 as a cooperative endeavor among 42 states in the United States, the District of Columbia, four territories, and the Department of Defense Education Activity (CCSSI, 2015). The National Governors

Association (NGA) and the Council of Chief State School Officers (CCSSO) were apprehensive about the considerable variances in academic expectations throughout the U.S. The concern was that student mobility could affect student learning and achievement because of the various contrasting state standards. Furthermore, both global and domestic job requirements are changing in the U.S. due to technological changes that require employees to learn or have new skills (Augustine, 2005, 2007; Doorey, 2012; Porter et al., 2011). To lessen monetary burdens on the states, federal funding became accessible to states through the Race to the Top (RTTT) (White House, Office of the Press Secretary, 2009), an economic stimulus package that was part of the American Recovery and Reinvestment Act (ARRA) of 2009. If the states wanted to receive funding resulting from their application for RTTT funds, they were required to adopt the CCSS as part of the stimulus package. President Obama approved $4 billion for the RTTT, and those states had to adopt policies the administration selected that included, but were not limited to, teacher evaluation based in part on student outcomes from state data systems and innovative school improvement (White House, Office of the Press Secretary, 2009).

The CCSS are a result of the reauthorization of the Elementary and Secondary Education Act (ESEA) (U.S. Department of Education, 2010), and the New Jersey State Board of Education (NJDOE) adopted the CCSS in 2010 (NJDOE, 2010). New Jersey is also a partner in the PARCC consortium, the assessment used by 26 states and the District of Columbia in 2010 (NJDOE, 2010; PARCC, 2013; Porter et al., 2011). In 2014, there were nine states and the District of Columbia in the PARCC consortium (Gewertz & Ujifusa, 2014). In 2016, the number of states using PARCC was reduced to six, and New Jersey remains a consortium member (Hart, 2015).

The PARCC and the CCSS caused both national and state resistance, and parents wrote letters to school administrators requesting their children not take the PARCC assessments. The power of parents questioning the use of PARCC assessments for determining high school graduation and teacher evaluations caused policymakers to make changes for public schools (Johnson, 2015), and support for Common Core standards fell substantially at the national level. According to Tanenbaum (2015), “A Gallup poll taken toward the end of 2014 indicated that 60% of Americans opposed Common Core…while a Stanford University poll found 40% of teachers were against the standards, up 12% from 2013” (para. 6). In New Jersey, PARCC assessment scores will count toward graduation in 2019 (Clark, 2015a, para. 2; NJDOE, 2017). Teachers are required to teach the CCSS in the WCPSD and prepare students for the future PARCC assessments.

Porter et al. (2011) argued that the CCSS is essentially a national curriculum, an effort by the federal government to require the states to maintain consistency by focusing on math and competence and using excellent assessments (p. 103). According to Conley (2011), two reasons for the national standards are to clearly specify the knowledge and skills required of students and to raise student achievement. Teachers are the key educators to improve student achievement and implement the CCSS. Thus, they must know the CCSS, their curriculum resources, and their students’ strengths, experiences, and interests (Bransford, Brown, & Cocking, 2000). By learning the curriculum and learning about their students, teachers may assist students “in becoming self-sustaining, lifelong learners” (Bransford et al., 2000, p. 5).

Importance of Interdisciplinary Units

This study was a qualitative exploratory holistic case study (Eisenhardt, 1989; Glaser & Strauss, 2009; Reason & Bradbury, 2008; Yin, 2014). Its purpose was to investigate ways to adapt the CCSS through the use of interdisciplinary units at WHS (Brydon-Miller, Greenwood, & Maguire, 2003; Levin, 2012; Reason & Bradbury, 2008). In addition, student retention of mathematical concepts is a problem, the study aimed to determine ways to increase student engagement and their retention of mathematical concepts. The study was a collaborative effort among the participating teachers and the researcher.

My study evolved during the discovery process (Stringer, 2007). Interdisciplinary units were tentatively defined in the planning stages of this study as a detailed lesson plan stating the CCSS and lesson objectives found in curriculum resources, teachers' directions, and student assignments or labs. Mathematics was the frame of my qualitative case study, and core curriculum high school teachers using interdisciplinary units to teach the CCSS were the focus of my study because they teach students enrolled in math courses. Importantly, high school algebra I, geometry, and algebra II concepts are difficult for some students to comprehend. Mathematical concepts may become meaningful to students if core curriculum teachers incorporate them into interdisciplinary units (Hillman, 2014). The CCSSM refer to solving problems both inside and outside of the classroom (CCSSI, 2018), and the standards in each core discipline are common in all disciplines (Lee et al., 2013). Furthermore, interdisciplinary units may be incorporated as teaching strategies to help students make connections throughout their high school learning experiences (Hillman, 2014). Learning to understand relationships among various disciplines may help prepare students for college and careers (Jacobs, 1989, 1997, 2010; Partnership for 21st Century Skills, 2002).

Context of Case Study

The context of my study was WHS, the only high school in the WCPSD, where I have been employed for 10 years as a secondary mathematics teacher. The WHS student population was 532 students in grades 9-12 in the 2017-2018 year, with seven English, seven math, six science, and five social studies qualified teachers. I chose WHS because each student in grades 9-12 received a laptop at the beginning of the year, they used their computers at school or at home, and internet access was available on school grounds. Access to the internet offered students and teachers opportunities to investigate cross-curricular activities and possibly help motivate students to learn.

My experiences teaching both honors and non-honors math courses at WHS have corroborated Järvelä and Renninger (2014) assertion that math students are both intrinsically and extrinsically motivated to achieve higher grades or have a desire to succeed. Moreover, a student chooses to excel in math if he expects success and thinks the tasks are important and may benefit him. Feelings of self-efficacy accompany motivation, and the quality of the support a student has from his teachers, parents, or peers may change his level of motivation (Järvelä & Renninger, 2014). Secondary teachers may use teaching practices to motivate students to learn and assist them in setting their goals after graduation (Jacobs, 1989, 1997, 2010; Partnerships for 21st Century Skills, 2002). In addition, discovery of these teaching practices may offer insight into preparing students for state assessments.

Furthermore, the PARCC practice tests and the internet PARCC resources use interdisciplinary topics by incorporating literacy, science, and social studies in high school math assessments (NJDOE, n.d.). Therefore, I proposed to discover other teachers' strategies for teaching interdisciplinary units that support high school mathematical concepts. I asked the 25 core curriculum teachers to participate in my study, and 14 agreed to be interviewed before or after school, during their planning period, or during other times convenient to the teacher. I proposed to conduct a qualitative exploratory case study with participating teachers to explore how students are learning the CCSS high school math concepts through the application of interdisciplinary lessons (Eisenhardt, 1989; Glaser & Strauss, 2009; Reason & Bradbury, 2008; Yin, 2014). Using the experiences of the teachers, I developed a research agenda to investigate the participants' understanding of teaching interdisciplinary units and discovered how they enact the CCSS (Stringer, 2007).

This study aimed to identify how core curriculum teachers enacted the CCSS, how they used interdisciplinary units, and the barriers to teaching cross-curricular units or the CCSS. In the process, I became a teacher-participant and a leader at WHS (Fullan, 2007, 2011; Hargreaves & Fullan, 2013; Stringer, 2007). This study was bounded by using the perceptions of the teachers and students on interdisciplinary units as the foundation of the case study. Additional boundaries on this study included the time, place, and detailed data collection from various sources (Hamilton & Corbiett-Whittier, 2013, Yin, 2014). I may take a leadership role in advising school and district administrators about incorporating interdisciplinary units at the secondary level by sharing the findings (Fullan, 2007, 2011; Hargreaves & Fullan, 2013; Stringer, 2007).

Findings from my study may benefit other teachers in their teaching practices, and the process may support school administrators incorporating bottom-up decision-making (Bolman & Deal, 2008; Fullan, 2007, 2011; Hargreaves & Fullan, 2013; Northouse, 2013; Stringer, 2007). Understanding the results of my study on interdisciplinary units may help improve communications about the CCSS and standardized tests between parents and teachers (Breiner, Harkness, Johnson, & Koehler, 2012). Publication of this study may assist teachers and administrators to comprehend students' need for cognitive strategies (Auerbach & Silverstein, 2003; Booth, Colomb, & Williams, 2008; Conley, 2001; Kane & Chimwayange, 2014; Saldana, 2013). Jacobs (1989) and Songer and Kali (2006) explain that interdisciplinary units may be the catalyst for students' opportunities to improve math comprehension and comprehension in each discipline included in the IU.

Discovering how core teachers incorporate mathematical concepts when teaching the CCSS illuminated practical skills that may be shared with other math teachers nationally and internationally through the National Council of Teachers of Mathematics (NCTM) publications or other educational journals. Teachers who implemented the CCSS using interdisciplinary units created leadership opportunities by sharing their practices within their department or with the school leadership committee (SLC) at WHS or with other high schools. Additionally, the process may provide a model of servant leadership (Northouse, 2012). Publishing the details of their units may provide teachers a forum to experiment with their own teaching practices as they share their findings (Auerbach & Silverstein, 2003; Booth, Colomb, & Williams, 2008; Saldana, 2013).

Furthermore, there is a lack of research in teaching the CCSS using interdisciplinary units at the secondary level. Perceptions and strategies of secondary teachers using interdisciplinary units to implement the CCSS provided valuable information for improved teaching models, evaluation of programs, and development of appropriate interventions (Baxter & Jack, 2008). The results of the study verified the theory that making connections from prior knowledge, experiences, and personal interests enhances the learning skills of students and increases their capability to use critical thinking and problem solving throughout their high school learning experiences (Anyon, 1980; Hillman, 2014; Maxwell, 2013; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Yin, 2014).

Collaboration with other core curriculum teachers has been productive for me previously. I shared all data with participants for verification, and observing their work was not a threat to them (Yin, 2014). I plan to share the findings I discovered, and my findings helped answer my research questions (Rossman & Rallis, 2013). By observing how core curriculum teachers taught the CCSS, I discovered how they incorporated interdisciplinary units. The following research questions guided my exploratory case study to determine how teachers used interdisciplinary units to enact the CCSS.

Research Questions

My qualitative case study focused on the following general qualitative research question: how do core curriculum teachers at one high school teach the CCSS using interdisciplinary units? Four sub questions include:

(1) How do core curriculum teachers at one school conceptualize and enact interdisciplinary unit lessons?

(2) How do core curriculum teachers at one school understand and enact the CCSS?

(3) How do science, social studies, and ELA teachers at one school incorporate mathematical concepts when teaching the CCSS?

(4) How do the core teachers at one school relate their instructional leadership to the implementation of the CCSS using interdisciplinary units?

Rationale

The need for this study became significant because of researching two seemingly disparate topics: math and social justice. In fact, they are quite related as described in a research project about teaching mathematics. Anyon (1980) discussed social reproduction of communities and schools after a five-year qualitative research study. Anyon (1980) found that schools in affluent communities provided time for teachers to create interdisciplinary units, and the teachers gave students more autonomy in the classroom. Schools in lower socioeconomic communities taught more rote, repetitive methods in math, and the teachers did not encourage students to think creatively to solve math problems. From a personal lens, WHS has over 68% of the students on free or reduced lunch; therefore, it is considered to be a lower socioeconomic community. My study about how teachers teach the CCSS using interdisciplinary units is a collaborative effort between me and other core teachers, and my findings may become an impetus to create positive changes for some teachers at my high school.

Students learn new concepts when they make connections based upon experiences and interests (Dewey, 1902; Jacobs, 1989; Songer & Kali, 2006). Furthermore, the process of learning to understand the relationships among various disciplines may help prepare students for college and careers (Jacobs, 1989, 1997, 2010; Partnership for 21st Century Skills, 2002). Interdisciplinary units may be the catalyst to provide these learning opportunities for students (Adler & Flihan, 1997; Applebee, Adler, & Flihan, 2007), and the use of the research questions helped me discover learning opportunities for students. Importantly, the study indicates that students' preferred learning structures and teachers' teaching structures were not compatible to each other.

The research questions focused upon the implementation of the CCSS because student success on standardized math assessments depends upon improving math comprehension (Jacobs, 1997). The questions also provided teachers an opportunity to relate their instructional leadership to implementation of the CCSS using interdisciplinary units (Hallinger, 2003). Moreover, this study added to the knowledge base of teaching practices in high school math classes by publishing the findings and the data collected.

I collected data from observations of various teaching strategies, face-to-face interviews with teachers (see Appendix A), face-to-face interviews with students (see Appendix B), and graphic elicitations with teachers and students (see Appendix C). I wrote analytical memos based on all classroom observations, interviews, daily journals and field notes, graphic elicitations, public documents, and other forms of data I collected while discovering patterns or themes (Auerbach & Silverstein, 2003; Saldana, 2013). This plethora of sources provided me rich data (Maxwell, 2013). After gaining administrative approval, I will share the results with the faculty at WHS, and the findings may help teachers make changes in their delivery of CCSS in various disciplines. The research community in secondary math may use the findings in my study to implement similar interdisciplinary units that may help improve student math comprehension.

Scope

The scope of my qualitative action research study was an evolving process over time (Efron & Ravid, 2013; Stringer, 2007). I anticipated that this study would begin with a start date of September 2017 to May 2018. The study timing accounted for the school calendar, teachers' schedules, standardized test dates, and midterm and final exam dates (Efron & Ravid, 2013). Public documents I used included students' test scores, attendance records, and policies of the WCPSD and WHS, and I adhered to the policies of research within WHS (Coffey, 2014).

All participants signed an informed consent form in order to participate in my proposed research activities (Flick, 2007; Roulston, 2014). Permission was granted from both the Rowan University Institutional Review Board (IRB) and from the WCPSDBOE where the study took place. This process allowed me to gain permission to conduct this qualitative case study and collect archival documents from the superintendent of the WCPSD (Coffey, 2014). By following protocols, I avoided glaring forms of unethical and illegal research throughout the study (Rowan University, 2013).

Because the customary practices at WHS are both informal and positive, I did not encounter any resistance to the study (Bolman & Deal, 2008). Positive relationships also exist between the staff and community organizations through WHS. For example, the WHS Alumni Association holds an annual golf outing, and all proceeds benefit the Scholarship Fund for graduating seniors to attend college. Furthermore, Family and Friends of WHS is an organization promoting positive communications between home and school, and the Parent Teacher Organization (PTO) meets once a month in the school library. Using public documents from these community organizations helped me discover answers to my research questions. I plan to present my findings to the WHS administrators and, upon their approval, share them with the faculty (Booth et al., 2008; Efron & Ravid, 2013; Saldana, 2013). Results may be disseminated in state or national level publications.

Conceptual Framework

The conceptual framework of this study was based on the theory that “properly designed interdisciplinary units can lessen the fragmentation that too often results” from teaching specific disciplines (Jacobs & Borland, 1986, p. 159). The importance of interdisciplinary units has been documented in several studies (Andrews 2011; Eilers & D’Amico, 2012; Jacobs, 1989; Jacobs & Borland, 1986; Spalding, 2002). Specifically, I discovered how secondary core curriculum teachers at one school enacted the CCSS using interdisciplinary units.

The roles of secondary teachers are many and varied. Secondary teachers have a responsibility to prepare their students for graduation, college, a career, or military service (Jacobs, 1989, 1997, 2010; Partnership for 21st Century Skills, 2002). The CCSS and the CCSSM refer to interdisciplinary concepts of the core curriculum, and teachers are critical in the implementation of these standards (ASCD, 2012; Wendt, 2013). Some students may have difficulty comprehending secondary math concepts, and students may retain mathematical concepts longer when they base new concepts on experiences and prior knowledge (Bransford et al., 2000). Core curriculum teachers may reinforce the CCSSM by using interdisciplinary unit lessons, and this led to the purpose of my study.

My conceptual framework included how teachers and students enact or perceive interdisciplinary units, uses of interdisciplinary units to prepare students for standardized assessments, and challenges to incorporating interdisciplinary units in core courses. As we prepare our students at WHS for graduation, my study revealed how core curriculum teachers relate their instructional leadership to the implementation of the CCSS using interdisciplinary units (Hallinger, 2003), and the findings may help other teachers implement new teaching practices.

I proposed to take a leadership role as a teacher-practitioner and present the results of my research to the faculty of WHS with approval from school administration (Anderson, 2010; Stringer, 2007; Tashakkori & Teddlie, 1998). My theory-in-use is Theory Y because I enjoy teaching high school students, and teaching is my passion (Argyris & Schon, 1974; McGregor, 1960). I use a pragmatic worldview because I focus on teaching my students, and I learn my students' mathematical abilities to enhance their mathematical progress (Dewey, 1902; James, 1975).

Teaching interdisciplinary units is a different way of teaching for me. Perhaps my study and the knowledge I gain may help me through the three-step process of changing my status quo (Lewin, 1947). Lewin (1947) used the term unfreezing in the first step to describe the process of recognizing a change from the status quo; in this case, that is interdisciplinary unit lessons. Lewin's (1947) second phase is movement, and I may move into a new creative method of teaching practices by teaching interdisciplinary unit lessons and incorporating appropriate CCSS from science, social studies, and ELA. After I try this process of teaching, I need time to reflect personally, with other teachers, and with my students (Osterman & Kottkamp, 2004). The third step, freeze, means I become comfortable with the new teacher practice and make it my own with my viewpoint (Lewin, 1947).

Teachers have different "biases, predilections, and expectations about particular topics" (Hare & Fitzsimmons, 1991, p. 376), and I view my study through my interpretive community. This means my knowledge learned in one situation may conflict with new knowledge or experiences (Hare & Fitzsimmons, 1991, p. 376). Furthermore, I may have different interpretations of interdisciplinary units as compared to those of other teachers. Additionally, cooperative learning objectives may be written or implicit to the unit.

Interdisciplinary Units Development

Jacobs and Borland (1986) state there are four necessary steps to develop an interdisciplinary unit: select a topic, brainstorm associations, formulate guiding questions, and design and implement activities. First, the topic should be of interest to the teachers and students and be appropriate for the curricula. Second, teachers use brainstorming techniques to incorporate each of the disciplines for the selected topic. Students may become participants in the brainstorming process following the teachers' model (Jacobs & Borland, 1986, pp. 161-162). In Jacobs and Borland's (1986) third step, participants examine the brainstorming ideas and search for common themes. The themes may form larger concepts, and this analysis process continues until all the brainstorming ideas are used. The goal is to list the concepts into questions that students may research. The length of time for the research depends upon the topic and the concepts developed. Fourth, teachers design instructional activities based upon the curriculum and the methods students may use to research answers to the questions (Jacobs & Borland, 1986, pp. 162-163).

The four-step process should be a decision to develop students' higher-level thinking processes in a significant context. As teachers focus upon the content of the unit and student activities, they may demonstrate their educational beliefs of modeling the value of knowledge and learning to their students (Jacobs & Borland, 1986, p. 162). This process is not easy, and it requires teachers who believe their role is to encourage students to value knowledge (Jacobs & Borland, 1986, p. 163).

Summary

This qualitative research case study was primarily concerned with the discovery of how secondary core curriculum teachers at one school, WHS, enacted the CCSS. This study was guided by one general research question: how do core curriculum teachers at one high school teach the CCSS using interdisciplinary units? The methods teachers used and their potential to incorporate other core curricula is guided by their experiences, career stage (Fullan, 2007; Huberman, 1989), self-efficacy (Bandura, 1993), and the support provided by school administrators practicing instructional leadership (Hallinger, 2003; Leithwood & Sun, 2012). The four sub questions for my study concentrated on the core curricula, interdisciplinary units, incorporation of mathematical concepts, and teachers' instructional leadership. The findings from this exploratory case study may allow school administrators to comprehend a variety of methods teachers use to fulfill the enactment of the CCSS and any barriers they encountered.

Data was analyzed by coding interview transcripts from teachers and students. Themes were generated from the interviews, graphic elicitations, and analytical memos. This study resulted in findings about how teachers made changes in their practice since the adoption of the CCSS and the implementation of PARCC assessments.

Chapter 2

Literature Review

The adoption and the implementation of the CCSS are both a challenge and continued controversy. Technology is required for students taking the Partnership for Assessment of Readiness for College and Careers (PARCC) assessments in English Language Arts (ELA) and math, and the controversy around basing teacher evaluations upon PARCC scores continues. The CCSSM are mathematical practices, and math teachers need PD to teach these math standards using appropriate technology and curriculum resources. School administrators may use a variety of leadership theories and practices to determine the changes that need to be made to ensure the CCSSM standards are taught simultaneously with the rigorous content expected in high school math courses. In this chapter, I explain the rationale for this study, a history of the CCSS, some criticisms of the CCSS and the PARCC assessments, the CCSSM practices, interdisciplinary units, implications for school leadership, how teachers react to change, and the role of mathematics in secondary education.

My rationale for this exploratory case study includes my leadership as a teacher. Good leadership should take the research findings from Anyon (1980) about social justice and social reproduction into consideration. Affluent schools scheduled time for teachers to collaborate on interdisciplinary units, and those teachers gave students more freedom in class. Anyon (1980) discovered that teachers in low socioeconomic communities were not provided time to create discussions with other teachers about cross-curricular units and instead taught more skill-drill-and-kill methods in math. Furthermore, students were taught one method to work a math problem, and they were not encouraged to work math problems creatively (Anyon, 1980).

I became interested in the use of interdisciplinary units after reading Anyon (1980), and based upon my preparation from the doctoral program at Rowan University, I believe that I have the knowledge and skills to incorporate interdisciplinary units in my teaching practices. Importantly, teachers are the change agents (Swanson & Stevenson, 2002), and we practice pragmatic worldviews to develop interdisciplinary units based upon what works (Creswell, 2014; Dewey, 1902; Johnson & Onwuegbuzie, 2004). Describing a brief history of the CCSS provides background of the adopted curriculum.

CCSS History

The NCLB in 2002 mandated schools to improve student achievement regardless of socioeconomic status, race, ethnicity, disability, or English language proficiency (ASCD, 2012; CCSSI, 2017; Jerald, 2008; Ritter, 2009; Tienken, 2010; VanTassel-Baska, 2012). The "NCLB's student proficiency targets and strict accountability for meeting those requirements were a step forward in closing the achievement gap; however, they led to gamesmanship across the nation" (ASCD, 2012, p. 7). The NGA and CCSSO formed separate groups with state representation, held public hearings for comments, and began an advisory group with members of Achieve, ACT, the College Board, the National Association of State Boards of Education, and the State Higher Education Executive Officers (ASCD, 2012, p. 9; Jerald, 2008).

After receiving input from members of these groups, the NGA and CCSSO gave drafts of the standards to the public for review in September 2009 and in March 2010. The NGA and the CCSSO introduced the initiative to develop college and career readiness standards in April 2009 (Jerald, 2008; Porter et al., 2011). The CCSS were released on June 2, 2010. The U.S. Secretary of Education, Arne Duncan, through the U.S. Department of Education's (USDOE) Race to the Top (RTTT) initiative, offered incentives for states to adopt the CCSS (ASCD, 2012; Christensen, Shyyan, & Johnstone, 2014; U.S. Department of Education, 2009; White House, Office of the Press Secretary, 2009). States were not required to adopt the standards, but the added points if they did provided extra motivation (ASCD, 2012; McDonnell & Weatherford, 2013; Schmidt & Houang, 2012). Forty-six states, the District of Columbia, and other U.S. territories adopted the CCSS by September 2012 (ASCD, 2012).

In NJ, the CCSS were discussed in a report from Achieve, *Benchmarking for Success: Ensuring U.S. Students Receive a World-Class Education,* that called for policy reforms for college and career readiness and internationally benchmarked standards in math and ELA to prepare students for global competition (ASCD, 2012; Jerald, 2008). The ASCD (2012) described the CCSS as an effort for all 50 states to have the same set of education standards (NEA, 2015), and yet this goal remains unobtainable because state agencies and legislatures in eight of the 50 states did not adopt the CCSS. In 2016, 36 states and the District of Columbia kept them (Ujifusa, 2015). These academic standards state what students are expected to learn from K-12 to become prepared for a career or college. The CCSS and PARCC are components of higher expectations and increased rigor in the K-12 system, and classroom teachers are critical to ensure high quality instruction (ASCD, 2012; Wendt, 2013).

In 2015, President Obama signed Every Student Succeeds Act (ESSA), which reauthorized the Elementary and Secondary Education Act (ESEA) from 50 years ago

(U.S. Department of Education, 2017). In 2016, President Donald Trump and Secretary of Education Betsy DeVos became the educational leaders, and they may create swift changes nationally; however, these changes do not invalidate my work because this study contains collected data from teachers and students from one year. I chose WHS in the WDPSD because the staff aligns their lesson plans to the CCSS.

New Jersey is one of the 46 states that adopted the CCSS in 2009, and the WCPSD adopted them as required by the New Jersey State Department of Education. The WCPSD adopted the CCSS for mathematics in 2012 and purchased Pearson math curriculum resources for grades 7-12. Lack of teaching resources that align the CCSSM and the PARCC assessments is one of the criticisms of the CCSS.

Criticisms of the CCSS

Critics of the CCSS state that the educational reforms are endless, and teachers and students endure another disservice with each new mandate of questionable educational policies (Crowder, 2014). The CCSS would take 12 years to implement to be successful, due to the scaffolding nature of the standards (Crowder, 2014). This means that teachers support the learning of the students in mathematics as they progress through the grade levels, and students become more responsible for their own learning eventually.

Political influences, the NGO, the CCSSO, and President Obama are perceived to be the directors of the CCSS and the accompanying PARCC assessments (Crowder, 2014). Critics express concerns that the CCSS are another top-down educational policy system from politicians who have no leadership experience in education (Bolman & Deal, 2008; Crowder, 2014; Dickey, 2013). Student achievement on high-stakes tests may decrease until students and teachers adjust classroom instruction to yet another curriculum change (Crowder, 2014); however, teachers may be held accountable for students' test scores. Additional criticisms of the CCSS include the lack of field testing of the standards, unknown related expenses such as new curriculum resources, the use of one type of curriculum for all students, lack of public debate prior to a state adopting the standards, the additional required high-stakes testing, and the support of the Gates Foundation for the tests (McDonnell & Weatherford, 2013). The Gates Foundation gave $233 million in grants to states supporting the CCSS, building a political support system across the U.S., and persuading state governments to make universal and expensive changes.

Since the Eisenhower administration, the states had prevented a common national curriculum; however, Bill Gates organized and provided money and a framework for states to collaborate on a national curriculum. Gates gave money to the American Federation of Teachers, the National Education Association, and business organizations such as the U.S. Chamber of Commerce, and these organizations went against tradition and became supporters of the standards. Due to the efforts of the Gates Foundation leader, the CCSS were instituted in many states without elected lawmakers voting to approve them. Because of public and political negative feedback of the method used to adopt the CCSS, the standards became a political educational discussion in the 2016 presidential election in the Republican Party (Layton, 2014).

At the local level, the adoption of the CCSS by the WCPSD affected teachers, and funding was required for purchasing new, partially aligned resources. Because teachers are the most critical employees to implement new policies and programs (ASCD, 2012; Wendt, 2013), "Educators should have asked why we are implementing the CCSS instead of how do we implement them" (Tienken, 2010; p. 14). Tienken (2010) stated that the NGA and CCSSO used the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) math results as a justification for the CCSS, since no disaggregated data was provided for students living in poverty. Teachers without mathematical certification typically teach in districts with high poverty levels. Teachers with proper mathematical certification and highly qualified teachers frequently teach in middle- or upper-income communities (Hill & Dalton, 2013).

Furthermore, this international data indicated that Russia had the highest number of tested students living in poverty, and the United States had the second highest number of students living in poverty. Students who live in poverty may not have the opportunities, safe neighborhoods, or educational experiences that middle or high-income students enjoy (Hill & Dalton, 2013). Moreover, most U.S. students do not take calculus, and 23% of the math questions on the 1999 TIMSS test were calculus problems (Tienken, 2010).

Technology. Despite the criticisms of the CCSS, teachers are on the front lines to implement the curricula. In 2015, the NCTM adopted a Technology Principle that stated technology is essential in teaching and learning mathematics because technology influences the specific math concepts teachers teach. The outcome of using mathematical technology is to enhance student learning (NCTM, 2015). Technology may be the key for teachers to keep expectations high and prepare students for globally competitive workforces (Wendt, 2013).

Bransford et al. (2000) posit that technology supports student learning by providing resources for students to postulate possible solutions to real-world problems, have feedback in a timely manner on their solutions, and collaborate with both local and global communities. Reflection and revisions through communication over the internet may be accomplished by groups of students who share a common interest and provide teachers opportunities to learn creative problem-solving together by scaffolding thinking and activities (Bransford et al., 2000, p. 207; Hung, Lee, & Lim, 2012; Mills, 2003; Vygotsky, 1978). Teachers learn along with their students when using a new program, and they become partners in learning. A critical partnership must also exist between "teachers, administrators, students, parents, community, university, and the computer industry" (Bransford, Brown, & Cocking, 2000, p. 227). Student engagement increases during computer content activities compared to paper and pencil activities of the same content in math (Mulcahy, Maccini, Wright, & Miller, 2014). Students taking tests on a computer may or may not perform better than on paper tests.

PARCC

The CCSS and the PARCC assessments are an expensive investment in education, and each affects state and teacher accountability, K-12 instruction, and teacher PD (Hess & McShane, 2013). In 2009, President Obama's 2009 economic stimulus package awarded about $330 million to "a consortium of states to develop tests aligned to the Common Core" (Hess & McShane, 2013, p. 62). The PARCC Consortium "was joined by 22 of the participating states and the remainder joined the Smarter Balanced Assessment Consortium (SBAC)" (Hess & McShane, 2013, p. 62). Furthermore, the USDOE awarded the PARCC state consortia $170 million to develop assessments aligned to the CCSS (Conley, 2011; Porter et al., 2011). The costs of the PARCC tests remain an important concern today.

PARCC assessments cost $29 each, and this is more than half of the consortia states' budgeted line item for assessments. Out of 22 states using PARCC tests, only six states and the District of Columbia used Pearson's PARCC high school assessments in 2016. The six states are Colorado, Illinois, Maryland, New Jersey, New Mexico, and Rhode Island (Hart, 2015). States leaving the PARCC consortium to create their own tests jeopardize the concept of uniform testing, a foundation of the CCSS. Conley (2011) states that two reasons for national standards are to make clear the knowledge and skills students should know and to raise student achievement. Furthermore, students may be better prepared for global job competition with an accomplished background in high school math and science (Breiner et al., 2012; DeJarnette, 2012).

One of the purposes for the CCSS is to promote reasoning, analyzing, and assessing critically, and the PARCC may not measure these skills. Providing students with a strong mathematical background is the role of math teachers. Math teachers in the U.S. have been trained to teach the show and practice process, and true problem solving requires a different type of pedagogy. The math curriculum from the CCSS requires problem solving, communicating and reasoning, modeling, and data analysis based upon the PARCC assessments (Brown, Afflerbach, & Croninger, 2014; Center for the Future of Teaching and Learning at WestEd, 2012; Schoenfeld & Kilpatrick, 2013). Students who scored lowest on the National Assessment of Educational Progress (NAEP) may score lowest on the PARCC, and teachers may have to change teaching strategies to meet the needs of these students (Brown et al., 2014). Students who scored lowest on the NAEP are historically disadvantaged students, such as ELL, low-income students, African-American students, or students with learning disabilities. White and upper income students historically score highest on the NAEP in reading (Brown et al., 2014, p. 546), and disadvantaged students may encounter additional challenges on the PARCC.

Disadvantaged students face considerable challenges in earning high proficiency levels in critical-analytic thinking (CAT). The achievement differences between the disadvantaged students and those who score highest on the NAEP may become larger with the PARCC scores (Brown et al., 2014; Lombardi, Doren, Gau, & Lindstrom, 2013). Teachers using formative, targeted assessments may help each student be more successful with PARCC assessments because "formative assessment maps well onto the notion of zones of proximal development of Vygotsky (1978)" (Brown et al., 2014, p. 558; Konrad et al., 2014). Zones of proximal development refer to the learning that takes place when children interact with other students and learn from their experiences, especially if the others are more experienced in a topic or concept (Vygotsky, 1978). Tools used for solving problems include accessing memory and independent use of skills in literacy, math, and language (Rogoff, 2003; Vygotsky, 1978), and the student moves out of the zone of proximal development after acquiring these tools (Vygotsky, 1978). Math teachers may need PD to incorporate assessment items like PARCC released algebra I, geometry, and algebra II test items.

Opponents of high-stakes testing like PARCC posit that designing the tests for the benefit of both students and teachers requires a large amount of time and teacher input. Students may not have equal access to required materials, resources, and opportunities to learn. Schools may game the scores by excluding special education students, and students with the lowest scores usually drop out of high school (Kern, 2013, p. 96). Furthermore, graduation tests have no impact on 12^{th} grade math or reading achievement, and policymakers need to reconsider high-stakes testing for graduation requirements (Kern, 2013, p. 96).

Kern (2013) explains the high-stakes PARCC testing harms marginalized students. African-American and Latino students score lowest, and this may result in student apathy, therefore, creating instructional practices that may be punitive and promote the prison pipeline (Kern, 2013, p. 98). Gaming the system may result in lower expectations from school personnel and instructional methods that cause lower test scores later for marginalized students (Kern, 2013, p. 98). The PARCC tests should not be used for controlling high school graduation because it is a single assessment. Instead, Kern (2013) argues that funds spent on the PARCC would be better spent on school improvement processes. Some of Kern's suggestions include smaller class sizes for disadvantaged early childhood students, recruiting highly effective teachers in schools where there is a paucity of these teachers, offering college curriculum to all students, and improving the quality of life for students before and after school hours.

At WHS, the Performance Based Assessment (PBA) in March 2015 and the End of Year (EOY) assessments in May took 11.25 hours of testing time for students in ELA and Math (algebra I, geometry, and algebra II). Parents who wanted their children exempted from the tests wrote a letter to the superintendent, and students were not penalized for not participating. In New Jersey, almost 15% of juniors opted out of the PARCC assessments (Clark, 2015b).

Furthermore, a parent organization, Save Our Schools, does not support teacher evaluations linked to PARCC results. In New Jersey 30% of the evaluation of teachers in grades 4-8 in ELA and grades 4-7 in math is dependent on PARCC scores (New Jersey

Department of Education, 2017). The Save Our Schools is opposed to this because of concerns about instructional time spent on preparing for the test and rather than teaching the required curriculum (Gilpin, 2017). Standardized testing causes many teachers to “teach to the tests,” which only hinders a student’s learning potential. Teachers who practice student engagement to solve math problems creatively using the standards as a reference would have a better effect on standardized test scores than teaching to the test (Welsh, Eastwood, & D’Agostino, 2014). Summative and formative assessment support the CCSS and provide students opportunities to solve real-world problems using perseverance and both abstract and quantitative reasoning (Schoenfeld, 2015).

Moreover, Tienken (2013) asked if the PARCC can assess a child’s readiness for the 4,400 colleges in the US and the thousands of possible careers (Tienken, 2013). Because ELA and math are tested, other subjects may be perceived as less important (Au, 2007; Tienken, 2013), and teachers and principals may be punished or rewarded depending upon student scores. Students who score lowest on elementary and middle grades PARCC will be tracked in high school to lower achieving courses, and social reproduction occurs (Au, 2007; Tienken, 2013). Au (2007) asserts that high-stakes testing is leveraging formal control over the curriculum. The issue of high-stakes testing continues to be debated on all levels, and students may be tracked into different levels of math courses based upon their scores.

The 2016-2017 year was the third year New Jersey students took the PARCC high school geometry and algebra II tests. According to Mazzola (2017), “High school math results continued to lag expectations - only 29.8% of students who took the Geometry exam, and 26.6% … who took the Algebra II test, scored 4 or 5" (para. 7). A score of 4 or 5 means the student passed the test, and scores of 1, 2, and 3 are not passing.

CCSS and Mathematics

A student's history of math courses in high school predicts the student's college readiness. High school math courses can determine whether students enroll in two-year or four-year colleges (Lee, 2012). Secondary math courses also play a large part in whether students complete college degrees in science, technology, engineering, and mathematics (STEM) (Lee**,** 2012). Furthermore, Black students whose parents had less than a high school diploma are more likely to fail in college completion (Lee, 2012). The CCSSM may be an answer to raising teacher preparation, improving PD, and changing teaching methods or strategies to prepare students for standardized tests and college preparation.

Moreover, Schmidt and Houang (2012) found "a very high degree of similarity between CCSSM and the standards of the highest achieving nations on the 1995 TIMSS" (p. 294). The CCSSM are based upon the NCTM 2000 standards, and they provide states with articulate and demanding expectations (Dickey, 2013; Ross, Prior, & Guerrero, 2015). The eight mathematical practices of the CCSSM implemented in K-12 include making sense of problems, abstract and quantitative reasoning, critiquing other's reasoning, modeling with mathematics, using appropriate tools, being precise, using structure, and looking for patterns and generalities in problem-solving (Hakuta, Santos, & Fang, 2013; NCTM, n. d.; VanTassel-Baska, 2012, p. 222; Ross et al., 2015, p. 94).

Some of the strengths of the high school geometry CCSSM include "eighth grade exploration of geometric relationships in middle school to prepare students for formalization of those concepts at high school" and "support[ing] the articulation of…key learning trajectories in numeration and…geometry" (Confrey & Krupa, 2010, p. 4). The CCSSM do not dictate a sequence of high school math courses because students are enabled to take the courses as they learn underlying math concepts (Confrey & Krupa, 2010). Furthermore, in high school, the CCSSM states students should learn the "advanced mathematics, including algebra, functions, geometry, and quantification" (Mulcahy et al., 2014). Therefore, the goal of the NCTM practices of the CCSSM is to improve student learning.

Improving student learning depends on four factors: teaching essential content, providing student engagement using appropriate curricular materials, using interactive and teacher-student or student-student responsive instruction, and using students' feedback about their thinking and problem-solving process (Confrey & Krupa, 2010; Vygotsky, 1978). The key points in mathematics, grades 9-12, include practicing mathematical concepts with real world issues, allowing students to solve problems creatively and uniquely in new situations, and using mathematical models to analyze and solve a data analysis situation (Rust, 2012; Saunders, Bethune, Spooner, Browder, 2013; Wilson, 2013). Each of the NCTM practices and the standards in the CCSSM support the concept of teaching interdisciplinary units, and this process of teaching may assist secondary math teachers in developing teaching strategies to improve student comprehension in mathematics.

Interdisciplinary Units

An interdisciplinary approach is "a knowledge, view, and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (Jacobs, 1989, p. 8).

Teachers may plan and implement activities that are co-curricular with collaborative activities, but it can also be one teacher integrating content from other disciplines (Spalding, 2002, p. 700). Benefits of interdisciplinary units include different disciplines relating to the same topic, teaching the adopted standards, and using the students' interests while relating content to their concerns (Andrews, 2011). An interview with Michael Cole explained interdisciplinary collaboration allows "understanding the role of culture in development" of the students (Glaveanu, 2011, p. 11). Additionally, problems for analysis in an interdisciplinary unit need to have contributions from many academic disciplines (Glaveanu, 2011, p. 16), and participants need to focus upon what they need to know to solve the problems (Glaveanu, 2011). Time for teachers to discuss problem solving using interdisciplinary units is provided by the state of Georgia. The state supported interdisciplinary teaching teams and provides them common planning periods (Andrews, 2011). In contrast, the high school under study in this dissertation, WHS, does not provide a common planning period for core curriculum high school teachers, and providing opportunities for secondary core curriculum teachers to meet and plan cross-curricular lessons depends upon school leadership.

Leaders in the schools must first establish a purpose and vision, set goals, and focus a course of action to teach interdisciplinary units (Eilers & D'Amico, 2012). The CCSS may be implemented fully as teachers collaborate and communicate to teach cross-curriculum units. Teachers may promote a deeper understanding of mathematical concepts and how they are used in other disciplines through collaborative interdisciplinary teaching practices. History, science, and language arts are interspersed throughout the CCSSM, and technological applications are emphasized throughout all curricular areas (CCSSI, 2017, 2018; Eilers & D'Amico, 2012).

Teaching the CCSS requires different methods of teaching. For example, 50% of the teachers in the states that adopted the CCSS stated they require a fundamental change in instruction (Kober & Rentner, 2011). Moreover, California middle and high school math and science teachers stated they had never been taught how to teach the CCSS, and they need training to teach students how to work analytically (Center for the Future of Teaching and Learning at WestEd, 2012).

Teachers need training not only in teaching the CCSS but teaching interdisciplinary units, and the training may come from the school or district (Center for the Future of Teaching and Learning at WestEd, 2012; Vecellio, 2013). Adequate PD may provide teachers with additonal resources and teaching methods to support incoming high school math students who are not ready for the higher level, more intense CCSS in the core courses (Andrews, 2011; Vecellio, 2013). Real world applications may help middle school students make decisions about staying in school instead of dropping out, and preventing students from dropping out will help our economy in the U.S. For example, "nearly 64,100 students did not graduate from Georgia's high schools in 2009; the lost lifetime earnings for that class total more than $16.6 billion" (Andrews, 2011, p. 55). Andrews (2011) posits that interdisciplinary units may make standards more meaningful, perhaps reduce dropout rates, and lead to more classroom student participation.

CCSSM supports a plethora of student participation methods - individual oral presentations, small group discussions and presentations, pairs, and teacher led discussions that provide opportunities for students to incorporate various technological methods in their presentations (Hakuta et al., 2013; Hung, 2013). Students may research topics on the internet and use models, charts, graphs, and correct mathematical symbols in their work or presentations (Hakuta et al., 2013). Hillman (2014) posits, “The CCSS direct K-12 teachers to examine implicit literacy traditions” in each of the core courses, and using vocabulary alone does not help our students learn the connections between curricula, especially when working with an interdisciplinary unit (p. 399). Teachers of cross curriculum lessons may incorporate what Vygotsky (1978) called scaffolding structures to help students learn both disciplinary language and interdisciplinary connections (Hillman, 2014). Furthermore, curricular connections may be strengthened in other practical methods.

Mayes and Koballa (2012) explain that students who investigate real-world challenges in their community will be better able to make the connections between science and mathematics (p. 9). Furthermore, students must learn proficiency in mathematics while learning science to become “scientifically literate citizens of tomorrow” (Hung, 2013; Mayes & Koballa, 2012, p. 15). Educators, primarily secondary teachers, have an immense responsibility to prepare students for their future lives (Wendt, 2013). At the school level, the school culture at WHS may positively change as teachers focus on CCSS interdisciplinary lessons because of teacher communication and collaboration (Bolman & Deal, 2008). Continual growth and learning is the expectation of any profession, and interdisciplinary units may be the platform for change (Garet, Porter, Desimone, Birman, & Yoon, 2001; Mayes & Koballa, 2012). Teachers who view their courses as a source from the CCSS may be willing to attempt interdisciplinary units and still maintain their classroom roles as collaborators with their students (Hagay, Baram-Tsabari, & Peleg, 2013; Mayes & Koballa, 2012).

Teachers using interdisciplinary units need autonomy and freedom to experiment without punishment. They may establish units based upon students' interests and strengths. However, logistics and lack of appropriate resources may hinder some plans (Hagay et al., 2013). Interdisciplinary teams of teachers demonstrate the interdisciplinary communication and collaboration expected of students across the core curriculum, and students may learn that a team effort is sometimes stronger than an individual effort to solve involved, complicated problems (Hung, 2013; Mayes & Koballa, 2012).

High Schools Using Interdisciplinary Units

In 1976, the District of Columbia Public Schools in Washington, DC released the curriculum guide for interdisciplinary cooperative education programs. The 370-page document explained the eight units of study for the curriculum. The units were designed to help seniors learn and develop skills, "knowledge, personal traits, health habits, work habits, safety habits, pride in achievement," and conduct for success (District of Columbia Public Schools, 1976, p. 1). The curriculum was taught in cooperative learning situations to help seniors ease into a career after graduation from high school (District of Columbia Public Schools, 1976).

In 1999, teachers from Auburn High School in Riner, VA, presented a paper at the Annual Conference of the National High School Association. The document details the interdisciplinary instruction of a project entitled "From Shop to Shakespeare." The project was school wide, and students constructed an Elizabethan gazebo and a Shakespeare garden. The interdisciplinary project included students' use of high order thinking skills, making connections between different generations of the community, full inclusion of special education students, and the incorporation of several academic standards in the project. Furthermore, cooperative learning was used among the teachers and the students (Bull et al., 1999).

In 2014, the School for Science and Math at Vanderbilt (SSMV) produced an article entitled “An Innovative Research-Based Program for High School Students.” Students attend the SSMV for one day per week during a school year and attended a summer program following each of their ninth, 10th, and 11th years on the Vanderbilt campus. The staff at the SSMV provided a rigorous STEM curriculum in the summer internship. Some students were Intel and Siemens semifinalists and regional finalists over the past four years (Eeds et al., 2014).

Three STEM schools in the U. S. that have earned outstanding national recognition are Lake View in Chicago, Loving in New Mexico, and the MAST Academy in Florida. Lake View curriculum consists of STEM with a focus on project-based learning. Through the years, each student develops technological literacy, critical thinking, and collaboration skills. Loving offers career and technical education (CTE) opportunities in health science, construction, architecture and the STEM fields. In 2014, all the seniors at MAST Academy graduated, and the academy earned the U. S. Department of Education Blue Ribbon Designation (Noodle Staff, 2015).

Some New Jersey high schools use the STEM interdisciplinary approach to encourage students to graduate high school, earn college credits in high school, and major in a science, technology, engineering, or mathematics field in postsecondary schools. Resnick (2009) notes the Ridgewood High School Home and School Association recognized teachers for their work in an American Studies program with interdisciplinary teaching of American History and American Literature in 2009. Additionally, teachers who used interdisciplinary instruction with American History and Literature with Integrated Study in the Arts were honored. The Ridgewood Academy for Health Professionals (RAHP), a three-year program for students working with Valley Hospital and Bergen Community College, was recognized for incorporating English, health, and science in the curriculum (Resnick, 2009).

According to the Research & Development Council of New Jersey (n.d.), STEM schools have been established in Burlington City and Pemberton Township through a grant in the Burlington County College's College Bound Program. Camden County's Upward Bound Program offers high school students to complete secondary and pre-college education. One of the qualification requirements is that neither of a student's parents can have completed a bachelor's degree. Additionally, Camden County's College Bound Program offers pre-college courses to encourage Wonder City students to seek a STEM career in postsecondary education (Research & Development Council of New Jersey, n.d., pp. 10-17).

Furthermore, the Research & Development Council of New Jersey (n.d.) highlights the science, technology, engineering, math, and art (STEAM) curriculum incorporated at the STEAM Academy in the Black Horse Pike Regional Program of Studies in partnership with Camden County College. High school students may graduate with up to one semester of college credits through Dual Credit and College Now programs. The STEAM Preparatory Academy is an interdisciplinary program designed to provide academically gifted students opportunities for careers in the STEAM fields.

Other New Jersey schools that use STEAM programs include Tenafly High, Paterson Arts and Science Charter, Montclair, Weehawken High, Eastern Christina High in North Haledon, and Ma'ayanot Yeshiva High School. Additionally, a plethora of colleges offers STEM enrichment for high school students during summer sessions. For example, Seton Hall University's Project Acceleration offers up to 70 high school students a maximum of 22 credits (Research & Development Council of New Jersey, n.d., pp. 10-17).

Implications for Leadership

Demonstrating leadership in front of students by collaborating with other teachers on cross-curricular plans is a good model for students. The discussion between teachers regarding the objectives, materials, timelines, location, and student responsibilities demonstrates school leadership to the students and may serve as a model for students working on collaborative assignments. Grindon (2014) posits that teachers can implement the CCSS "within a framework of critical, empowering, and engaging lessons" (p. 251). However, significant barriers exist that may prevent teachers from achieving these types of lessons, including traditional teacher-dominant classrooms versus student-led classrooms, administrative pressure, and district policies (Grindon, 2014, p. 262). Using DuFour and Eaker's (1998) Professional Learning Community (PLC) models, teacher leaders should advocate for this time to study the CCSS and the integration of them into meaningful, challenging lessons that may help create discussion of international problems (Grindon, 2014).

One example of an international problem that can be incorporated into lesson plans is appreciation of natural resources. Educators face challenges in teaching students to appreciate natural resources shared by every country to improve life for all people to enjoy peace and security. School leaders must be multidimensional and understand the challenges teachers, students, and the communities face, and moral responsibility is required of school administrators (Starratt, 2005). Regulations and mandates become part of the school's culture through routines, administrative practice, and classroom practice (Bolman & Deal, 1998; Heifetz & Linsky, 2002; Spillane, Parise, Sherer, 2011). School administrators may find it easier to deal with the technical changes and make progress there instead of tackling the adaptive challenges that are more difficult to change. Technical practices may result in a separation between classroom instruction and administrators (Heifetz & Linsky, 2002; Spillane et al., 2011), and administrators need to provide the reasoning behind changes.

Teacher leaders participating in an assortment of professional activities within the school's context may improve both their own PD and therefore add to the knowledge of how to improve educational practices (Runhaar, Sanders, & Yang, 2010, p. 1154). Teachers who reflect with other teachers may evaluate their actions and improve their practice (Osterman & Kottkamp, 2004; Runhaar et al., 2010). Furthermore, teachers may improve their practice when they have opportunities to combine their abilities, motivation, and experiences with positive changes (Bandura, 1993; Runhaar et al., 2010, p. 1155). Ability refers to their self-efficacy (Bandura, 1993), motivation is demonstrated by their desire to improve competencies, and support provided by school administrators practicing transformational leadership provides teachers opportunities to improve teaching practices (Mills, 2003; Runhaar et al., 2010). A teacher's belief that coping with difficult situations requires the teacher's personal motivation to improve practices

(Bandura, 1993; Runhaar et al., 2010). This depends upon administrative leadership and may require transformational leadership.

Transformational leadership theory may be effective when both the leader and the employees work toward goals by becoming inspired to do so. The goals are linked to values the employees believe are important to their performance, and staff are supported by the leader in their efforts to make necessary changes (Leithwood & Sun, 2012; Mills 2003). Transformational leadership theory does not control the outcome or the consequences of individual employee efforts that are not related to the school goals (Leithwood & Sun, 2012, p. 388). Teachers who are inspired to try interdisciplinary units may demonstrate transformational leadership within their department and inspire others throughout the school.

Teachers need to change teaching methods for student achievement to improve, and this leads to a combination of transformational leadership and instructional leadership practices (Hallinger, 2003; Leithwood & Sun, 2012). Principals who use power that has been agreed upon by teachers and who promote this power use it with teachers and not over teachers (Leithwood & Poplin, 1992, p. 9). Teachers encouraged to try new instructional strategies and collectively solve school problems demonstrate consensual and facilitative power, respectively (Leithwood & Poplin, 1992). Instructional leadership used to make technical changes by monitoring teacher work and student progress is used at WHS by the principal. However, instructional principals make second order changes like collaborative decision-making (Argyris & Schon, 1974; Leithwood & Poplin, 1992). For example, the principal at WHS depends upon the suggestions of the members of the SLC to make technical changes for PLCs, and these changes may lead to adaptive changes (Heifetz & Linsky, 2002). Technical changes may also be implemented by using transactional leadership.

Argyris and Schon (1974) describe transactional leadership as that used by principals and teachers to get the usual daily tasks completed and maintain order. This is the first order of change (Argyris & Schon, 1974). A combination of the transactional and transformational leadership theories promotes teacher experimentation with classroom practices (Leithwood & Poplin, 1992). School leadership is essential for teachers to change classroom practices, and transformational leaders reinforce the self-efficacy of teachers. Deep changes in school culture may result from positive transformational change, or second order changes (Argyris & Schon, 1974), and teachers are essential in this change process. Including teachers in the decision-making process increases their self-efficacy, a necessary component to try new ideas including interdisciplinary units.

Student achievement depends upon classroom instruction, and principals who encourage teachers to try new practices assist in this effort (Hallinger, 2003; Leithwood, & Jantzi, 2006). Leadership produces an effect on the school’s quality and student learning (Leithwood, Harris, & Hopkins, 2008, p. 36), and the principal at WHS shared his learning experiences from collaborating and communicating with other high school principals in our peer group (NJDOE, 2014). He explained how we may make positive changes for our students or programs; he is optimistic and demonstrates high expectations for teachers when explaining that, if they can do it, we can do it. His focus and optimism are contagious and helps me give encouragement to my students, reinforcing the responsibility of my role as a teacher-participant (Stringer, 2007).

“High-quality mathematical tasks can be a centerpiece of efforts to implement …the CCSSM, but task-based PD is not implemented in a vacuum” (Johnson, Severance, Penuel, & Leary, 2016, p. 25). Teachers are the critical personnel in implementing the CCSSM, and the three elements—standards, assessments, and instruction—must be taught, used, and practiced, respectively (Woolard, 2012). Teachers who use these three components may provide “a rigorous and high-quality education” (Woolard, 2012, p. 616). Principals who have high expectations for faculty pass this to teachers, who instill high expectations for their students, according to my teaching experience. For example, the principal at WHS demonstrated instructional leadership in the summer of 2015 by meeting with volunteers of teachers, staff, and community members to create and adopt our vision and mission statement (Hallinger, 2003, p. 332). The three key words from this group of volunteers are *partnership*, *performance,* and *pride*, and they are displayed in the main foyer, the main hallway, on letters mailed to parents, and in weekly announcements to teachers via email.

In summary, educational administration has had too many influences from the state legislation and disciplines outside education. The administrators need to develop their own models and concepts of educational leadership, and in the process, the administrators create their own character (Sergiovanni, 1994). The community, local business leaders, parents, and the board of education must perceive schools as legitimate (Hargreaves, 2001). Purposes for educating children must be explicit, and the organization of staff “into departments and grade levels, developing job descriptions, constructing curriculum plans, and putting into place explicit instructional delivery systems” communicate to the various publics that the school is in session, and it is running the business of education (Sergiovanni, 1994, p. 215). As principals and other educational administrators practice the business of education, teachers perform the business of teaching students (Sergiovanni, 1994). Trust established between administrators and teachers, and the reciprocity of accountability between teachers and administrators, are foundations for distributive leadership that promotes professional learning (Copland, 2003, p. 379). These conditions make teaching the CCSSM possible because teachers may become empowered to try new teaching practices, allowing them to embrace changes (Endacott & Goering, 2014; Mills, 2003; Zimmerman, 2006)

Change

Descriptions of change. Principals “who exercise moral purpose and personal courage to promote what is best for their students and achievable by their staffs” become credible leaders, and teachers become committed to the new curriculum and assessments (Hargreaves, 2004, p. 306). Principals who encourage and use teacher empowerment may incorporate the four components of capacity building: human capital, social capital, program coherence, and resources (Beaver & Weinbaum, 2012, p. 1; Mills, 2003; Zimmerman, 2006). Human capital is the combined strengths and preferences of each person that can be used to benefit the school population (Beaver & Weinbaum, 2012; Hargreaves & Fullan, 2013). The WHS staff recognizes outstanding achievements with an employee of the month trophy honor, and teachers are encouraged to apply for the Teacher of the Year award.

Teachers at WHS who achieve instructional goals receive recognition in social media on Facebook and Twitter. Social capital refers to the aligning of mutual goals by encouraging mutual understanding, collective expertise, care and concern for staff, and having integrity (Beaver & Weinbaum, 2012; Hargreaves & Fullan, 2013). Administrators at WHS practice social capital by praising teachers, thanking them, and recognizing them for creative problem solving. Program coherence consists of instructional agendas that guide teaching, learning, curriculum, and assessment (Beaver & Weinbaum, 2012; Hargreaves & Fullan, 2013).

Students may improve achievement if the school has a high level of program coherence (Beaver & Weinbaum, 2012, p. 4). Program coherence was difficult when we started teaching the CCSSM because of the newly adopted curriculum and lack of appropriate printed and internet resources. Teachers were anxious about being evaluated by student performance on the math PARCC tests; however, WHS administrators listened to us and kept us informed of the political changes. The curriculum of program coherence is the CCSSM, and the assessments of program coherence are PARCC, in addition to teacher created assessments that are based upon Pearson resources and sample PARCC test questions. These changes were made due to the leadership of the WHS principal and are an example of Fullan's (2004) components of leadership.

Fullan (2004) posits the five components of leadership are moral purpose, understanding change, building relationships, creating and sharing knowledge, and making coherence (Fullan, 2004, p. 4). The principal at WHS continues to build relationships by using time and energy to bond with the teachers and staff, and this encourages me to be more successful with mandated or episodic changes (Fullan, 2004). Knowledge may be created and shared from administrators to teachers through a social network using good relationships (Fullan, 2004), and the WHS administrators practice this process daily during formal and informal discussions with teachers.

Lewin (1951) refers to a change process with three steps: unfreeze, move, and refreeze. Unfreeze means to accept the fact that a change has occurred and accept the change. Math teachers at WHS accepted the CCSSM curriculum. Next, move and make the changes that are needed; this is the hardest part of the three steps for change. Teachers need training, coaching, encouragement, and trust in administrators in the movement phase, and we need trust from administrators (Kotter, 1996). Administrators at WHS are supportive and assist teachers if asked. Refreeze means the changes are accepted, new relationships may have formed, and the change components are now standard. This phase takes time (Fullan, 2004; Hargreaves, 2004; Lewin, 1951). Organizational change is complex, and scholars may use a combination of theories to explain the change process.

Hargreaves (2004) asserted, “Change and emotion are inseparable. Each implicates the other. Both change and emotion involve movement” (p. 287). The first thought one has about change is how it will affect them personally (Hargreaves, 2004). Teachers tend to have positive feelings toward self-initiated changes and negative feelings for mandated changes (Dezieck, 2007). Teachers in denial refuse to accept the concept of a change and must go through a grieving process (Dezieck, 2007). Changes from one school year to the next are cyclical changes for teachers, with the end of the year and the excitement of a new year in the fall, and each is emotional (Hargreaves, 2004). However, there is never just one change at a time in education because we have many changes at once (Dezieck, 2007).

At WHS, an external change was the appointment of a new principal in 2015 (Weick & Quinn, 1999), replacing an authoritative principal (Hargreaves, 2004; Northouse, 2012). The former principal controlled all aspects of the school, and the SLC and department chairs had no positive experiences with making suggestions. This led to teachers working on minute details and time keeping records that no one ever checked (Hargreaves, 2004). It was tiring and took valuable time away from making lesson plans and planning for new teaching practices. The current principal practices instructional leadership, and this is a welcome change for teachers. The teachers at WHS select professional goals for each year, and we have the support of the administration to try new practices without fear of failure.

My self-initiated change this year has been using Google Docs for student communication, collaboration, and small group presentations. I have two student presentations required each month for my Professional Development Plan (PDP), and this is an example of a mandated state reform movement to implement the CCSS (NJDOE, 2017). These are technical changes for me because they do not require a departmental dictate or board approval.

Teachers' reactions to change may be categorized as "technical, cultural, and political" (Hargreaves, 2004, p. 305). Technical changes apply to all teachers from the beginning to implementation, and then it becomes part of the school. The administrator's role is to guide the teachers through the technical change steps, and the WHS principal is supportive of teachers trying new practices. Cultural change requires one to understand the meaning the change has for each person, "not just the stages of development" (Hargreaves, 2004, p. 305). My PDP goals help me to understand the meaning of the changes from teacher-led to student-led practices. Political change refers to the power and influence that affect the change initiatives and the possible empowerment or loss of power for teachers and other staff. The principal at WHS is careful to include teachers or inform them of changes to teaching assignments. Principals have a great responsibility to keep all components of the change process in focus while attending to mundane, required daily technical tasks, and they may encounter barriers to the changes they would like to make.

Barriers to change. Many barriers may impede the progress of change (Zimmerman, 2006). For example, teachers may fail to recognize the need for change (Dezieck, 2007; Fullan, 2004; Hargreaves, 2004; Zimmerman, 2006). Teachers need a reason for the change to be made before they can commit to letting go of the status quo or change their habits. Furthermore, teachers may be afraid of change, or they may have had so many changes in the past that they think this is just another method for naught (Fullan, 2004; Zimmerman, 2006). Teachers without administrative support may not have the security of changing teaching practices for a fear of reprisal (Mills, 2003; Zimmerman, 2006). Moreover, change may cause a disruption in power or social relationships or a reduction in funding for resources (Zimmerman, 2006).

Summary. Principals decide what changes they need to make and choose the appropriate leadership theory to implement the changes. They may select either first or second order changes depending upon the needs of their school (Argyris & Schon, 1974; Heifetz & Linsky, 2002; Hess, 2013; Zimmerman, 2006). During the second order change process, principals become the leaders for staff to embrace the changes and make them routine (Argyris & Schon, 1974; Heifetz & Linsky, 2002; Zimmerman, 2006). Principals may create a sense of urgency using data to help teachers understand a need for change (Kotter, 1996; Zimmerman, 2006). For example, the WCPSD budget had a charter school expense of over $200,000 for the 2015-2016 year (J. Super, personal communication, June 16, 2016). Teachers are critical in helping the community, and parents have a good perception of WHS and the elementary schools to keep students in the public school district (Zimmerman, 2006).

Staff~~s~~ who implement new programs should be recognized and praised for accepting challenges and creating a positive atmosphere in the school or community (Kotter, 1996; Zimmerman, 2006). To help create a positive school culture, leaders must celebrate short-term successes, or celebrate the fact that data is showing improvement in student achievement or attendance (Bolman & Deal, 2008; Kotter, 1996; Zimmerman, 2006). WHS recognizes teachers who are improving on PARCC math and ELA during morning announcements over the intercom. Teachers and staff who work with students in school-community organizations receive recognition in the local newspaper and on the district web site. Teachers need recognition for their work and especially the math teachers.

Mathematics

The changes teachers encountered at WHS in teaching mathematics to prepare students for PARCC and the other standardized tests were time-consuming for me and the other math teachers. Using the Pearson (2012) materials helped me align the course objectives to the CCSSM; however, I am responsible for discovering the underlying math concepts required to pass a standardized math test for my students. Using the released items from the PARCC high school geometry test, I matched the underlying concepts to the appropriate Pearson (2012) and IXL Learning (2014) objectives. The adoption of CCSSM and the alignment of the PARCC are two external changes that the math teachers have incorporated at the high school, and teaching mathematics is important for the success of the students and to the purpose of education.

The purpose of the education system is to provide high-quality instruction to help all students attain standards (Heyneman, 2005). Improving teaching is a means to help students achieve in any discipline, and the process may be described as instructional capacity building of a school (Corcoran & Goertz, 1995). Three components of capacity building are the “intellectual ability, knowledge, and skills of teachers and other staff; the quality and quantity of the resources available for teaching, including staffing levels, instructional time, and class sizes; and the social organization of instruction or instructional culture” (Corcoran & Goertz, 1995, p. 27). The connection between a teacher’s college coursework, especially in math and science, and student achievement is positive. Over time, student achievement is cumulative provided the math teachers are highly qualified and certified. Therefore, “teacher quality is associated with student achievement” (Corcoran, & Goertz, 1995, p. 28).

Instead of offering programs, “that meet teachers’ learning needs” (Corcoran, & Goertz, 1995, p. 29), reformers should focus on changing behavior in the classroom. Teachers need appropriate resources for learning how to teach the CCSSM despite the freedom provided in the interpretation of the standards. Examples of student work, mastering math concepts that require teacher time not available in the school schedule, and PD specifically for mathematical topics may help math teachers improve teaching practices (Corcoran, & Goertz, 1995). Furthermore, students may learn mathematical reasoning outside the math classroom.

Mathematical reasoning is not just from textbooks and math teachers. The community offers mathematical reasoning in solving real-world problems, and situational learning during appropriate field trips may help students with cultural identity (Collins & Kapur, 2006; Courtney, Caniglia, & Singh, 2014). Teachers may present a problem and give students opportunities to gain experience practicing math concepts during the field trip and afterwards in solving math problems and reflecting on their responses (Collins & Kapur, 2006; Courtney et al., 2014; Osterman & Kottkamp, 2004).

Student performance needs to be diagnosed to plan, implement interventions, and use appropriate resources that address the mathematical weaknesses in student understanding (Hunt, & Little, 2014). High school math courses and the more challenging advanced math courses are important for student success in college (Parke & Keener, 2011). This is true regardless of race or gender (Parke & Keener, 2011). Furthermore, the sequence of math courses has an impact on college success. Algebra I in the ninth grade or earlier may determine higher achievement levels in high school and more math courses available to students (Parke, & Keener, 2011).

Ninth grade students who are in classes that are not advanced or honors classes usually do not have a qualified algebra I teacher (Hill & Dalton, 2013). According to Hill and Dalton (2013), “Out-of-field teachers are more prevalent among high-poverty schools, and teacher assignment policies within schools often pair the least-experienced teachers with the most challenging students” (p. 403). Therefore, the least qualified teachers in a school are assigned to teach algebra I and remedial algebra (Hill & Dalton, 2013). High school students learn more from certified teachers or those who hold degrees in math (Hill & Dalton, 2013). Moreover, seventh grade math performance is a predictor of later high school math achievement. For example, in Washington, DC schools, 10^{th} grade math proficiency in almost three fourths of the schools is correlated to the students' 7^{th} grade math scores (Baird, 2011, p. 804). Practicing mathematical concepts is important for students to learn problem-solving and build self-efficacy in every math course.

Learning a new math concept and how to apply it while solving problems require practice. Twenty-six years of teaching high school math courses has taught me that students who practice this process are more successful on classroom and standardized tests. Furthermore, I changed my classroom practices to include social networking both inside and outside the classroom with Google Docs, and I require students to make presentations in groups of three to explain and interpret their solutions (Resnick, 2010). Students learn from each other in this social environment, and they learn their own strengths and weaknesses (Rogoff, 2003; Vygotsky, 1978). These skills are required in order to reason and solve real-world problems, and this learning process is more meaningful (Resnick, 2010). Moreover, the CCSSM, PARCC math assessments, and the 21^{st} century learning skills require these changes in teaching practices (Partnership for 21^{st} Century Skills, 2002).

Resnick (2010) posits "mathematics… is the field that has made the greatest advances in codifying methods of teaching that ensure both mastery of basic skills and conceptual understanding and problem solving" (p. 187). Secondary math teachers must recognize and understand underlying math concepts, and they orchestrate classroom activities to help each student share important findings and concepts (Resnick, 2010). The challenge to teachers, schools, and districts is to ensure appropriate PD and on-the-job training sessions are available in a timely manner (Resnick, 2010). Teachers' knowledge of math is important, and the teaching skills – communicating, engaging students, creating successful learning environments – and pedagogical content knowledge are important for student achievement throughout the country (Resnick, 2010, p. 191).

The number of states mandating algebra I, geometry, and algebra II for graduation is growing, and some states are passing legislation requiring a fourth math course. The CCSSM include math concepts that are prerequisites for college and career readiness for STEM fields. For example, graphing complex numbers, matrices, vectors, trigonometric functions, inverse functions, and solving trig equations are addressed in the CCSSM (Richardson & Eddy, 2011, p. 280).

Educators, politicians, and business leaders believe that high school math student achievement is important for the economic success of the United States. Countries outside the United States have higher scores on the TIMSS and PISA in math and science (Slavin, Lake, & Groff, 2009, p. 839). Mathematics performance in American middle and high schools is an internal problem in the U.S., and White middle-class students outperformed minorities and disadvantaged students on NAEP 2007 scores. Approximately 43% of the White students scored proficient or better, while only 11% of African American students, 15% of Hispanic students, and 16% American Indian students scored proficient or better on the 2007 NAEP scores. States that had penalties for schools that did not meet student achievement goals on standardized tests had more success in improving students test scores than states that had no penalties as evidenced by the NCLB for grades 3 through 8 by 2006 (Hanushek & Raymond, 2005).

The mathematics scores on the 2007 NAEP assessments for both Black and White public school students were higher than in any previous assessment in grades 4 and 8 nationwide. White students had higher scores, on average, than Black students on all assessments, and in 2004, students ages nine and 13 math scores were higher than in any prior assessment (Vanneman, Hamilton, Anderson, & Rahman, 2009, p. iii). The 2007 scores included students from impoverished areas, and this may have been a factor in the decrease of the scores.

Schools in impoverished areas need improvements in many ways and not only in math performance (Slavin et al., 2009, p. 840). For example, quality math teachers and proper teaching practices are necessary for math performance improvement. Educational leaders need to research programs that help middle and high school students improve their math accomplishments and encourage and empower teachers to try the new programs. If a program is successful with one group of students in a school, other groups may show success. Special funding may be available for high-poverty low-achieving schools to provide teachers with the appropriate PD to implement each phase or part of a program (Slavin et al., 2009, p. 887).

Conclusion

Schmidt and Houang (2012) found "a very high degree of similarity between CCSSM and the standards of the highest-achieving nations on the 1995 TIMSS" (p. 294). The CCSSM are based upon the NCTM 2000 standards, and they provide states with articulate and demanding expectations (Dickey, 2013; Ross et al., 2015). The mathematical practices of the CCSSM are to be implemented in K-12, and they include problem solving, abstract reasoning, and the ability to argue effectively, model situations mathematically, use appropriate tools, and discover structure and patterns (CCSSI, 2018; Hakuta et al., 2013; NCTM, n. d.; Ross et al., 2015, p. 94; VanTassel-Baska, 2012, p. 222). These concepts may be important for learning in other core curricula, and my case study about the use of interdisciplinary units discovered high expectations from teachers to support student learning.

Improving student learning depends on four factors: teaching essential content, actively engaging students using appropriate curricular materials, using interactive and teacher-student or student-student responsive instruction, and using students' feedback about their thinking and problem-solving process (Confrey & Krupa, 2010; Vygotsky, 1978). The key points in grades 9-12 mathematics include practicing mathematical concepts with real world issues, allowing students to solve problems creatively and uniquely in new situations, and using mathematical models to analyze and solve a data analysis situation (Rust, 2012; Saunders et al., 2013; Wilson, 2013).

The controversy surrounding the CCSS and PARCC assessments continues in New Jersey. In 2015, Governor Christie announced that he would like to have different standards, yet the PARCC assessments will continue (Weinberg, 2015). The CCSSM and the PARCC tests have mathematical content that was not in the New Jersey math standards when I began teaching here nine years ago. I enjoy the challenges of teaching my high school geometry and algebra II students the rigorous content and practicing the real-world sample PARCC situations. The principal at WHS has high expectations and trust in our faculty, and we transfer high expectations to our students. Believing students are capable of learning challenging math concepts will give them a strong foundation in their math preparation for the challenges of the 21st century.

Chapter 3

Methodology

Purpose

The purpose of this qualitative exploratory holistic case study was to investigate ways to adapt the CCSS through the use of interdisciplinary units at WHS (Brydon-Miller et al., 2003; Eisenhardt, 1989; Glaser & Strauss, 2009; Levin, 2012; Reason & Bradbury, 2008; Yin, 2014). In this dissertation, I investigated how core curriculum teachers at WHS teach the CCSS using interdisciplinary units as well as any barriers they encountered during implementation. The focus of my study was on the core curriculum teachers who are trying to use an interdisciplinary approach. An additional purpose was to add to the knowledge base surrounding the incorporation of interdisciplinary units at the secondary level.

Problem

The purpose and problem statements addressed in my qualitative case study are directly related because the problem of high school students retaining mathematical concepts exists despite the adoption of the CCSS (Goyl, 2009; Kagan, 1992; Ogbu, 1992; Thomspon, 1984). This study to discover connections between students' retention of mathematical concepts and interdisciplinary instruction at the secondary level is important because students need to pass a standardized test as part of their graduation requirements (New Jersey Department of Education, 2017). This case study was significant in that it allowed an in-depth approach to investigate uses of interdisciplinary topics across the core curricula at WHS (Maxwell, 2013; Yin, 2014). Details are explained in the conceptual framework that follows.

Conceptual Framework

The conceptual framework of my qualitative case study centered on investigating ways secondary teachers adapted the CCSS across curricula by interdisciplinary units (Maxwell, 2013). I collected data from face-to-face interviews and graphic elicitations (see Appendix C) with teachers (see Appendix A) and students (see Appendix B), observed teachers teaching a lesson, kept a daily journal, recorded field notes, researched public documents, and wrote analytical memos each day from the variety of data sources (Copeland & Agosto, 2012). The conceptual framework included my findings from all data collected and the findings from the data analysis. Furthermore, it included how teachers and students enacted or perceived interdisciplinary units and included the discovery of any challenges they faced in incorporating interdisciplinary units in core courses.

The findings resulted in verification for the theory that making connections from prior knowledge, experiences, and personal interests enhances the learning skills of students and increases their capability to use critical thinking and problem solving throughout their high school learning experiences (Anyon, 1980; Hillman, 2014; Maxwell, 2013; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Yin, 2014). The research questions that follow related to the problem, purpose, and conceptual framework of my case study.

My qualitative case study focused on the following general overview qualitative research question: how do core curriculum teachers at one high school teach the CCSS using interdisciplinary units (Eisenhardt, 1989; Flick, 2007; Glaser & Strauss, 2009;

Reason & Bradbury, 2008; Rossman & Rallis, 2013; Yin, 2014)? Four sub questions included:

(1) How do core curriculum teachers at one school conceptualize and enact interdisciplinary unit lessons?

(2) How do core curriculum teachers at one school understand and enact the CCSS?

(3) How do science, social studies, and ELA teachers at one school incorporate mathematical concepts when teaching the CCSS?

(4) How do the core teachers at one school relate their instructional leadership to the implementation of the CCSS using interdisciplinary units?

Each of these questions is a qualitative research question I used for investigating and discovering the teaching of the CCSS at the secondary level. These research questions identified the problem of students using mathematical concepts in other disciplines, and stated the purpose of my qualitative case study to investigate ways to adapt the CCSS through the use of interdisciplinary units at one school (Brydon-Miller et al., 2003; Levin, 2012; Reason & Bradbury, 2008). They also provided the basis for my case study research, which provided a means to examine the real world and significant qualities of the core curriculum implemented using interdisciplinary units at a secondary school, WHS (Yin, 2014, p. 5). The investigation of these questions led to communication and collaboration with colleagues about our instructional program, and the findings will be shared with the staff upon administrative approval.

Role of Mathematics Teaching

One real world practice is that of mathematics teaching and the impact it has upon the future education of high school graduates. University and college admission personnel customarily use prospective students' academic history to decide admission and placement in mathematics courses. The students' high school math courses, grades, and scores on various aptitude exams such as the Scholastic Assessment Test (SAT) serve as reliable predictors of university math performance and placement (Norman, Medhanie, Harwell, Anderson, & Post, 2011, pp. 434-435). The math curriculum taught in high school that includes algebra and geometry has "a positive effect on college graduation and on earnings later in life" (Rose & Betts, 2001, p. iii).

Students who successfully complete advanced math courses and graduate from high school may earn more than 7.5% more income than a student who graduates but did not take a rigorous advanced math course (Rose & Betts, 2001, p. xvi). Similarly, students who complete advanced math courses and postsecondary education may earn an additional 9.8% more income than students with no formal education beyond high school (Rose & Betts, 2001, p. xvi). Furthermore, Rose and Betts (2001) state that a rigorous demanding sequence of math courses is required for all secondary schools (p. 57), and hiring qualified, trained math teachers and preparing all students to take advanced math courses is a priority for each local district (p. iii). WCPSD is committed to offering advanced math courses at the high school, WHS.

Setting

Wonder City has a population of approximately 11,300 and is in the southern half of New Jersey. The city boundaries are the Delaware River on the west and US Highway

76 on the east, and the area is urban, covering 2.8 square miles. The heavy industry of oil refinery has steadily declined, and the main industries are fishing and weaving. The most common occupations in 2015 were construction, management, sales, food preparation, maintenance and repairs, material moving, and production. According to the United States Census Bureau, construction jobs were the most common in 2010, with 14% of the workers being in this field. Approximately 63.4% were employed and 9.6% lived in poverty. Unemployment was over 6.1%, and the estimated median household income was approximately $53,000. In September 2015, the population was approximately 90% White, 6.7% Hispanic, 2.7% Asian, and 3% Black. Of all Wonder City residents, 85.1% were high school graduates or attended college, and 19% had earned a bachelor's degree or higher.

WHS was chosen as the site for my research study because its teachers are representatives of others across New Jersey who prepare secondary students to satisfy graduation requirements. WHS is one of 443 secondary schools in New Jersey, and the WCPSD is one of the 474 districts that manage a high school (New Jersey Department of Education, 2017). Each of the 443 secondary schools in New Jersey is adhering to the requirements of Achieve NJ by implementing the CCSS (New Jersey Department of Education, 2017), and WHS is typical of the participation of teachers across the state in similar settings (Yin, 2014).

WHS offers all advanced math courses to students, and all math teachers are trained and certified in secondary mathematics. WHS is the only high school in the WCPSD, with a district student population of approximately 2,200 in grades Pre-K through 12. Three elementary schools feed into WHS, and the junior-senior high school population is approximately 800 students in grades 7-12. The WCPSD is a Title I District with a total operating budget for the 2016-2017 year of approximately $41 million and approximately $1.3 million from federal aid (New Jersey Department of Education, 2014). WHS staff includes four administrators, 75 teachers, and two academic supervisors.

The NJDOE uses the School Performance reports to categorize schools within peer groups to compare data in college and career readiness, academic achievement, graduation, and postsecondary education (NJDOE, 2014). WHS is in a peer group of 30 other schools with similar characteristics, with 69% of the students economically disadvantaged based upon the Free/Reduced Lunch Programs (NDOE, 2014). Limited English Proficiency learners are 0.6% of the student population, and 21.4% are enrolled in Special Education Programs (NJDOE, 2014). WHS is one of three schools with over 68% of the students enrolled in the Free/Reduced Lunch Programs, and one of six schools with over 21% of the students in special education.

The NJDOE School Performance Report Card shows WHS met its graduation performance and academic ESEA Waiver in English and Math. WHS lags behind its peer group in College and Career Readiness. The graduation rate was 82% in 2015, and WHS met the target indicator for graduation. Additionally, 66% of the graduates enrolled in either a two-year or a four-year institution (NJDOE, 2014). Secondary core curriculum teachers teach students identified by any of the NJDOE demographics, and I asked them to participate in this study. The approachable communication and collaboration among secondary teachers that I experience daily at WHS continued throughout my study, and I will share information that I discover with other teachers after administrative approval.

Participants

Teachers of math, ELA, science, and social studies at WHS, as well as some students, were the population for this study. Core curriculum teachers enacting the CCSS may have incorporated the topics from a discipline that differed from their own, and this linking of topics across curricula is a key element of the CCSS and interdisciplinary teaching techniques (CCSSI, 2017; Hillman, 2014; Coalition of Essential Schools, n.d., p. 11; Lee, Quinn, & Valdés, 2013).

I have taught high school math at WHS for nine years, and the high school is the center of the community with a history of over 100 years. The administration at the district and school are positive about employees furthering their formal education, and they recognize the challenges of pursuing a doctorate. I know most of the core curriculum teachers, especially the department chairs, and they are helpful and knowledgeable about the culture of WHS, its history, and the core curricula (Bolman & Deal, 2008). During the 2016-2017 year, there were 25 teachers teaching the core curricula—math, science, social studies, and ELA—in grades 9-12. I asked 14 teachers at WHS to volunteer to participate in my study because of their perceptions of teaching interdisciplinary units in core curricula.

Therefore, the participants for the study were selected by purposeful and criterion sampling methods (Sandelowski, 1995). These methods provided the most straightforward data for the study, and criterion sampling strengthened the rigor of the study (Patton, 2002). My choice of participants in the criterion sampling met the following three criteria. First, the participants teach full-time at WHS, and this was necessary because teachers must know the adopted curricula in their core discipline and have knowledge of appropriate internet sites used in their department for instruction. Second, knowledge of the state and federal mandates concerning CCSS and standardized testing was important because we align lesson plans to the CCSS in ELA and math using the Oncourse (n.d.) lesson plan function on a weekly basis. Third, teachers who teach the core CCSS—math, science, social studies, and ELA—were critical to the study. Most teachers have been teaching at WHS for over 14 years, and all teaches are certified in their field.

Other participants were students who have been enrolled at WHS for at least one year, and they were selected by purposeful criterion sampling (Sandelowski, 1995). I asked students to volunteer to be interviewed and complete a graphic elicitation during half of a class period in my classroom. The integration of math, social studies, ELA, and science helps students learn new concepts by making connections based upon experiences and interests (Dewey, 1902; Jacobs, 1989; Songer & Kali, 2006). I investigated ways teachers integrate other core curricula, and this discovery process may add to the knowledge base surrounding interdisciplinary units.

Protection of a participant's confidentiality is vital to my study, and pseudonyms were used for students, teachers, and employees. Furthermore, all participants signed a letter of consent to become a member of the study, and students' parents or guardians signed consent forms for underage students. I protected participants from any harm or deception, and I protected their privacy by not listing them in any category in my findings where their identity may be revealed. I followed the rules of involvement for students from the WCPSD and the Rowan University Institutional Review Board (IRB).

Definition of Interdisciplinary Units

Interdisciplinary units have tentatively been defined as detailed lesson plans stating the CCSS and lesson objectives found in curriculum resources, teachers' directions, and student assignments or labs. Mathematics was the subject of my qualitative case study, and core curriculum high school teachers using interdisciplinary units to teach the CCSS were the focus of my study. I chose high school algebra I, geometry, and algebra II subjects as my focus because the concepts may be difficult for some students to comprehend; however, math concepts may become meaningful to students if core curriculum teachers incorporate them in interdisciplinary units (Hillman, 2014). The CCSS refer to solving problems both inside and outside of the classroom (CCSSI, 2018), and the standards in each core discipline connect to each other (Lee et al., 2013).

Furthermore, interdisciplinary units may be incorporated as teaching strategies to help students make connections throughout their high school learning experiences (Hillman, 2014). An interdisciplinary curriculum focuses "on broad areas of study since that is how children encounter subjects in the real world—combined in one activity" (Coalition of Essential Schools, n.d., p. 11). This thematic activity provides students unity in learning and helps them to create new models of understanding by incorporating the methodology and language from the various disciplines within the unit (Coalition of Essential Schools, n.d., p. 11). See Appendix D for one model of an interdisciplinary unit based upon the research of Connect Ed in California (Connect Ed: The California Center for College and Career, 2010). The authors of the report collected models from 11 high schools across the country and developed a model that mirrors the broad topics used in units. I modified the model into a listing for ease of use by teachers at WHS and presentations to the administration.

In contrast, the lack of retention of math concepts by students is a problem in high school (Kagan, 1992; Ogbu, 1992; Thomspon, 1984). Most states adopted the CCSS devices to promote integration of concepts across curricula (CCSSI, 2017). However, if schools do not have cross-curricular integration, then the integration will not happen, and mathematical concepts may not be retained effectively (Coalition of Essential Schools, n.d.). Nevertheless, interdisciplinary units help students learn (Dewey, 1902; Hillman, 2014; Coalition of Essential Schools, n.d.; Jacobs, 1989; Songer & Kali, 2006). Therefore, my methodology was a qualitative exploratory case study to discover how core teachers at a secondary school incorporated the CCSS and mathematical concepts.

Methodology

To answer the research questions, explore and understand the perceptions of the selected teachers and students, and utilize various methods of inquiry, a qualitative exploratory holistic case study was selected (Eisenhardt, 1989; Flick, 2007; Glaser & Strauss, 2009; Reason & Bradbury, 2008; Rossman & Rallis, 2013**;** Yin, 2014). Qualitative research starts with questions that seek the answers to the purpose of the study and produce knowledge for the investigator during a collaborative process with the participants (Rossman & Rallis, 2012). A qualitative case study methodology provides instruments to study complicated situations within their contexts using a variety of data sources (Baxter & Jack, 2008; Yin, 2014), and allows research from a variety of lenses for the situation to be disclosed and understood (Yin, 2014). Participants collaborate with the investigator and have an opportunity to relate their interpretations of the situation, and the investigator has an opportunity to understand the decisions of the participant (Lather, 1992; Lincoln & Guba, 1985; Maxwell, 2013; Miles, Huberman, & Saldana, 2014; Rossman & Rallis, 2012; Rubin & Rubin, 2012). Participants are unique, and their experiences establish their responses to the research questions (Gertz, 1974; Miles et al., 2014; Rossman & Rallis, 2012). The use of unique participants and one unique high school were within the context of the study (Yin, 2014).

A qualitative study focuses on the process of researching (Maxwell, 2013), and it enables the investigator to gather detailed information through face-to-face discussions with the participants (Gertz, 1974; Miles et al., 2014), as well as other methods of data collection. Interviewing, observation, and review of artifacts are some of the methods to collect data that were used in this study (Maxwell, 2013; Miles et al., 2014; Pope & Mays, 2006; Rossman & Rallis, 2012). Information was discovered through interpretation of the data that was analyzed inductively and examined methodically (Rossman & Rallis, 2012), and the resulting conjectures were submitted (Creswell, 2014; Creswell & Plano Clark, 2011). For this qualitative study, an exploratory holistic focus was selected.

A qualitative exploratory holistic case study was the strategy of inquiry selected to explore the situations teachers encounter when deciding to use interdisciplinary units to implement the CCSS (Eisenhardt, 1989; Glaser & Strauss, 2009; Reason & Bradbury, 2008; Yin, 2014). An exploratory holistic case study focuses on discovering outcomes that are not predicable in a unique context and is global in nature in that it uncovers multiple perspectives from each participant, the various factors of adapting the CCSS, and teachers’ decisions to use interdisciplinary units (Eisenhardt, 1989; Glaser & Strauss, 2009; Reason & Bradbury, 2008; Yin, 2014). Furthermore, an exploratory holistic case study was chosen because there are no uncomplicated solitary outcomes, WHS is a unique school (Yin, 2014), and it is representative of other high schools in New Jersey adapting to changes required under the provisions of Achieve NJ (NJDOE, 2017). Holistic provided a means to describe the global nature of exploring the choices teachers made to use interdisciplinary units; each teacher is unique, and a theory may be discovered after data analysis and interpretation (Auerbach & Silverstein, 2003; Corbin & Strauss, 2008; Glaser & Strauss, 2009; Maxwell, 2013; Saldana, 2013; Yin, 2014).

During my study, I discovered the real-world factors of teaching interdisciplinary units from core curriculum teachers. Cushman (1992) explains that the real factors of teaching may include teachers faced with preparing students for standardized tests, specific curriculum objectives that must be taught and learned as prerequisites for the next course, and parental concerns that this is not the way they were taught in high school. Cushman explains further that secondary school schedules prevent teachers from teaching the same group of students at the same time, and time and resources to prepare the lessons is limited. Teachers need time to implement specific activities and reflect upon the teaching practices afterwards by collaborating with each other, but time is not available (Cushman, 1992, para. 12). In addition, teachers may realize that the objectives for their discipline are not taught as rigorously as those in the other disciplines in the unit (Cushman, 1992, para. 14). Similarly, teachers' beliefs and values about interdisciplinary units influence their instructional methods, their lesson preparations, and their level of commitment to the integration of other subjects into their core course (Cushman, 1992; Coalition of Essential Schools, n.d.; Kagan, 1992; Ogbu, 1992; Thompson, 1984).

Despite these real situations and barriers, teachers are change agents (Swanson & Stevenson, 2002), and they deal with changes each year. For example, different students, different curriculum resources, or new state or local mandates are part of each school year, and teachers are critical in implementing new policies or administrative regulations (ASCD, 2012; Berg, Carver, & Mangin, 2014). Teachers are necessary for teaching the standards and objectives in the CCSS of their discipline, and especially for helping students learn (Kagan, 1992; Thompson, 1984). This is particularly true for teaching students mathematics (Kagan, 1992; Thompson, 1984).

Furthermore, teachers must collaborate with each other when trying new teaching practices, such as using topics from other disciplines in a lesson or creating an interdisciplinary unit across disciplines. Teachers learn from other teachers through collaboration (Dilley, 2000; Osterman & Kotthamp, 2004; Rossman & Rallis, 2013; Rubin & Rubin, 2012), and having their support is necessary as they practice new ways to teach (Runhaar et al., 2010). The support and collaboration from other teachers helps each teacher as they take a risk with a new way of teaching (DuFour & Eaker, 1998; Osterman & Kottkamp, 2004).

In brief, the purpose of my study was to investigate ways to adapt the CCSS and teaching interdisciplinary units. Teachers are critical to student learning, and interdisciplinary connections made by students help them learn new concepts in the core curricula. My research question is, how do core curriculum teachers teach the CCSS using interdisciplinary units? My methodology was a qualitative case study to investigate how teachers at one secondary school enacted the CCSS and integrate other core disciplines. My study required a plethora data types to create a thorough and valid research study that may add to the knowledge base surrounding secondary interdisciplinary units while protecting the confidentiality of all participants. The process of discovering how teachers may or may not use interdisciplinary units was one of collaboration and communication between the participants and myself. All data that I collected was shared with the participants to review and validate.

Data Collection

Using a qualitative exploratory case study (Eisenhardt, 1989; Glaser & Strauss, 2009; Reason & Bradbury, 2008; Yin, 2014), I used three data collection protocols – an interview with semi-structured questions (see Appendices B and C) (Rubin & Rubin, 2012; Ryan & Bernard, 2003), classroom observations (TNTP, 2017), and a graphic elicitation (see Appendix A). I interviewed core curricula teachers and some students during a convenient time at school. An interview protocol listing a set of semi-structured questions (see Appendices B and C) was submitted to the participants at the beginning of each face-to-face interview, and the interviews were recorded with the participants' permission.

Additionally, I scheduled classroom observations using an observation tool (TNTP, 2017), and I shared my notes with the teacher. Conjointly, I used a graphic elicitation protocol using a pre-printed concept map (see Appendix A), that is a social artifact that helped the participant relax and provide me with an understanding of the his or her interpretation of the components of an interdisciplinary unit (Copeland & Agosto, 2012; Crilly, Allan, & Clarkson, 2006). I asked each teacher and student participant to fill in the blocks on the graphic organizer with their interpretation of an interdisciplinary unit that contains math concepts. Interviews, graphic elicitations, and classroom observations created opportunities for me to collaborate with the core teachers and students (Dilley, 2000; Rossman & Rallis, 2013; Rubin & Rubin, 2012), and my notes became part of my daily journal and field notes (Corbin & Strauss, 2008; Flick, 2007; Maxwell, 2013; Miles & Huberman, 1994; Miles, Huberman, & Saldana, 2014; Rubin & Rubin, 2012).

The interview protocol presented an opportunity to understand the data the participant drew or wrote on the graphic elicitation. For example, some teachers collaborated and communicated with other teachers in cross-curricular planning (Dilley, 2000; Rossman & Rallis, 2013; Rubin & Rubin, 2012), and I discovered how the teachers incorporated this time into the daily or weekly schedule. My field notes from these discussions created more data collection protocols, and I used purposive criterion sampling for all interviewed participants (Sandelowski, 1995). The participant sampling was based upon the attributes that cultivated insight and knowledge about the incorporation of different disciplines in one unit of study based upon the CCSS (Patton, 2002; Teddlie & Tashakkori, 2009). Choosing teachers who provided relevant, thorough, and valid information enlightened the qualitative study by providing detailed information about their beliefs and values concerning teaching interdisciplinary units and the CCSS (Cushman, 1992; Coalition of Essential Schools, n.d.; Kagan, 1992; Ogbu, 1992; Thompson, 1984).

Additional data collections included field observations to gain an understanding of how teachers enacted the CCSS and how they planned or worked with standards outside their discipline (Rossman & Rallis, 2013). Field observations included daily journal notes from attending math departmental meetings while observing teachers and their reactions to information presented or discussed within their department (Patton, 2002). Additionally, Patton (2002) explains that field observations offer different methods to determine cultural norms and values that may not be observed in formal interviews. The data collected from field observations and daily journal notes added details that produced emerging categories through the data analysis process.

Collecting unobtrusive data by reading archival documents and public documents from the WCPSD Board of Education Meetings and administrator meetings provided espoused theories or perceptions about implementing the CCSS (Argyris & Schon, 1974; Coffey, 2014). These documents offered additional information about implementing interdisciplinary units in a teacher's lesson. The forms of data I collected included departmental meeting agendas and minutes, curriculum documents, the school improvement plan, and other pertinent documents.

As mentioned earlier, I used face-to-face interviews and graphic elicitations for each participant. The taped interviews were transcribed verbatim and the transcriptions stored on a computer. I wrote analytical memos the same day as the interview sessions and stored them on a computer. The graphic elicitations are filed in a filing cabinet at my home, and all papers will be destroyed after my study is completed.

I kept a daily journal, recorded my field notes in my journal, wrote daily analytical memos from my field notes, and stored them on a computer. Upon approval by the principal at WHS, I created an observation schedule for observing core classroom teachers using an observation tool (TNTP, 2017). The analytical memos I created from the classroom observations are stored on a computer, and I shared my notes with the observed teachers (Anderson, 2010). I created a methods matrix (see Appendix E) that related my research questions to the data sources (Anfara, Brown, & Mangione, 2002).

Teachers communicate and collaborate at WHS during departmental meetings, lunches, before or after school hours, and in informal conversations during hall or cafeteria duty. My study was a collaborative project because I shared information with teachers, and what I learned from them I shared with others. Many years as a high school math teacher taught me that conversations with other teachers is a valuable use of time to discover various types of teaching practices and resources that I may incorporate into my instructional program. Findings from my study will be shared with our staff upon approval from the principal at WHS. Finally, I discovered the underlying beliefs of participants' viewpoints about interdisciplinary units.

Teachers Influence

Teachers' beliefs and values about interdisciplinary units surfaced during the data collection process through interviews, graphic elicitations, and classroom observations (Kagan, 1992; Thompson, 1984). Graphic elicitations from teachers or students helped them relax and recall important concepts during the interviews and helped produce quality communication and collaboration between me and the participants (Dilley, 2000; Rossman & Rallis, 2013; Rubin & Rubin, 2012). The interdisciplinary unit discoveries included an assessment modeled after the PARCC sample tests (PARCC, 2015); however, this study did not include pre-test or post-test PARCC assessments. This qualitative case study did not include Student Growth Objective (SGO) test items that related specifically to math) (NJDOE, 2017); however, math improvement was not the focus of this study. Furthermore, I analyzed all data using the methods discussed in the data analysis section that follows.

Data Analysis

I wrote analytical memos immediately after each observation and interview. I also wrote memos of my findings of the artifacts, field notes, transcribed interviews, classroom observations, and graphic elicitations. These memos contain my interpretation of the aspects of the study and any questions for further research (Auerbach & Silverstein, 2003; Corbin & Strauss, 2008; Glaser & Strauss, 2009; Maxwell, 2013; Saldana, 2013; Yin, 2014). Each type of data was coded initially as descriptive or topical, and this process helped establish insight into use of interdisciplinary units (Auerbach & Silverstein, 2003; Flick, 2007; Saldana, 2013; Schreier, 2014; Yin, 2014). I developed a codebook to arrange and rearrange the data in various categories that helped answer my research questions (Maxwell, 2013, p. 107). Using the codes daily to analyze data helped me discover repetitive concepts and themes from the various types of input in my study (Maxwell, 2013).

Next, I used descriptive coding in the first cycle from all the interviews and graphic elicitations to analyze data. Descriptive coding was appropriate to discover the integration of math in other disciplines and support my research question (Auerbach & Silverstein, 2003; Flick, 2007; Saldana, 2013); that is, how do core curriculum teachers teach the CCSS using interdisciplinary units? I transcribed each interview verbatim and went line-by-line through the dialogue to compare and contrast across and within participants' comments and answers. Furthermore, descriptive coding allowed me to identify emerging categories of similar topics within the context of the data focusing on my research question (Flick, 2007; Saldana, 2013, p. 88).

After discovering similar topics within the data, I used pattern coding as my second cycle of coding (Auerbach & Silverstein, 2003; Flick, 2007; Miles & Huberman, 1994; Rossman & Rallis, 2012, Rubin & Rubin, 2012; Saldana, 2013; Schreier, 2014; Yin, 2014). Identifying emerging patterns of data by systematically coding all data provided overarching themes related to the research questions from the categories discovered during the first cycle (Auerbach & Silverstein, 2003; Corbin & Strauss, 2008, Flick, 2007; Glaser & Strauss, 2009; Maxwell, 2013; Saldana, 2013; Yin, 2014). Pattern coding provided a method to determine similarities and differences among and within the context of the data that were pertinent to how interdisciplinary units may improve math comprehension (Auerbach & Silverstein, 2003; Saldana, 2013). The progression from codes to categories to themes that related to my research question provided me with documented responses supporting the use of interdisciplinary units that may improve math comprehension (Auerbach & Silverstein, 2003; Saldana, 2013, p. 210).

Data was triangulated from the data sources and created comprehensive themes using pattern coding (Craig, 2009; Patton, 2002; Toma, 2006; Yin, 2014). The themes within the memos provided the inclusion of math, other core curricula, and collaboration among teachers (Auerbach & Silverstein, 2003; Saldana, 2013). I sent participants a copy of their transcribed interviews through email and asked them to verify the document for accuracy. One participant responded with two corrections, I made the corrections, and sent the interview transcription back for corrections, and there were none (Anderson, 2010). This process ensured validity and trustworthiness in my qualitative research (Craig, 2009; Guba, 1981; Maxwell, 2013; Patton, 2002; Toma, 2006; Yin, 2014).

The themes discovered were determined by using code iterations and data applications (Anfara, Brown, & Mangione, 2002). I produced a table showing the first iteration naming the initial codes and surface content analysis; the second iteration stated the themes, and the third iteration stated the data analysis (Anfara et al., 2002). Furthermore, the integration produced a framework about the experiences of teachers trying interdisciplinary unit lessons (Corbin & Strauss, 2008; Creswell, 2014). Discovering themes from code iterations (Anfara et al., 2002; Eisenhardt & Graebner, 2007; Roulston, 2014) and data applications led to discovering a theory from the themes (Corbin & Strauss, 2008; Eisenhardt & Graebner, 2007; Patton & Appelbaum, 2003), which was “the ultimate goal of the case study" (Patton & Appelbaum, 2003, p. 67).

In summary, the data collection from many sources, the data analysis of the analytical memos and notes, and the coding of the data addressed the research questions and the purpose of my study. The themes I discovered from the data analysis enabled me to discover an emerging theory (Corbin & Strauss, 2008; Eisenhardt & Graebner, 2007; Patton & Appelbaum, 2003). Furthermore, triangulation of data confirmed the validity of my study (Craig, 2009; Maxwell, 2013; Patton, 2002; Toma, 2006; Yin, 2014). Sharing the results of my study with the teachers at WHS may provide a platform to improve conversations about improved teaching and learning at WHS (Berg, Carver, & Mangin, 2014). The application and combination of the several sources of data established validity and triangulation as discussed below (Craig, 2009; Patton, 2002; Toma, 2006; Yin, 2014).

Validity

Internal validity was maintained by using my journal notes from field observations, departmental meetings, data analysis, analytical memos, field notes, word for word transcriptions of interviews, and classroom observations (Eisenhardt, 1989; Patton, 2002; Yin, 2014). Maintaining internal validity led to trustworthiness, and trustworthiness was strengthened by verifying interviews and graphic elicitations with participants (Anderson, 2010; Creswell, 2013; Miles et al., 2014) and making any changes with them through emails (Barbour, 2014; Burnard, Gil, Stewart, Treasure, & Chadwick, 2008; Yin, 2014). Using the documents and analyses produced triangulation as described below.

Triangulation

Triangulation is a method to ensure validity (Patton, 2002; Yin, 2014), and I created triangulation by using public documents and maintaining ethical considerations throughout my study (Argyris & Schon, 1974). Triangulation and validity were established by obtaining informed consent forms for all participants (Mertens, 2014; Roulston, 2014), gaining permission for my study from Rowan University through the IRB, and gathering permission from the WCPSDBOE to conduct my study. Furthermore, I explained my study and my role as a teacher-participant to the principal of WHS prior to starting (Stringer, 2007). This required process allowed me to gain permission to collect archival documents and conduct this qualitative action research study from the superintendent of the WCPSD. Moreover, I followed protocols to prevent blatant forms of unethical and illegal research throughout the study. As a teacher-practitioner in the educational research study, I had a dual role of participant observer and researcher, and I encountered challenges concerning objectivity (Craig, 2009). I addressed any issues that happened as a participant and an observer-researcher by maintaining honest, ethical procedures (Booth et al., 2008).

Teacher-Participant

My roles throughout my study included being a teacher-participant (Stringer, 2007) and an observer (Booth et al., 2008). As I gathered data, wrote analytical memos, and analyzed data for themes, I did not discover outliers, which are statements from participants that did not fit into a popular pattern or theme (Booth et al., 2008; Miles et al., 2014). Any outliers would lead to a different study in the future. Moreover, avoiding bracketing during the interviews or classroom observations was important because I did not want to destroy the validity of my study if I used my preconceptions about the topic discussed by the participants (Auerbach & Silverstein, 2003; Booth et al., 2008; Gearing, 2004; Levin, 2012; Miles et al., 2014; Saldana, 2013; Shapiro & Stefkovich, 2011). By allowing enough time for interviews, scheduling interviews, and scheduling classroom observations collaboratively with the participants, I may have earned their respect as an educational researcher.

What was implicit in the culture of WHS may have affected the participants' responses and actions about my work during their interviews, classroom observations, or graphic elicitations (Corbin, & Strauss, 2008). I was aware of some concerns teachers had about losing their planning period, so I conducted interviews before or after school hours as well as during planning periods. Furthermore, I provided each participant a copy of the transcribed interview, and my interpretation of the graphic elicitation prior to using any responses in my data analysis (Anderson, 2011; Miles et al., 2014).

In summary, the purpose, research questions, rationale, data collection, data analysis, and ethical considerations in my study may have affected my integrity and the integrity of the school staff if I had not followed all ethical protocols. Furthermore, WHS is the center of Wonder City, and generations of families have graduated from WHS. The reputation of school personnel is important to each teacher and the community, and teachers become the leaders within their classroom, department, the school, and the community.

Implications of Leadership

Educators at the school level encourage new sources of leadership due to the challenges created by changes in mandates from federal, state, and local board of education governments (Anderson, 2009; Copeland, 2003; Goldstein, 2004). School administrators who maintain a focus on improving instruction improve student achievement while incorporating new mandates (Leithwood, Louis, Anderson, & Wahlstrom, 2004; Waters, Marzano, & McNutty, 2003). Teachers become leaders through professional learning, constant change, and increased student achievement (Hopkins & Spillane, 2015; Spillane, Halverson, & Diamond, 2001). Furthermore, teacher leadership promoted by administrators helps create an environment favorable to change by increasing the number of teachers implementing instructional leadership and eventually improving student achievement (Blasé & Blasé, 2000; Hopkins & Spillane, 2015). My goal was to become a resource for school improvement, and earning the trust of other teachers provided me opportunities to practice distributive leadership in an ethical manner (Berg et al., 2014).

Anyon's (1980) study inspired me for this study and based upon my preparation from the doctoral program at Rowan University, I believe that I have the knowledge and skills to discover how to incorporate interdisciplinary units in my teaching practices. Importantly, teachers are the change agents (Swanson & Stevenson, 2002), and we may practice pragmatic worldviews to develop interdisciplinary units based upon what works (Creswell, 2014; Dewey, 1902; Johnson & Onwuegbuzie, 2004). As a researcher-practitioner (Stringer, 2007), I had the freedom to choose a qualitative case study and discovered the methods required to create interdisciplinary units of the core curricula (Anderson, 2010; Corbin & Strauss, 2008; Creswell, 2014). I also have the trust of my co-workers and included the barriers encountered when creating interdisciplinary units. I plan to share my work with the administration of WHS and offer my services as a teacher-leader. The principal is open to suggestions and very helpful to me in my studies at Rowan.

The principal at WHS uses referent leadership and establishes a friendly and supportive culture for teachers to try new teaching strategies and take risks (Hersey & Blanchard, 1972). The administrative team, the principal, and vice-principal communicate and collaborate with teachers and meet regularly with the SIC. School administrators ask questions and provide instructional leadership using suggestions from the SLC (Hallinger, 2003).

Because I am an educator with over 40 years in education, and I have taught high school math students for over 26 years, I have encountered many different students in my high school math classes. What works in one class on one day may not work with a different class of students on the same day, even if the lesson plans are identical and the class structure is the same. I adjust my teaching practices according to the culture and personalities of the students (Bolman & Deal, 2008), and pragmatism is my worldview because it is practical for my students (Creswell, 2014; Dewey, 1902; James, 1975; Johnson & Onwuegbuzie, 2004). This pragmatic worldview leads me to explain my assumptions.

My Assumptions

My assumptions were that any student with the intellectual capability to learn concepts and skills in high school math courses may benefit from teachers' teaching strategies that include Vygoskian constructivism and components of cognitive apprenticeship dimensions. Teachers and students communicating and collaborating can create a classroom climate that is safe and challenging for all students. I believe that students can work to the level of the expectations of the teacher and increase their own individual learning strategies.

Summary

This qualitative exploratory case study examined how core curriculum teachers taught the CCSS using interdisciplinary units. Furthermore, I explored how teachers enacted interdisciplinary unit lessons, the CCSS, incorporated mathematical concepts, and how they related their instructional leadership to implementation of the CCSS using interdisciplinary units. Teachers and school administrators who focus on the goal of improving instruction maintain the best interests of the students, other school staff, and the members of the community.

This study discovered the theory that teaching using interdisciplinary units helped students retain concepts in the individual courses (Jacobs & Borland, 1986). The findings resulted in verifying the theory that making connections from prior knowledge, experiences, and personal interests enhanced the learning skills of students and increased their capability of using critical thinking and problem solving throughout their high school learning experiences (Anyon, 1980; Hillman, 2014; Maxwell, 2013; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Yin, 2014)

Chapter 4

Findings

The purpose of this qualitative exploratory holistic case study was to investigate ways to adapt the Common Core State Standards (CCSS) using interdisciplinary units (IU) at one high school, Wonder High School (WHS) (Brydon-Miller et al., 2003; Levin, 2012; Reason & Bradbury, 2008). This study expanded on Jacob's (1989) and Songer and Kali's (2006) research about teaching core disciplines at the secondary level using IU that may enhance students' mathematical comprehension. This study explored the theories espoused by teachers and students about incorporating mathematical concepts in IUs within secondary core disciplines. Instructional leadership practiced by teachers was researched through their perception of teaching the CCSS using IUs.

The following research questions were used as a guide throughout this study and were the organizational focus of this dissertation. The overall research question was how do core curriculum teachers teach the CCSS using interdisciplinary units? Four sub questions were essential in identifying findings and creating themes through data analysis:

(1) How do core curriculum teachers at one school conceptualize and enact interdisciplinary unit lessons?

(2) How do core curriculum teachers at one school understand and enact the CCSS?

(3) How do science, social studies, and English Language Arts (ELA) teachers at one school incorporate mathematical concepts when teaching the CCSS?

(4) How do the core teachers at one school relate their instructional leadership to the implementation of the CCSS using interdisciplinary units?

The first three chapters of this dissertation included the educational topics that created a sense of purpose and curiosity about how high school teachers enact the CCSS using IUs, a literature review of the theory that students comprehend disciplinary concepts if they are included in an IU that allows students to make connections from previous experiences, and finally, the method used to explore and discover the answers to the research questions. The literature review contains the theoretical framework of teaching the CCSS using IUs and implementing instructional leadership. The methodology of an exploratory case study allowed the flexibility to collect data from a variety of sources and analyze the data as presented in this chapter. The research process of the first three chapters enabled the analysis of the data and discovery of how teachers enacted the CCSS using IUs and incorporated mathematical concepts in one school.

Four themes emerged using a recursive analysis and the protocols in this study, and they were framed by the research questions. Subthemes were used to categorize data within the discovered four themes that follow: a) How teachers conceptualized an IU in a discipline and the barriers encountered, b) Mathematical concepts incorporated into a lesson and the effect on students' math comprehension, c) Instructional strategies teachers used frequently and subthemes of constructive apprenticeship, and d) Instructional leadership in the classroom and administrative expectations.

The participant population and data collection are discussed in the next section, which contains tables that categorize teacher and student participants. A summary of the protocol for collecting data from participants, a summary of the data collected from classroom observations, a teacher survey, and the results are included. A summary of the data from both teacher and student interviews are displayed in tables or appendices.

Participant Population and Data Collection

Teachers from each of the four core disciplines and students from the sophomore, junior, and senior classes created the participant population. I observed one of the classes taught by each of the 14 teachers, and each teacher sat for a face-to-face interview. Ten of the teachers returned the printed survey. Furthermore, eight students were interviewed, and the data collected from both teachers and students was used to reveal their perceptions of the use of IUs. This section of Chapter 4 is divided into the following subsections: teacher participants, student participants, summary of protocol, teacher observations, technology, teacher survey, teacher interviews, student interviews, and a summary of this section.

Teacher participants. During departmental meetings, each teacher received an email with an overview for this research study in the form of an attached PowerPoint presentation. Each teacher in the disciplines of science, math, social studies, and English Language Arts received a printed copy of the consent forms, the observation tool, and a handout explaining definitions of an IU. Some teachers volunteered, and I spoke with other teachers individually after the meetings. Fifteen teachers agreed to be participants to be observed. One teacher was not able to complete the study due to a family emergency; therefore, 14 teachers completed the study protocol.

Teacher participant anonymity was protected by categorizing teacher participants according to their life cycles within five stages of career paths (Huberman, 1989). Huberman (1989) researched Switzerland teachers at the secondary level, grades 9 through 12, and described five stages according to their years of teaching experience. The first stage was survival and discovery during the first three years. These teachers were overwhelmed but excited to be in the classroom. The second phase was stabilization in the fourth to sixth years, when teachers became committed to teaching. Teachers added more strategies, became more autonomous in their classes, and developed a sense of pride in their teaching strategies (Huberman, 1989).

Huberman's (1989) third stage – experimentation/activism or self-doubt/reassessment – occurred between the seventh and 18th years of experience. Teachers went through one or both phases and became aware of organizational culture and traditions that prevented them from taking a leadership role within their school or district. The self-doubt or reassessment phase described teachers who considered leaving the profession. Teachers moved through these phases during their careers, and they experienced them at different times (Huberman, 1989).

Huberman's (1989) fourth stage was between 19 and 30 years, labeled the serenity or conservative phase. Teachers were confident, distanced themselves from the students, and focused more on the environment outside the classroom. The conservative phase categorized teachers who were more critical of students and beginning teachers. The fifth stage from Huberman's (1989) research was disengagement, described during the years between 30 and 40. Teachers looked forward to retirement and were positive when they reflected on their teaching career. Table 1 lists the teachers in this study by their years of teaching experience aggregated by their career stages to protect the identity of the participants.

Table 1

Number of Teachers Sampled from Each of Huberman's Stages

Years of Teaching	Huberman's Phases	% of Wonder High Staff	# of Teachers Sampled (N=14)
1-3	Survival and Discovery	11%	2
4-6	Stabilization	9%	2
7-18	Experimentation/Reassessment	59%	8
19-30	Serenity/Conservatism	21%	2

Note: Based on 53 teaching staff members at WHS

Participant anonymity was protected by categorizing participants according to their pseudonyms and their years of experience using Huberman's (1989) career stages. See Table 2 for this organization designed to avoid identifying participants according to their department and years of experience.

Table 2

Participant Pseudonyms and their Years of Experience

Participant pseudonym	Years of Experience	Experience Group
Emily	1-3	Survival and Discovery
Fitz	1-3	Survival and Discovery
Irving	4-6	Stabilization
Brenda	4-6	Stabilization

Table 2 (continued)

Participant pseudonym	Years of Experience	Experience Group
Karen	7-18	Experimentation/Reassessment
Harvey	7-18	Experimentation/Reassessment
Garth	7-18	Experimentation/Reassessment
Anne	7-18	Experimentation/Reassessment
Lenny	7-18	Experimentation/Reassessment
Carrie	7-18	Experimentation/Reassessment
Nate	7-18	Experimentation/Reassessment
Mary	7-18	Experimentation/Reassessment
Denise	19-30	Serenity/Conservativism
Jack	19-30	Serenity/Conservativism

Refer to Table 3 for the number of teacher participants from each of the core disciplines.

Table 3

Number of Teachers Sampled from Each Discipline

Discipline	# of teachers sampled in each discipline (N=14)
Science	5
English Language Arts	4
Social Studies	3
Math	2

Student participants. Freshmen were not participants in this study due to the challenges they encountered transitioning from middle school to high school. Some challenges were that ninth grade students had to earn a passing score in the core disciplines to graduate. These freshmen core courses were some of the most difficult in high school. Furthermore, freshmen must pass standardized tests to graduate, and this added to the stress and challenges they encountered in a new school environment (McCallumore & Sparapani, 2010). Sophomores, juniors, and seniors were selected by purposeful sampling as representatives of the student body at WHS (Patton, 2002). Classroom teachers agreed to have student participants come to my classroom for a private interview for half a class period during their elective, English, science, or history class.

Participant identity was protected by using the pseudonym Student followed by a number. Table 4 lists the student participants by grade level.

Table 4

Number of Students Sampled from Each Grade Level

Grade Level	# of students sampled in each grade (N=8)
Sophomores	5
Juniors	1
Seniors	2

The Table 5 provides the pseudonyms for students, Student 1 through Student 8, and the grade level. Student numbers were chosen instead of names due to the plethora of students' names used at WHS.

Table 5

Student Pseudonyms from Each Grade Level

Student pseudonyms (N=8)	Grade Level
Student 1	Sophomore
Student 2	Senior
Student 3	Sophomore
Student 4	Sophomore
Student 5	Sophomore
Student 6	Sophomore
Student 7	Senior
Student 8	Junior

Summary of protocol. I analyzed the data collected from the teacher observations, teacher surveys, teacher interviews, and student interviews. The data was triangulated to report how, why, and what teachers did to enact the CCSS using IU and how students preferred to study and learn mathematics in other core disciplines (Teddlie & Tashakkori, 2009). Furthermore, the data was analyzed using NCTM Practices to discover how teachers in English, science, and social studies supported learning mathematics.

The first part of the protocol was my observations of the teachers using their planned lesson and strategies without making changes to their routine. I shared the data collected from the observations via email with the teachers only. Teachers had the opportunity to respond to the observation notes regarding recording or typographical errors. The second step was a printed survey that contained the same 18 questions for each of the 14 teachers. Ten surveys were returned from the 14 participants. The third step was the semi-structured face-to-face interview that focused upon the research questions. The classroom observations and the printed survey were used to allow participants the freedom to elaborate upon the interview protocol questions. The data collection protocol began with the classroom observations, followed by the survey, and then the interview; this process allowed teachers to reflect on their teaching strategies and not change their routines based upon questions from the survey or the interview.

Teacher observations. Teachers in the core disciplines taught a 45-minute period for each class. I observed either the first or second half of 12 classes and, due to scheduling, during my lunch or planning period. If I observed a teacher during the second half of the class, the teacher shared with me the introduction of the lesson and directions given to the students. Teachers explained this information either during the observation or after I met with them at a more convenient time that day. Refer to Appendix F for the Observation Tool used for handwritten note-taking during the observations.

The administrators required the objective from the CCSS to be displayed in each classroom; therefore, all teachers except one had the objective posted, and some had the identification codes of the standard as referenced in Oncourse (n.d.). For example, Garth, a science teacher, had the following written on the chalkboard at the side of the science lab room: HSLS 1-4- Enzymes. Teachers were required to insert standards for the lessons that the district personnel organized according to disciplines and courses using OnCourse, and all disciplines and courses were available to teachers. Teachers submitted lesson plans for the week by Monday to administrators using OnCourse. An example of a daily plan regarding logarithms in an algebra II class submitted to administrators is displayed in Figure 1 and is from a print screen in OnCourse.

SWBAT	Anticipatory Set	Lesson	Closing
Lesson 7-4 use properties of logarithms	Warm up from Smart Board	Teacher Overview Students work in small groups for review of exponential and logarithmic functions using Google Classroom, and other Internet resources	Smart Board - HMWK Assignments Oral Questions Exit Problems Include PARCC EOY or SAT problems aligned to objectives

Figure 1. Sample of daily lesson plan in Oncourse for one class.

Refer to Figure 2 for a sample of the standards referenced in an algebra II course, printed from an Oncourse screen shot. The standards displayed the CCSS reference identity for technology (TECH), Math (MA), and Language Arts (LA). The grade levels were printed next to the discipline, followed by codes for that discipline, and teachers used the codes to upload the standards from submenus.

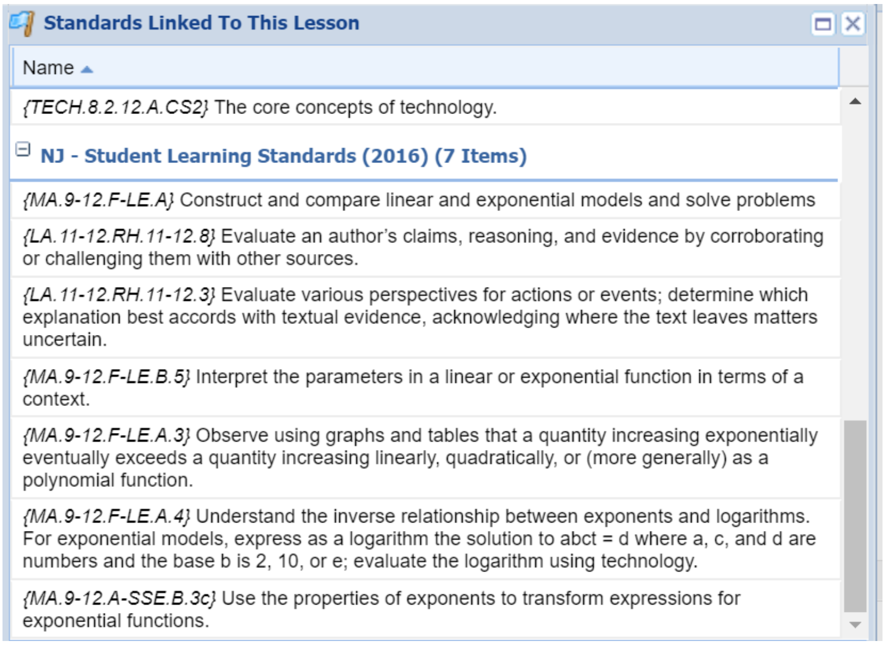


Figure 2. Standards on Oncourse linked to algebra II logarithms.

Technology. Oncourse was one example of Computer Assisted Instruction (CAI) technology required by administrators for teacher use. This section presents additional CAI sites as part of the curriculum resources. Technological equipment that included a desktop computer in each classroom was observed, and different classroom displays were used by the following departments. The four English teachers and three social studies teachers had a computer display projector in the ceiling and a screen at the front of the room. Two math teachers and five science teachers had a ceiling display projector and a Smart Board at the front of the room.

Two math teachers, Emily and Fitz, used the Smart Board for demonstrating how to solve linear equations in one variable or factor quadratic expressions, respectively. Students were given practice problems afterward to work on in class and complete for homework. One science teacher, Irving, used the Smart Board to demonstrate how to find the average molar masses from a previous experiment, and he asked the students to show their work on a paper handout. Irving's students worked in groups of four on a paper handout to solve the problems and entered data later into Google Docs.

Google Classroom was another tool the teachers used in most observed classes. Social studies teachers required students to enter answers to questions in Google Docs. Science teachers required students to use either Google Docs, Google Slides, or Excel to enter data and the analysis of the data from labs. Two science teachers used virtual labs, and two used physical materials for labs with students divided into groups. Students in physical labs were required to enter data and their analysis in Google Docs or Google Slides and produce appropriate mathematical graphs.

Teacher survey. The second part of the data collection protocol was the teacher survey. Surveys that are aligned with objectives provide an important tool for triangulating qualitative data collected during observations (Fink, 2003), resulting in collecting richer, more in-depth data (Teddlie & Tashakkori, 2009). The purpose of the survey was to help teachers recall the observed lesson. Each of the 14 teachers was given a printed survey, and 10 teachers returned it. Each survey addressed the observed lesson in terms of conceptualizing an IU and teaching mathematical concepts in an IU. Refer to Appendix M for the survey questions. Questions numbered 6, 10, 11, 13, 15, 16, 17, and 18 addressed conceptualizing an IU. Questions 3, 4, 5, 7, 8, 9, 12, and 14 addressed incorporating mathematical concepts in an IU.

Teacher interviews. The third part of the teacher data collection protocol was the interview. Each of the 14 teachers in the core disciplines was interviewed individually during one planning period or after school about their strategies for enacting the CCSS using an IU. The interviews explored how they incorporated mathematical concepts in non-math disciplines, what they expected students to do with the math concepts, and why they incorporated math. The interview questions addressed their years of experience because Huberman's (1989) career stages helped explain their espoused theory and their theory of practice with an IU and incorporating mathematical concepts.

Refer to Appendix A, Interview Protocol for Teachers, for the semi-structured interview questions teachers were asked during the interview (Rubin & Rubin, 2012; Ryan & Bernard, 2003). Teachers were asked about their experiences teaching the CCSS and an IU using questions 2, 3, and 4. How they conceptualized an IU was discussed through questions 5 and 6. Teachers were asked how they incorporated mathematical concepts in an IU in questions 7, 8, and 9. An instructional leadership question, number 10, was the last question in the semi-structured interview.

Student interviews. The data was collected from students through interviews. I met individually with eight students during my lunch or planning periods. The participants came for the interview during their elective, English, math, science, or social studies class. Students filled in the graphic elicitation (Appendix C) and used it as a guide for the interview questions. None of the students understood the phrase interdisciplinary unit; therefore, I explained it meant cross curricular or two or more subjects taught in one lesson. The semi-structured interview questions allowed me to give explanations and answer their questions and allowed them to relate their experiences using the graphic elicitation and the interview questions (Appendix B) (Rubin & Rubin, 2012; Ryan & Bernard, 2003).

Students' learning strategies related to instructional strategies and were based upon their experiences with the CCSS and IUs. Refer to Appendix B for the Interview Protocol for Students. The interview questions 2 and 3 were asked to explore their experiences with instructional or learning strategies. Questions 4, 5, 6, and 10 were asked to discover their experiences with conceptualizing an IU themselves. Questions 7, eight, and 9 were asked to discover what mathematical concepts had been included in non-math courses, and their thoughts about how that may affect their math comprehension.

Summary. During the interviews, teacher participants representing four of Huberman's (1989) career stages provided a plethora of their primary teaching strategies, and students explained their primary studying strategies. The teachers and students in most of the observed classes used computers, and most teachers used the Google Classroom Suite for student work, as expected by administration. The printed survey results were returned to me, and the survey questions with the interview questions were used during the teacher interviews. This allowed the teachers to provide their perspectives and experiences about teaching an IU and the incorporation of any mathematical concepts.

The student interviews provided important data about studying habits, favorite methods they used to learn, and their perceptions of an IU. No student recalled any IUs in the high school, and their recall of mathematical concepts in courses other than math were basic math skills and some pre-algebra concepts like slope and use of exponents. For support, students used the graphic elicitation to focus and organize their thoughts.

Teachers chose not to use the graphic elicitation, and the teachers were focused and relaxed during the interviews.

Descriptive Coding

Descriptive coding was used to grasp specificity and complexity, and sub codes were used to organize data because this coding summarized the basic topic of the text from the observations, survey, and both teacher and student interviews (Saldana, 2013). The discovered patterns were a result of the recursive process and explained the themes of this study. The themes were the "theoretical construct from the data" (Saldana, 2013, p. 212), and the validity of the data sources is discussed in this section. The remainder of this dissertation explains the analyzed data in a thematic approach. This study situates the data within the enactment of the CCSS using IUs with a focus on incorporating mathematical concepts. Furthermore, instructional leadership as perceived by teachers was discovered.

Classroom observations, field notes, public documents, and each of the participants' interviews were included in the descriptive coding process. A first cycle produced the word or phrase of the content, and a second cycle led to patterns. The patterns that were analyzed to produce the themes are discussed in the sections that follow: first cycle coding teachers, second cycle descriptive coding teachers, first cycle coding students, and second cycle coding students.

First cycle coding teachers. Descriptive coding was the initial type of data analysis used to summarize the basic topic of a passage into one word or a phrase (Saldana, 2013). The phrases were determined by a recursive process that organized first cycle of descriptive codes and sub codes into patterns. During the first cycle of descriptive coding, the codes emerged continuously as I used a recursive data analysis method (Creswell, 2014; Miles et al., 2014). For example, sub codes were necessary to explain the code “primary teaching strategies” based upon the subtle differences between the meanings discovered in the data within the code (Miles et al., 2014). The primary teaching strategies described by teachers were categorized as “hands-on,” “groups,” or “analyze.” During the first cycle of coding, a total of 54 independent ideas became apparent from the collected data. Appendix G displays the comprehensive list of the first cycle of descriptive codes used.

The item in the first row and first column of Appendix G refers to the teachers’ responses to interview questions starting with question 2. The titles located in the rows are Primary Teaching Strategies, Barriers, Instructional Leadership, Determine Disciplines to Incorporate into an IU, Conceptualize an IU, Incorporate Mathematical Concepts in an IU, Effect on Students’ Math Comprehension Based on IU, Modeling, Cognitive Apprenticeship, and Vygotskian Constructivism. The additional columns contain the responses from the teachers for the first column headings.

Cognitive Apprenticeship and Vygotskian Constructivism were unanticipated categories. “Cognitive apprenticeship emphasizes two issues: apprenticeship and cognitive skills rather than physical ones” (Collins & Kapur, p. 110). Cognitive behavior requires the use of mental actions to learn through thinking, experiences, and the senses, and apprenticeship means that knowledge must be a catalyst for solving problems (Collins & Kapur, p. 110). Content, method, sequence, and sociology are four dimensions that create a learning environment, and content and methods were discovered during classroom observations (Collins & Kapur, p. 111).

The Vygotskian approach was used in two observed English classes. Vygotskian Constructivism, in the form of groups/pairs/partners, was mentioned 13 times by teachers in the interviews, was observed six times in the observations, and was mentioned once by a student. The collaboration and social interactions were a match for Vygotsky and what teachers want when students work together in the classroom. However, none of the Vygotskian social constructivism interactions between the teacher and students or between students and students were observed or mentioned in detail in the teacher or student interviews (Steele, 2001).

Second cycle coding teachers. The second cycle pattern codes categorized the first cycle of descriptive codes with labels that identified similarly coded data (Saldana, 2013, p. 209). These categories were developed through the study's research questions, the conceptual framework of the study, the participants' perceptions, and my teaching experiences (Miles et al., 2014). For example, the category Instructional Strategies was created from the comprehensive research question that prompted the study and the codes that described the procedures teachers used to teach the CCSS. The second cycle pattern codes included the themes and concepts created from a compatibility of the elements described in Appendix H. The second cycle of pattern codes were as follows: Instructional Strategies, Critical Thinking, Barriers, Instructional Leadership, Determine Disciplines in an IU, Conceptualize an IU, Incorporate Math in an IU, Effect on Students' Math Comprehension, Cognitive Apprenticeship, and Vygotskian Constructivism.

First cycle coding students. During the first cycle of descriptive coding of student interviews, the codes emerged continuously as I used a recursive data analysis method (Creswell, 2014; Miles et al., 2014). For example, sub codes were necessary to explain the code “primary learning strategies” based upon the differences between the learning approaches discovered in the data within the code (Miles et al., 2014). Students described their primary studying/learning strategies as “flash cards,” “partner,” and “objective posted in the classroom.” A total of 32 independent ideas became apparent from the collected data.

Appendix I displays the comprehensive list of the first cycle of descriptive codes. The heading of each row is the code used to group the related responses from students. The fractions in Appendix I represent the number of responses discovered divided by the total of eight students. The headings are Primary Learning Strategies, Determine Core Disciplines to Incorporate into an IU, Conceptualize an IU, Incorporate Mathematical Concepts in an IU, Effect on Students’ Math Comprehension Based on an IU, Mathematical Topics Easy to Recall in Other Disciplines, Cognitive Apprenticeship, and Vygotskian Constructivism.

Second cycle coding students. The second cycle pattern codes categorized the first cycle of descriptive codes with labels that identified similarly coded data (Saldana, 2013, p. 209). Like the teachers, the categories for students were developed through the study’s research questions, the conceptual framework of the study, the participants’ perceptions, and my teaching experiences (Miles et al., 2014). For example, the category Learning Strategies was created from the comprehensive research question that prompted the study and the codes that described the procedures students used to study and learn CCSS objectives. The second cycle pattern codes for students included the themes and concepts created from a compatibility of the elements described in Appendix J, and some are like the patterns found for teachers.

Procedures that produced themes. Thematic analysis is part of the qualitative exploratory case study design that focuses on the research questions, the conceptual framework, purpose, and literature reviews (Saldana, 2013, p. 177). I included the teacher observations, survey, teacher and student interviews, student graphic elicitations, field notes, and public documents from the district website to triangulate the data. I discovered the first cycle of descriptive codes, the second cycle to produce patterns (Miles et al, 2014), and then the themes for teachers followed by the themes for students.

The data collection process included recursive descriptive coding cycles, and data analysis using a second cycle of pattern coding resulted in four themes from the teachers' data. The first theme, Conceptualize an IU, refers to the disciplines that teachers used in an IU and any barriers that prevented the teaching of an IU. The second theme, Mathematical Concepts in an IU, describes the mathematical topics teachers used and what their beliefs were about teaching math in a different discipline, or teaching other disciplines in a math course. Furthermore, teachers discussed the effect on students' math comprehension. The third theme, Instructional Strategies, refers to teachers' experiences teaching the CCSS, why they teach them, and what resources they used. The fourth theme, Instructional Leadership, represents the teachers' perceptions of their personal leadership and the leadership of the administration.

Validity. Various data sources were used within this study and collected data were triangulated to generate the themes (Creswell, 2014). A triangulation matrix (Table 6) was used for a display of the data sources that supported the findings (Anfara, Brown, & Mangione, 2002). The matrix shows how the merging of the sources led to the discovery of the themes (Creswell, 2014). The integrity of the methodology used to collect the data and actual data itself were examined by using the triangulation matrix (Miles et al., 2014).

Table 6 displays the triangulation matrix from teacher interview transcripts, public documents, classroom observations, and field notes (Craig, 2009; Patton, 2002; Toma, 2006; Yin, 2014). The bold **X** represents the data discovered from the sources, and the regular type X is a subtheme and its source. If a cell is blank in the table, that source did not produce that theme or subtheme.

Table 6

Triangulation Matrix of Themes and Sub-Themes - Teachers

Study Themes & Subthemes	Interview Transcripts	Documents	Observations	Field Notes
Conceptualize an IU	**X**	**X**	**X**	**X**
Determine Disciplines	X	X	X	X
Barriers	X			X
Mathematical Concepts in IU	**X**	**X**	**X**	**X**
Effect on Math Comprehension	X		X	
Instructional Strategies	**X**	**X**	**X**	**X**
Cognitive Apprenticeship	X		X	X
Vygotskian Constructivism	X		X	
Instructional Leadership	**X**	**X**	**X**	**X**
Classroom Leadership	X	X	X	X
Administrative Expectations	X	X	X	X

Refer to Table 7 for the frequency of the pattern codes and the sources that produced the tallied occurrences. There was a total of 506 coded segments from the collected data and the sources displayed in the table. The percentages were based upon the total number in each row divided by 506.

Table 7

Second Cycle Pattern Code Frequency Teachers - Themes

Second cycle pattern code	% of coded segments of data	Number of coded segments from teacher interviews	Number of coded segments from observations	Number of coded segments from field notes	Number of coded segments from documents
Conceptualize an IU	13.0	22/506	17/506	23/506	4/506
Mathematical Concepts in IU	17.0	36/506	28/506	22/506	0/506
Instructional Strategies	61.1	159/506	141/506	7/506	2/506
Instructional Leadership	8.9	13/506	23/506	7/506	2/506

Note: 506 coded segments of teacher data including teacher interviews, classroom observations, field notes, and documents from the district level website.

Summary. This study is a thematic approach, discussing the findings of this exploratory case study and integrating it with the Chapter 2 literature discussion. The subthemes are discussed in terms of the four themes and are addressed in corresponding sections that follow. All data sources that referred to teachers were included in the discussions or examples of teachers' communications, and the data sources for students were kept separate from the teachers' data.

Conceptualize an IU

The first theme discovered using data from teachers' observations, the survey, and interview was Conceptualize an IU. The following section refers to that data, and it is presented by the teacher and the discipline the teacher teaches. The next two sections, curriculum resources and experiences teaching the CCSS, surfaced as teachers referred to their curriculum resources while discussing an IU and their experiences teaching. Some teachers used an IU approach in an observed class, and some discussed the difficulty of using an IU. The data from this discussion is in the section on disciplines to include in an IU.

Conceptualize an IU was also discovered as the first theme when analyzing student interview data. Students used the graphic elicitation (Appendix C) to create an IU visually and explained their reasoning. Some students recalled math topics from some of their courses, and they included those courses in their elicitation and discussion.

Teacher participants. Research into the WCPSD website public documents that stated, "The curriculum shall include interdisciplinary connections throughout," and "It shall be the responsibility of the Building Principal to ensure that curriculum guides are being followed." These statements were the only references about an IU from the district website, but they had an impact on teachers and their teaching strategies. Furthermore, The Technology Plan, 2013-2016, for the district stated, "Students will have the opportunity to…solve problems and communicate in a collaborative and interdisciplinary environment." This was the only reference to an IU in the plan. Teachers were provided with the Google Classroom Suite, and this study referred to the suite as part of the collected data.

The CCSS were adopted in 2012 by the Wonder City Public Schools Board of Education (WCPSBOE). Most of the 14 teachers participating in this study taught for more than five years at WHS. In all classrooms but one, teachers displayed the standard(s) for the lesson, and they espoused the use of IUs in terms of standardized tests. An interdisciplinary approach is “a knowledge, view, and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience” (Jacobs, 1989, p. 8). Classroom observations produced a range from no IUs or other disciplines in the lesson to three disciplines in one lesson, as stated in the following discussion of the data.

Denise told me at the beginning of her English lesson that I would not see any math. She instructed students to make the *Scarlet Letter* relevant to their lives in this century: “Put yourself there. Can’t write a narrative unless you put yourself there.” Students continued to use their laptops to write their documents, which Denise checked later with Turnitin (2018), a website that detects plagiarism in students’ writing and provides personalized feedback. Carrie told her English class the percentage of students who had not completed the Albert English assignment was “thirteen out of 18…is that 33%?” Carrie explained, “I’m not good at math.” Albert (2018) is a website that provides students with individualized practice experiences in core academic areas and provides instructors with data of the students’ results.

Fitz told his algebra II class, “Warm Up is factor the quadratic expression, $x^2 - 12x + 32$.” He used more examples that he worked on the Smart Board, and asked students to practice factoring throughout the lesson. Learning how to factor quadratic equations in isolation of practical applications does not help students retain the mathematical concepts. During his interview, Fitz explained, “I usually like to introduce material by pretty much standard whole class discussion. Lecturing.” Later, when asked how he conceptualizes an IU, he replied, “Today I had students complaining about projects, wanting to do projects. We have to hit so many standards that it's a little tough to take a pause.”

At the other end of the range of IUs observed, Harvey incorporated three disciplines in his science class: science, math, and English. First, he introduced the science lesson by reading aloud the menus on the students’ screens, “The virtual Stickleback Evolution Lab on schoology. Use bar graphs to interpret data. Use asymmetry.” Students were reading the headings on their laptops as Harvey read them aloud. Students performed a virtual lab on their laptops, and Harvey assessed student understanding formally by checking student work online on his laptop. Harvey monitored students’ work personally and answered students’ questions quietly, and each student was engaged in the virtual lab.

Harvey included math as the second discipline. He required the analysis of the lab results and students were required to graph data using a link to review different types of graphs. The experiment contained three components: Analyze Fish from Lakes, Analyze Fossil Fish, and Pelvic Asymmetry. An interdisciplinary approach was used in this lesson by incorporating reasoning skills in science, data analysis in math, and producing appropriate graphs to represent the data. Students used Google Sheets or Microsoft Excel to produce their graphs for the teacher to view and score. Finally, students used the third discipline, ELA, to write their responses using complete sentences when answering the questions for their analysis that was posted on Google Docs by the teacher.

Each teacher was asked how to conceptualize an IU during the interviews, and the responses ranged from indicating they found it easy to use curriculum resources to be indicating they do not use them at all. Carrie in English explained,

> It starts with the key concepts that we want our students…to master…The common core specifies for the 11th-grade curriculum that…primary documents…foundational documents, like the Federalists papers…are part of the curriculum. For an interdisciplinary unit, I…look towards those…. For science, it's kind of just how it presents itself.

Harvey explained, “I'll try and map it out…some of the topics in [Advanced Placement] AP just kind of flow with each other.” Lenny in social studies explained, “I’ve converted to…make my plans on a unit basis…take into consideration…where … I incorporate interdisciplinary units. Specifically, where…I incorporate graph chart analysis…reading comprehension, word usage, things that are on the PARCC, the SAT, the PSAT.”

Emily in math explained, “I think using money in word problems…helps them calculate it easier because it's money…and having something that might actually apply to their life…makes it easier for them to understand.” Emily continued, “On our Oncourse we have language arts standards that I hit and technology standards that I hit, and just having them speak in correct English is everyday life.” Nate in social studies explained, “I wouldn't say purposely, but I can't go out of my way in order to do it because I got so much other to focus on.”

Curriculum resources. OnCourse provided the school board's adopted Internet teacher resources that accompanied the texts in each core discipline and some electives. However, OnCourse did not provide any internet textbooks, individual teachers' Smart Board saved files, or Word or Google documents. These individual teachers' creations were saved under the teachers' names, and they were available to other teachers by request.

Each teacher used Linkit for midterm and final exams and the Benchmark tests that counted for 15% of their evaluation (Linkit, 2012). Standardized test practice items from the websites of the Scholastic Achievement Test (SAT), Preliminary Scholastic Aptitude Test (PSAT), and Partnership for Assessment of Readiness for College and Careers (PARCC) were available to each teacher, and AP practice test items were available to the AP teachers. All core curriculum teachers received a two-hour training session in Albert (2018), a testing program with sample test items and a recordkeeping method to analyze students' results in August 2017. One social studies teacher became certified as a trainer in Albert (2018), and he offered a morning Professional Development (PD) session to small groups of teachers for support and help. All core discipline teachers used components of the Google Classroom Suite.

Departmentally, English teachers required students to use Turnitin to check for plagiarism. Each math teacher used ixl (IXL Learning, 2013), and the science department chair provided appropriate Computer Assisted Instruction (CAI) websites to each science teacher. For example, two interactive programs were biomanbio and schoology. Each teacher had access and used components of Google Classroom.

Experiences teaching the CCSS. Each of the teachers agreed that they taught the standards from the CCSS, and they used the curriculum resources approved by the WCPSBOE that were aligned to the standards. I discovered that the standardized tests, PARCC, PSAT, and SAT, were emphasized by teachers in each core discipline, except the two math teachers. Examples from teachers' interviews follow by department (English, social studies, science, and math).

Brenda explained about the CCSS, "It's all we use. English world. It's so intertwined with everything that we're doing, especially test prep." Lenny in social studies stated, "I find it easy to enact the CCSS in these interdisciplinary units because …the CCSS is…crafted…to be interdisciplinary." Nate explained in terms of AP History, "Generally…most of my class focuses on the AP curriculum…but I'm more focused on the standards and skills that the kids need in order to pass the AP test." Jack in science responded, "Core curriculum standards as opposed to next generation science [NGSS]…they're no longer considered the same thing.…You're kind of fishing around for something to fit…to do…it's been challenging. But… it gets…easier." Emily in math said, "I find that the standards are broken down very easily. You hit them multiple times in a year.... They're very easy to follow with the subcategories."

An example of teaching the CCSS between disciplines was the sharing between the English, science, and social studies departments. The English teachers shared weekly science prompts from the SAT practice website (College Board, 2018) with science teachers. Science students were required to read the articles and practice comprehension skills, and teachers discussed the answers students produced. Students were required to write responses in complete sentences. Additionally, English teachers used primary documents from the social studies department as a platform to prepare students for the PARCC English and SAT tests. English students were given social studies test prompts from each of the standardized tests, and English teachers used the same process the science teachers used in their classes.

However, there was no collaboration discovered between the math department and the other core disciplines in this study. For example, the math departmental chair, Mr. Head, emphasized the following during a math departmental meeting on August 31: instructional practices that maintained high quality assessments, use PARCC-released items, utilize data and review assessments when possible, and discuss the problems that students answered incorrectly on Linkit (personal communication, August 31, 2017). No mention of teaching the CCSS or teaching strategies were discussed or asked about during the meeting.

The principal, Mr. Leader, made one comment regarding cross-curricular activities: science and math go together, and English and social studies go together during the same meeting (personal communication, August 31, 2017). No examples were discussed; the time to meet with different departments or how the collaboration might take place were not mentioned. Mr. Leader attended a second meeting, his last for the year, and explained that preparing for the SAT also prepared students for the PARCC (personal communication, November 8, 2017). Mr. Head did not mention IUs with science teachers, and the district math coach did not mention IUs in the only PD session held for math teachers.

The only PD session for math teachers at WHS during the 2017-2018 year was organized by the district curriculum director and presented by the district math coach.

The coach demonstrated how to correct math problems in the testing program Linkit (2012) and how to upload the standards from the CCSS if they were not posted previously on the test items. The Linikit submenus contained uploaded test items from ExamView (Pearson, n.d.), and there was a plethora of problems that had incorrect answer choices or items that were written incorrectly from the Pearson company. The time-consuming process of correcting those items was not a priority for me; therefore, I selected Linkit math items from submenus labeled PARCC, NY Regents, or tests created from math teachers that had corrected items and responses saved in Linkit.

Disciplines to include in an IU. English teachers shared weekly standardized released test prompts with science teachers, and English teachers used primary source documents to prepare students for standardized tests. Additionally, social studies teachers used the prompts in appropriate courses. Examples follow from the interviews of teachers in English, science, social studies, and math.

Carrie stated, “it's science-based texts or history-based texts because those are what students will see on the PARCC and on the SAT. On the SAT, there's only one literary text. On the PARCC it's one-third literary, it's two-thirds informational.” Jack in science, recalled, “I have…always focused on interdisciplinary units. I…think it makes my job easier. And…it's far more interesting and…it has more of an impact when I can get language arts and math into it.” Irving in science stated that, “math is very involved with chemistry…our school's doing a good job now of incorporating…English lessons. We get an article every week to give the kids…SAT prep…even a little history. It's not like world history.”

Lenny in social studies stated, “world history…lend themselves…to the language arts interdisciplinary units. There's…reading… writing…comprehension. And the math, that would…be the second interdisciplinary unit that can be incorporated…when we're talking about maps, charts, graphs, statistics.” Fitz in math, gave this example in his interview, “I used the real-life scenario of building a pen for my…hedgehog…using the quadratic formula…that allowed me to maximize the materials I had.”

Student participants. Refer to Table 8 for the triangulation matrix of themes and subthemes for students and Table 9 for the second cycle of pattern coding that produced the three themes for students. Saldana (2013) explains the trinity as three categories that are the culmination of triangulating data. This study created three themes from students’ interviews, graphic elicitations, and field notes (Craig, 2009; Patton, 2002; Toma, 2006; Yin, 2014). Table 8 displays the triangulation matrix of themes and subthemes for students. The bold **X** denotes the codes found from the data referred to in the headings of the columns, and the regular X displays the sub-themes found in those sources of data. The blank cells represent that the data was not found from the source in that column.

Table 8

Triangulation Matrix of Themes and Sub-Themes - Students

Study Themes & Subthemes	Interview Transcripts	Graphic Elicitation	Field Notes
Conceptualize an IU	**X**	**X**	**X**
Determine Disciplines	X	X	X
Mathematical Concepts in IU	**X**	**X**	**X**

Table 8 (continued)

Study Themes & Subthemes	Interview Transcripts	Graphic Elicitation	Field Notes
Effect on Math Comprehension	X		X
Learning Strategies	**X**	**X**	**X**
Cognitive Apprenticeship	X		X
Vygotskian Constructivism	X		X

Table 9 displays the frequency of the data that supported the themes. There was a total of 99 segments of data discovered from the second cycle of pattern codes in student data. The numerator in the fractions represents the number of segments from the specific source listed in the column heading, and the denominator is the total, 99. The percentages of coded data for a theme were determined by adding the fractions in one row together, and then dividing by 99.

Table 9

Second Cycle Pattern Code Frequency Students Themes

Second cycle pattern code	% of coded segments of data	# of coded segments – student interviews	# of coded segments - graphic elicitation	# of coded segments - field notes
Conceptualize an IU	19.2	7/99	7/99	5/99
Mathematical Concepts in IU	58.6	38/99	7/99	13/99
Learning Strategies	22.2	16/99	0	6/99

Note: There were 99 coded segments of student data including student interviews, graphic elicitations, and field notes.

Conceptualize an IU - students. No student understood the phrase interdisciplinary unit; therefore, I used the phrase cross-curricular to help students understand the topic of IUs. I asked them to write math in the center of the graphic elicitation (Appendix C), because math was the focus of the study, and then students wrote other disciplines or courses in the circles surrounding math. Students read orally what they wrote on the graphic elicitation, and the recording was transcribed. Seven of the eight students added science, four added history, two added English-Language, two added Spanish, two psychology, and two added art. Student 4 had the most variety: photography, landscape, and social numbers. Student 4 explained social numbers as:

> Anything like social media…keeping track of phone numbers, or any coding that requires…that. I want to make code. I want to speak with math and have that language.... It’s basically you talking to a computer to do something, and that's how I see it. With coding, you can make anything you want.... You can make a new app on your phone, or you can make a new phone, or you can make anything you want out of your brain, which is like the new art in this era of time.

Student 4’s example described understanding of underlying mathematical concepts in coding and the creation of communication devices. Student 4 applied math and coding together and verbalized a positive creative future.

Other students answered the question of which disciplines they would include in an IU using the graphic elicitation as a focus, and examples of their responses follow. Student 6 responded, “I think math could be incorporated into social studies, because you need to know the years that certain subjects take place.…Science, because of measurements.” Student 1 replied, “I'd put all mini lessons I guess…like a lab or something.” Student 3 would include an IU connecting many subjects: “Definitely biology. Definitely Spanish…psychology in terms of knowing how much neural impulses the brain needs.…I know there's like a ton more. I know math can deal with everything in the world.”

No student recalled an IU experience at WHS; however, two recalled an IU experience at the middle school. Each one gave their perspective of what the teachers presented. Student 4 explained, “They tend to get out of their box mostly, to help other classes. If you're working with history, they'll do something with language arts, or if you're working with math, they'll probably do something with science.” Student 7 responded, “I think it's good because it helps the students really do more in different classes, so it helps them think about doing math in language, or math in science, and then science in math, and they interconnect together.”

Students were asked how they incorporated objectives from the CCSS into an IU when they were studying or learning on their own. I read Jacob’s (1989) definition on their handout, and we discussed the meanings of the IU model (Appendix D). Student 3 explained objectives could be incorporated “to help for the test we're doing, I think the SAT.” Student 7 stated, “How to incorporate it, objectives around CCSS. I think using the standards in these things, I feel like it helps a lot to see that this is being used in these classes, and it helps you understand.” Student 8 made the connections between “language and science. We do vocab.” Student 4 replied:

> My interdisciplinary units, it would be probably like science to math, because of most of the problems in science. Science is a language of math, and most of the

equations there I learn from math. I can get a better test grade, or a better grade overall.

This last statement referred to the student's ability to use math in science and showed concern for grades.

Mathematical Concepts in an IU

Mathematical concepts in an IU was the second theme discovered from both the teacher and student data sources. Some teachers used math in their observed lessons and explained how they included math using their curriculum resources during their interview. I categorized the math concepts that I observed according to the NCTM (n.d.) practices, and I discovered that basic math skills or some algebraic concepts were included.

Standardized tests were discussed frequently, and some teachers explained that test results were the reason for combining disciplines. Additionally, teachers discussed the barriers to include an IU and the barriers to incorporating math concepts. Furthermore, students recalled how they remembered using math in other courses. Their examples were basic math skills and some algebraic concepts. All participants agreed that incorporating math topics would have a positive effect on student math comprehension.

Teacher observations. Nine participants incorporated some math concepts in their observed lessons. Five science teachers, one English teacher, two social studies teachers, and one math teacher used a real problem in algebra I. For example, Irving in science explained the math from a previous lab experiment as follows. Irving wrote on the Smart Board "(107*55.7+109*44.3)/100 = molar mass." A student responded with the answer: 5959.9+4828.7 = 10,713.7, then divide by 100= 107.137." Irving explained, "That is the average mass. Do the order of operations." Irving's students were required to work in their group, write their solutions on the handout, and used Google Docs to explain the answers to posted questions.

Anne in English had written the following math on the board at the front of the room before students entered.

1.5 million
200,000 Child Bearing
-30,000 b/c they can care for kids
170,000
-50,000 miscarriages/sick die
120,000
-20,000 breeding (5,000 males and 15,000 females)
100,000 Sold as food

Anne explained to the class as she showed them the math, "Women had abortions to avoid having to provide for them…very poor." They studied the satire in Johnathan Swift's Gulliver's Travels, and Anne explained in the interview that she followed the suggestions of the authors in the curriculum resources and incorporated math as it related to the subject.

Mary in social studies incorporated math into a lesson using a scatter plot entitled "Imports from Britain, 1764-1776" that was provided to the students on Google Classroom. Mathematical reasoning and applications in the lesson referred to the questions, "Why did imports from Great Britain to the colonies decline?" and "When did the greatest drop in British imports occur, and why?" The second part of the lesson focused on tax rates around the world, and the title was “Tax Rates Around the World Questions.” Mary’s students typed their answers on their laptops using Google Docs.

Teacher interviews. I used the survey to focus the interview questions on math concepts in an IU. During the teacher interviews, teachers either discussed teaching math in lessons or stated they did not include math. Science teachers incorporated more mathematical concepts than any other non-math discipline in the observed lessons, and they explained the type of math during the interviews. In most interviews, the type of math observed used in the lessons was also mentioned. One English teacher explained her comfort with including math, and three avoided math concepts as explained below.

English teachers Anne, Brenda, Carrie, and Denise explained their experiences with incorporating math in an IU. Anne explained, “Mathematical concepts…during that lesson…it was talking about all kinds of statistics. Sometimes…the kids say to me, ‘Is this math class?’ The other way… is their grades.…Math works its way into everything, I think.” Brenda hit her fist on the desk and replied, “I'd say, I don't. There are no mathematical concepts, really, unless it lends itself to the material that we're reading. Same with the interdisciplinary units.” Carrie explained that she did not include math topics because, “I have severe math anxiety, it would be basic math sense.” Denise described her experiences as “difficult. What we've been doing recently was…a journal, much the same way Ben Franklin did…in which he would jot down how many times a day he said, ‘Thank you,’ to someone. I have my kids count on their fingers.”

Math teacher Emily’s explanation of understanding the mathematical concepts was a summary statement of the purpose of teaching math using real problems. She explained it’s about “the desire to…hav[e] them actually think about something instead of just doing it over and over again.” Science teachers Garth, Jack, Karen, Harvey, and Irving explained their applications of math concepts. For example, Garth said he uses “lower level math, not geometry or algebra.” Jack explained, “We are calculating percent efficiency of glycolysis. What's going on inside of us? And how do they feel about that?” This data suggests the science teacher incorporated math as needed in labs, textbook discussions, and assignments.

Karen stated, “They're in a lab, so they'll receive data. They're required to put that into some type of chart. With that chart full of data…provide some type of visual image, take that data, and apply it to graphing skills.” Harvey explained that he uses math in “biology…genetics…based on probability…For the AP Bio, we…use…statistical analysis. Also, how…standard percent error…differs with an entire bigger population.” Irving said, “We were doing density…. The kids were taking…aluminum, and they were finding the mass and the volumes, and…plotting it on a graph. They found the slope of that line… is the density.”

Social studies teachers Nate, Mary, and Lenny offered their use of math concepts. Nate replied, “Probably the only real mathematical concepts [I use are] …perhaps economic charts. We don't work with…numbers and calculations ‘cause I got a…period of time that I have to have them ready to take this AP test in mid-May.” Mary stated, “from my perspective, students have a grasp on the easier math, the adding, subtracting, multiplying and dividing. I'm not doing algebraic equations here.” Lenny explained, “The textbook is good that we use because…in each chapter there's always maps. Graphs and charts. So, I find it easiest to incorporate those things in each chapter.” Social studies teachers used math skills as directed by their curriculum resources.

Curriculum resources. All teacher participants relied on the adopted and printed curriculum resources purchased by the WCPSDBOE and websites that were contracted on an annual basis by the board as mentioned earlier in this study. Anne explained it very well that the teacher resources in the disciplines were trusted, and she used them throughout the English course.

Anne responded, “I'm a real big textbook lover…There's already somebody… making…more money than I am…20 people…that created that textbook, so I trust in them. That's how I come up with what I'm doing.” This data suggests the teacher understood the English standards very well and incorporated math topics that were in the text or accompanying teacher resources. This data suggests the teacher valued the input from the authors of the resources and used the referenced materials in lessons. Additionally, she was not intimidated by math or any other discipline outside of her assigned courses due to her observed comfort in her class with math.

Furthermore, Brenda in English used outside reading novels, and Carrie in English added that English teachers used additional social studies resources because “now the world we live in is a different world, it's an information world. Foundational documents, like the Federalists papers, the Declaration of Independence, the Preamble to the Constitution, those are part of the curriculum.” Therefore, English teachers changed their platform of student reading materials to informational texts.

NCTM practices. The NCTM Effective Mathematics Teaching Practices are: 1. Establish mathematics goals to focus learning, 2. Implement tasks that promote reason and problem solving, 3. Use and connect mathematical representations, 4. Facilitate meaningful mathematical discourse, 5. Pose purposeful questions, 6. Build procedural fluency from conceptual understanding, 7. Support productive struggle in learning mathematics, and 8. Elicit and use evidence of student thinking. One math teacher and five science teachers implemented the NCTM practices 2, 3, 4, 7, and 8 in their observed classes. In each science class, the students used mathematical reasoning to compute a solution or analyze data from a virtual or physical lab. There were basic mathematical operations mentioned in the textbook or on a handout, but no NCTM practices were discovered in the observations of the English or social studies classes. Examples from the six observations illustrate the practices.

Emily, in math, read the problem: “Office manager needs a new copier. He can spend $650 on a new copier and reduce the electric bill from $122 to $88 per month. How many months will the copier pay for itself?” This is an example of the NCTM (n.d.) practice 2: implement tasks that promote reasoning and problem solving.

Karen in science used NCTM practices 3 and 4. Practice 3 is to connect mathematical representations. Students had to analyze information, and the teacher encouraged students to represent their thinking while problem solving when they were in groups in the physical lab (NCTM, n.d.). Practice 4 is to facilitate meaningful mathematical discourse. Karen facilitated discourse among students to build shared understanding of mathematical ideas by analyzing and comparing students’ approaches and arguments during the lab (NCTM, n.d.). Karen said to the students, “On your chart, where you mark the colors. Potency can get altered. The strength, capability of doing its chemical reaction. Look at your bag. Did it change color? Is it absent or present? Okay.”

Harvey in science used NCTM practice 7: support productive struggle in learning mathematics. Students had to label accurately when measuring and graphing within the virtual lab. Harvey encouraged accuracy and efficiency in expressing data with a degree of precision for the context of the problem (NCTM, n.d.). Harvey read aloud the titles and the headings he expected students to type on their graphs: “Graphs – layers one to six. Fifteen thousand years. Scoring – complete – pelvic girdle and two pelvic spines. Reduced – simplified girdle and no pelvic spines.” Sample graphs were provided on the website; however, students used different data from their individualized problem.

Irving in science used NCTM practice 8: elicit and use evidence of student thinking. The handout provided three different masses, and the corresponding relative percent. The students had to reason quantitatively using the order of operations and averaging. The teacher provided the opportunity for students to reason quantitatively using the handout that contained readings on a spectrograph (NCTM, n.d.). Irving told the students to use the “Isotopes on the spectrogram of a transition metal. Calculate the average molar masses from the experiment and show your work.”

Standardized tests. The WCPSBOE website includes the following policy on state assessments: “the data derived from state assessments will be utilized by teachers and administrators to pinpoint areas of difficulty and customize instruction accordingly.” The principal emphasized the urgency for teaching English language arts and math courses using the released items and websites from the PARCC, PSAT, SAT, and other standardized tests. Teaching to the test in math classes only hinders a student’s learning potential, and student engagement to solve math problems creatively using the standards as a reference would have a better effect on standardized test scores (Welsh, Eastwood, & D’Agostino, 2014). The two math teachers did not address standardized testing as a reason to teach the standards because they focused on students learning the mathematical concepts. Teachers from other core disciplines explained why they taught the CCSS in relation to the testing, and some teachers doubted this method as noted in the following examples.

Lenny in social studies said, “Specifically, where can I incorporate graph chart analysis, and reading comprehension, word usage, things that are going to pop up on the PARCC, the SAT, the PSAT.” Harvey in science also explained the reasoning for teaching testing prompts.

> A lot of the tests, whether it's AP or…the SAT exams, they're geared towards taking data and analyzing it.…I mean there are…things with the PARCC, they're not necessarily tested on science content, but…they're going to be given that science content…and make sense of it for the literary part. The same thing with math…so getting them used to it now…will pay off in terms of increasing their scores not just on the PARCC, but on the SATs, and the AP exams.

However, Karen in science voiced concern about teaching testing prompts outside of the NGSS standards: “It's a little difficult…with science, we have our own state testing…I have to ensure that I cover my curriculum as best as possible while trying to incorporate those standards that are there.” Mary added concerns about the changes in social studies towards teaching to the tests and explained, “what we're doing in the classroom is almost directly relating to what is going on, on PARCC and SAT.” Denise added:

> The thing with English is, especially literature, literature is definitely so much bigger than what the standards are addressing, so it's almost a shame to cut out some of the literature that is being now put on hold so that we can just attend to

> informational text, which is obviously what's being taught on the SAT and the PARCC, so I feel a little frustration with that.

Barriers. Some teachers stated that the standards and the standardized tests were limiting the creativity and variety of important resources. For example, Denise in English stated:

> The standards are very cut and dry. With College English 3, with the documents that I teach as part of American Literature, I feel that some of them are being cut out because the core curriculum content standards only want certain ones to be taught. I think the kids are losing out…over…the period of literature.

Furthermore, Karen in science explained:

> I think they're a good guideline to helping students become successful in their education, but I do…feel that they can inhibit the teacher's ability to give a little bit more, because they can be so rigid in what they want the kids to learn.

Time for planning and collaborating with teachers in other core disciplines was a barrier for incorporating math concepts, and some teachers had not experienced working with NCTM standards. Math teachers struggled to find time to incorporate other disciplines, and examples from teacher interviews explain these findings. The data suggests that math teachers did not collaborate with teachers in non-math core disciplines. Refer to Table 10 for examples of barriers addressed by teachers within departments.

Table 10

Barriers to Incorporating Mathematical Concepts in an IU

Department	Examples from Teachers
Math	Fitz explained, "You can't spend a whole lot of time doing a real-life problem…I need to make sure that they are following the standards.... Otherwise I'm wasting their time and mine."
Math	Emily shared, "That is difficult for me…to remember that when I'm making my lesson plans that I need…to include things from other disciplines.... When kids say,…how am I ever going to use this in my life?"
English	Brenda explained, "It takes time…we do so much with history…but we're bringing science.... It's not something that we would…go out of our way for, but it takes time to get them used to that type of material."
English	Denise stated, "I…say that I'm still a rookie with getting to know the standards for math or science. It's more time-consuming to go through…. Wish I had more time."
Science	Garth stated, "mathematical concepts are usually the lower level…don't do the geometry or the algebra."
Science	Irving explained, "The stuff we're doing mathematically in chemistry. We're not sitting here doing calculus or anything like that. It's basic algebra for the most part."
Social Studies	Mary stated, "percentages…would be…for a historical perspective on charts and graphs…. We look at years, dollars, amounts of money. That would be add, subtract, multiply and divide....I'm not doing algebraic equations here."

Mathematical concepts in IU—students. The question asking students to recall what mathematical topics were incorporated into non-math subjects resulted in various responses. They ranged from none that could be recalled to measurement in art and science, basic math skills, and some algebra I and geometry. For example, Student 1 offered, “Measurements in art.” Student 5 recalled, “in biology, I've used math like adding and subtracted and dividing stuff. We have used how to measure stuff. We've used a ruler and stuff.”

Student 2 spoke with enthusiasm as he explained the use of math in forensics: “We use math in forensics. Where we just did blood splatter. We were trying to find the angles of where it drops from and we were doing a lab on that.” Student 8 specifically stated, “We don't do word problems…[in] Algebra II.”

The question asking students how they incorporate mathematical concepts into their other subjects resulted in data from no response to studying for a test in other courses that incorporated math concepts. Some students referenced practicing math solution problems at home. For example, Student 2 explained, “I know I take sports marketing…. We do revenue…Like, increase profit and then decrease…expenses. We usually have a math problem on the tests and quizzes.” Student 4 described how, when studying at home, it is “fun doing math…in my opinion. The job I'm going to get, whenever I'm older, it requires math, so yeah. I like it. I want to be a computer software engineer.”

Teachers’ perspective on math comprehension. Teachers were asked, how would you describe the effect of integrating other disciplines on students’ math comprehension? Teachers’ responses ranged from no way to evaluate this process to that they incorporated other disciplines in their courses as a matter of habit. All teachers espoused the theory that IUs support math comprehension; however, the following data suggest that English and social studies teachers did not incorporate math concepts unless they were basic skills.

The two math teachers referenced students' interests and the difficulty of relating higher level math topics into other disciplines. Dewey (1902) discovered from his research that students who use their personal interests and prior knowledge may make connections and may enhance their problem-solving techniques. Refer to Table 11 for teachers' explanations of students' math comprehension by department.

Table 11

Effect of Students' Math Comprehension Based on IUs

Department	Examples from Teachers
English	Brenda replied, "I have no idea. I don't do any math in there."
English	Carrie explained more than the question was asking and gave her beliefs about academic strengths of students. "I think…when students are more confident in their mathematical abilities than they are in their reading, writing, speaking, listening skills, it's noticeable. When they're given a task in this class that involves some sort of math concept, they're more confident…either good at math or you're good at language arts. There are very few people that I've encountered are really good at both, so I see that in students."
English	Denise explained the observations made in her classes and referred to the math capability of the students. "I see them… counting on their fingers, and not doing…basic computations…being dependent on their calculators…is something that should have been memorized years…ago.…Just things like draw a straight line or draw a plane…draw a hexagon. They'll just stare at me sometimes, like, why are you saying that? Hexagon? You kidding me?"
Math	Emily explained from her classroom experiences, "I think if you find something that the students are interested in then it makes them pay attention more and are more engaged, so it makes the lesson a lot smoother. I think if they're thinking about a science topic that they might have talked about…they already have some prior knowledge of it, and it will…be easier."

Table 11 (continued)

Department	Examples from Teachers
Math	Fitz told of his experiences with using higher level math in real-world situations. “It is hard to tie it into other things that you're doing…Because math, especially when you get to these higher levels, is hard to tie in with maybe what they're doing in history, or what they're doing in Spanish three.”
Science	Jack related his experiences with IUs and math comprehension: “I think it has an incredibly positive effect on them. And I base it on their feedback…I just had somebody come to me from an honors physics course that I taught, and they said…what I did with honors physics helped them with trigonometry….Two of them came and said the same thing….And now they're engineers.” The following data supports the theory that IUs provide a platform for students to use their skills throughout their high school experiences (Anyon, 1980; Hillman, 2014; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006).
Science	Karen supported Jack’s findings: “I think that the more you can integrate different disciplines into one, the better the skills of any subject for a student, including math. It's just a matter of…finding that balance to be able to teach your content.”
Social Studies	Nate viewed AP courses as resources to support students’ learned skills of organization and good habits. He explained, "I think any high-level course that they take, like an AP level course, I think leads into all other disciplines, 'cause it's the high level of expectations that are there and the skills that they're learning, and study skills.”
Social Studies	Lenny said, “I think it's certainly beneficial to a student's math comprehension to have math practice into other disciplines. I think the more practice the better.”

Students’ perspectives on math comprehension. All students responded that integrating math concepts in other disciplines helped them recall math better. Student 7 explained this reasoning clearly: “Using it with other classes helps me do better in math because…I know that I could use this in the future…. Definitely slope, we used a lot in science for doing graphs.” Student 4 explained his experiences: “It makes it easier to answer the question…I take in anything I can from math, and I plug it into…other classes…and get that answer, and later…help me study for a test or a quiz.”

Summary. Mathematical concepts in an IU was the second theme discovered in this study, and all teachers and all students agreed that IUs helped students comprehend math concepts. Science teachers incorporated a plethora of mathematical concepts and NCTM practices. Furthermore, science teachers incorporated a weekly PARCC or SAT prompt that was selected by the English teachers. Students were assessed on their language arts skills and written answers to the prompts.

Furthermore, English teachers either did not incorporate any math concepts or only basic math as they encountered them in their curriculum resources. However, they included PARCC or SAT prompts that addressed science and social studies topics. Moreover, English teachers changed the departmental focus from literature to informational texts.

Social studies teachers included basic math skills as presented in their curriculum resources. They taught the social studies standardized test prompts from the PARCC or SAT, and they incorporated them as part of their usual reading, writing, and comprehension activities. Math teachers did not address the issues of standardized tests as a reason to teach mathematical concepts. Their concerns were incorporation of other disciplines and making the math concepts understandable for students. Teachers in each core discipline expressed lack of time as a barrier to using IUs, or a lack of math self-efficacy as a barrier to including math in an IU.

Students had no IU experiences at WHS in which two or more teachers from different departments worked together on the same units. However, the students recalled mathematical concepts of basic skills and some pre-algebra concepts taught in their non-math courses. Students practiced math solutions at home when preparing for a test and used prior math knowledge in other non-math courses.

Instructional Strategies

Data collected from teacher classroom observations, the survey, teacher interviews, field notes, and public documents were used to discover the first and second cycle of descriptive coding using a recursive process. Instructional strategies was the third theme that resulted from the pattern coding process, and the data was triangulated from the findings (Teddlie & Tashakkori, 2009). Cognitive apprenticeship was not anticipated, and parts of the discovered cognitive apprenticeship environments included content, domain knowledge, heuristic strategies, and learning strategies. Cognitive apprenticeship methods, scaffolding, and articulation were also discovered (Collins & Kapur, 2006).

Student data collected from the graphic elicitations and interviews revealed the third student theme, Learning Strategies. Furthermore, students related their favorite studying strategies and they discussed the following concepts of constructive apprenticeship: content, domain knowledge, heuristic strategies, and learning strategies. One student discussed finding a partner for studying and learning, and this was a reference to Vygotskian constructivism. Examples from the discovered data for instructional strategies for teachers and learning strategies for students are included in this section.

Teacher observations. The reference to instruction in the WCPSBOE policies website stated, “Instruction shall be designed to engage all pupils and modified based on pupil performance.” Classroom observation data for instructional strategies revealed a use of lecture throughout most classes. One math teacher, Fitz, used lecture for the entire class period, and each of the other teachers incorporated some lecture as the lesson warranted. For example, Brenda made a transition from students sharing their results verbally to another activity. Brenda changed the students’ assignments orally by describing how their interpretation of the author’s purpose counted as a quiz grade, and if students had completed the author’s purpose and submitted it, then start reading the assigned book starting with the Jesse Owens incident. Her verbal directions were, “Okay…authors’ purpose counts as a quiz grade…so far, need this score to reflect that. If you finished yesterday, start with Jesse Owens incident and stop before part two.”

Teachers included a variety of hands-on activities for students to use in English, social studies, math, and science classes. English teachers used Turnitin (2018) for writing creatively or the Albert (2018) testing program for testing. One English teacher, Anne, used the teacher’s computer and Computer Assisted Instruction (CAI) provided by the authors of the curriculum resources. Anne played the recording of an actor reading Johnathan Swift’s story, paused it when necessary, and directed students’ attention to their student guides to answer oral questions as well as write responses in their guides. Lenny in social studies required students to use their text and a handout to enter their work on Google Docs. Emily directed the math students to write corrections on their papers that were graded and returned to them at the beginning of class. Irving in science passed out a printed handout, and students worked in their group to solve the problems and write their answers.

Cognitive apprenticeship. Harvey, in science, used cognitive apprenticeship when students worked individually on their laptop analyzing data from a virtual lab about stickleback evolution (Collins & Kapur, 2006). I viewed the menus on the teacher's laptop, and students were required to graph data and use a link to review different types of graphs. Students worked on an experiment with three components: analyze fish from lakes, analyze fossil fish, and pelvic asymmetry. A notebook was included in the CAI schoolology lab manual for students' notes. This is an example of the cognitive apprenticeship dimension method "to promote the development of expertise" (Collins & Kapur, 2006, p. 112).

Other methods observed included scaffolding and articulation. Scaffolding is directly helping students at the beginning and then fading away (Collins & Kapur, 2006). Jack, a science teacher, explained to me after class, "I learned tricks to help solve problems and use these tricks to give students support." Jack used flash cards for students to organize and have support for new terminology and meanings. Another example of Jack's scaffolding was the handout students used to submit their lab findings, and it represents handouts used by other teachers. Refer to Appendix K for the sample handout used also by social studies teacher Lenny that students used to answer questions about the lesson on a document in Google Docs. Denise in English also distributed a handout to students, who used it to write a creative narrative about the short story using Turnitin (2018).

Articulation is allowing "students to verbalize their knowledge and thinking" (Collins & Kapur, 2006, p. 112). Carrie and Brenda, in English, asked students to turn to a partner and discuss the topic of the week. For example, Brenda instructed the class, "Once a week be creative. Only use 20 words or phrases for the rest of your life, what would they be? Choose wisely…[consider] real world situations. You have a limited ability to communicate." Students had time to talk to each other and explain how they interpreted the problem.

Modeling was an observed concept of constructive apprenticeship in Irving's science class (Collins & Kapur, 2006). Irving explained orally as he wrote on the Smart Board:

> Percent Abundance is 2.18% of atoms of element have a mass of 54 amu, 9.5% mass of 53 amu, 83.9% mass of 52 amu, and remaining mass of 50 amu. [Find the] average molar mass and identify the element…[I'll] give you five minutes to figure this out.

Vygotskian constructivism was observed in the three science classrooms (Collins & Kapur, 2006). Students in science classes performed physical labs using a prescribed process from a handout and oral directions given from the teachers, Karen, Jack, and Irving. Irving arranged the students' desks in groups of four, and individual students worked on the handout following Irving's oral and written examples on the Smart Board. Group work was not observed in Fitz's class nor in Emily's math class, and groups were not observed working in social studies classes.

Critical thinking. Teachers used the word "analyze" in objectives written on the board, printed in handouts, or in their oral directions given to students for a total of 10 times. An example was Nate's social studies objective written on the board: "Analyze and compare New England, Chesapeake and Southern Colonies. Analyze the Atlantic Slave Trade." Brenda in English told the class, "Create four intelligent questions to bring to the table in our seminar. Analyze."

"Teachers most often ask lower-order, convergent questions that rely on students' factual recall of prior knowledge rather than asking higher-order, divergent questions that promote deep thinking, requiring students to analyze and evaluate concepts" (Tofade, Elsner, & Haines, 2013, p. 1). Oral questioning was used by nine teachers during the warm up, the first activity of the class, or later in the class. The teachers waited for students to answer the question without asking a particular student. For example, Carrie in English asked, "People who own homes, cars. Is the intended audience teenagers?" One student replied, "No." Emily in math asked, "How many months will the copier pay for itself?" Emily did not get a response and then worked the problem at the Smart Board giving the students the answer.

Nate, in social studies, asked oral questions, and the same student answered each question. For example, "What's the head right system?" A female student responded with the answer, "System adds to indentured servitude." Nate asked a second question, "Why was the Chesapeake unhealthy? True or false?" The same female student replied, "Import and immigrants…male dominated society." A second example of one student responding to each oral question was in Anne's English class. Anne asked, "Why this age?" A male student said, "Older children have tough meat." Anne asked, "What is the irony?" The same male student said, “Cruel to target a population …Irish Catholics.” In each case, Nate and Anne asked at least five oral questions, and the same student answered each of the questions verbally. Students in Nate’s class worked on their laptops answering questions on Google Docs after the five oral questions. However, Anne continued the questioning process and the same male student answered all questions.

Teacher survey. Saldana (2013) states that questionnaires “assume direction and intensity of a value, attitude, and belief…allowing for…varying levels of depth” (Saldana, 2013, p. 114). The teacher survey was the second component of the data collection protocol in this study. The 17 questions relating to the observed lesson of the high school teachers were selected using the 2000 National Survey of Science and Mathematics Education (Horizon Research, Inc., 2001). The survey questions focused on students practicing and learning mathematical concepts and relating math to other disciplines or careers. Questions 1, 3, 4, 5, 6, 7, 10, 12, 14, and 15 relate to mathematical concepts. Questions 2, 8, 9, 11, 13, 16, and 17 relate to other disciplines or careers.

The survey questions combined with the teacher interview protocol focused upon the use of math in each class, thus allowing teachers to state their experiences implementing the CCSS and their perceptions of using IUs. Ten of the 14 teachers returned the survey, and the numerical results are posted in Table 12. Furthermore, the survey question, the actual number from each of the five Likert responses, and the percent of the responses from the Likert scale are displayed in Table 12.

Table 12

Mathematical Concepts in Core Disciplines Survey Results

Question	Number of Responses for each Likert Scale Response	Percent of Agreement
1. The mathematics content in the observed lesson was significant and worthwhile.	1/10 D 6/10 A 3/10 SA	10.00% D 60.00% A 30.00% SA
2. The content of the lesson increased the students' interest in math	1/10 D 7/10 N 2/10 A	10.00% D 70.00% N 20.00% A
3. The content of the observed lesson helped students learn mathematical concepts.	2/10 D 1/10 N 7/10 A	20.00% D 10.00% N 70.00% A
4. The content of the observed lesson helped students learn mathematical procedures.	3/10 D 1/10 N 5/10 A 1/10 SA	30.00% D 10.00% N 50.00% A 10.00% SA
5. The content of the observed lesson helped develop students' computational skills.	1/10 D 2/10 N 5/10 A 2/10 SA	10.00% D 20.00% N 50.00% A 20.00% SA
6. The content of the observed lesson helped students solve problems.	1/10 D 1/10 N 6/10 A 2/10 SA	10.00% D 10.00% N 60.00% A 20.00% SA
7. The content of the observed lesson helped students reason mathematically.	1/10 D 2/10 N 6/10 A 1/10 SA	10.00% D 20.00% N 60.00% A 10.00% SA
8. The content of the observed lesson helped students learn how mathematical ideas connect with one another.	2/10 D 3/10 N 2/10 A 3/10 SA	20.00% D 30.00% N 20.00% A 30.00% SA
9. The content of the observed lesson helped students prepare for further study in mathematics.	1/10 SD 1/10 D 5/10 N 2/10 A 1/10 SA	10.00% SD 10.00% D 50.00% N 20.00% A 10.00% SA
10. The content of the observed lesson helped students understand the logical structure of mathematics.	3/10 D 3/10 N 3/10 A 1/10 SA	30.00% D 30.00% N 30.00% A 10.00% SA

Table 12 (continued)

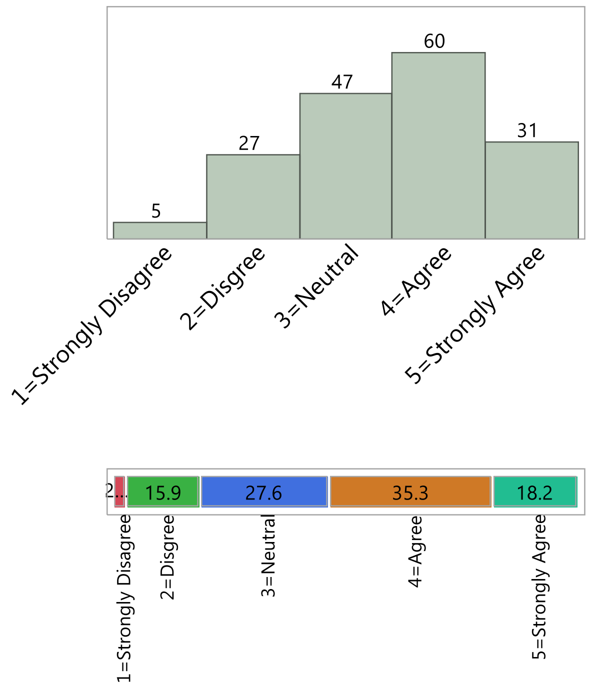
Question	Number of Responses for each Likert Scale Response	Percent of Agreement
11. The content of the observed lesson helped students learn about the history and nature of mathematics.	2/10 SD 6/10 D 1/10 N 1/10 A	20.00% SD 60.00% D 10.00% N 10.00% A
12. The content of the observed lesson helped students learn to explain ideas in mathematics effectively.	2/10 SD 2/10 A 5/10 N 1/10 SA	20.00% SD 20.00% A 50.00% N 10.00% SA
13. The content of the observed lesson helped students learn how to apply mathematics in business and industry.	2/10 D 3/10 N 1/10 A 4/10 SA	20.00% D 30.00% N 10.00% A 40.00% SA
14. The content of the observed lesson helped students perform computations with speed and accuracy.	2/10 D 3/10 N 4/10 A 1/10 SA	20.00% D 30.00% N 40.00% A 10.00% SA
15. The content of the observed lesson helped prepare students for standardized tests.	1/10 D 3/10 N 4/10 A 2/10 SA	10.00% D 30.00% N 40.00% A 20.00% SA
16. The content of the observed lesson helped students make appropriate connections to other areas of mathematics, or other disciplines, or to real-world contexts.	3/10 N 2/10 A 5/10 SA	30.00%N 20.00% A 50.00% SA
17. The content of the observed lesson provided students opportunities to apply or generalize skills and concepts to other areas of mathematics, other disciplines, and/or real-life situations.	4/10 N 2/10 A 4/10 SA	40.00% N 20.00% A 40.00% SA

Note. The following are the meanings for the abbreviations above: SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, and SA = Strongly Agree

A graphical plot displays the results of the returned survey using Citrix (2018), a statistical website available through Rowan University. Out of 170 responses, five were

Strongly Agree, 27 were Agree, 47 were Neutral, 60 were Agree, and 31 were Strongly Agree. Please refer to Figure 3.

Response



Frequencies

Level	Count	Prob
1=Strongly Disagree	5	0.02941
2=Disgree	27	0.15882
3=Neutral	47	0.27647
4=Agree	60	0.35294
5=Strongly Agree	31	0.18235
Total	170	1.00000

N Missing 0
5 Levels

Figure 3. Graphical plot of mathematical concepts survey—teachers.

Teacher interviews. Vygotskian social constructivism was not observed in the classes (Steele, 2001); however, teachers said having their students work in groups or with a partner was a teaching strategy. Fitz in math explained, “I guess that is, my main strategy's more lecturing, and then group work for reviewing.” Mary, in social studies explained, “I have the kids pair/share, partner pair/share…I'll ask for volunteers to raise their hands.”

One teacher, Irving in science, referred to peer collaboration within the groups during the interview. This was the only reference to Vygotskian constructivism from teacher interviews (Collins & Kapur, 2006). Irving explained his rationale for having students work in groups:

> I choose the groups, and I make sure certain kids are where they are. Sometimes it's based off…their academic level…or…maybe…I know these two really work well together…and they like to teach other people, so I'll…put them around the kids that are struggling.

Teachers used the word "analyze" in handouts for students in science and social studies classes. Refer to Appendix K for an example of a handout. Furthermore, science and social studies teachers provided CAI programs for students to analyze the data shown in a graph or to create a graph from data discovered during a lab. For example, Harvey in science explained,

> There is something to say about conducting a lab, but a lot of the tests, whether it's AP or some of the SAT exams, they're geared towards taking data and analyzing it, so the virtual labs do get them some of the limited exposure to how to do the techniques, but it's more that I can fine tune questions to analyze or have them demonstrate whether they can analyze data or not.

Irving, a science teacher, was the only teacher who discussed differentiated instruction as a teaching strategy. Irving explained:

> Differentiated instruction…but it's always not the easiest thing to implement…Here's 10 problems…each of you guys to pick three or four…and then circle the ones that you think are more challenging…If you did problem four

and someone at your group did not do problem four, see if you can explain to them…how you…do that. Then from there, there sometimes are ones that nobody can do…then we do those as a class.

Student learning strategies. Teachers who use the dimensions of cognitive apprenticeship may inspire students to learn (Collins & Kapur, 2006). Student 3 explained how the science teacher was an inspiration when asked about his/her favorite class this year. Student 3 said, “I would have to say biology. Mostly because [Jack] is just an amazing teacher, and biology's one of my favorite subjects. I just want to go into it in the future.”

Vygotskian constructivism was discovered when Student 4 explained a favorite learning strategy as being able to “study with a partner if I could find one.” Additionally, content is a dimension of cognitive apprenticeship that was discovered from student interviews as domain knowledge learned by both heuristic and learning strategies. Student 2 expressed using domain knowledge for studying: “I like to do the strategy where you learn it the day, study it the next day, and then study it before the quiz. That's how I learn best.” Student 6 also expressed learning domain knowledge as he/she relayed, “Before each test, I like to look over some parts of the book.”

Each of the eight students explained that they liked to create and use flash cards or note cards to help them study and learn. Students used the heuristic strategy as shown in the following examples. Student 7 remarked, “My primary study strategies over the years are note cards, I like index cards and flip them over.” Student 8 explained, “I like the writing. My primary studying strategies over the years. I like writing out notes, like flashcards.”

Furthermore, more learning strategies for learning domain knowledge included the following. Student 3 explained, “I'm a visual learner, so having things taught to me on the board, Smart Board, things being drawn out.... I need the teacher to interact with me for me to fully understand something.” Student 5 added “watching videos on YouTube.” Student 7 explained, “My primary study strategies over the years are note cards…and my mom helps me with them.” Student 8 added, “I like the writing. My primary studying strategies over the years. I like writing out notes.”

Summary. Teachers’ instructional strategies included having students use their laptops to analyze data from standardized test websites or virtual science labs. Some classes worked on assignments by writing answers on a handout or followed a guide using the Google Classroom Suite. Teachers in different departments used specific websites such as Turnitin (2018) in English for creative writing. Math teachers used ixl for practice of mathematical concepts, and science teachers used schoolology or biomanbio. Instructional strategies not anticipated but discovered included constructive apprenticeship principles of content by domain knowledge, heuristic strategies, and other learning strategies. The methods of scaffolding and articulation were also revealed.

The teacher survey was a resource for the teachers to reflect upon their observed lesson and their beliefs about incorporating math concepts across the core disciplines. The survey was also a resource for teachers to respond to the semi-structured interview questions about their instructional strategies that were not observed and their use of instructional strategies that included IUs. The analysis of the connections between the teachers’ instructional strategies and the students’ learning strategies are discussed in Chapter 5 of this study.

Student participants were given the opportunity to discuss their favorite learning strategies. During the semi-structured interviews, students revealed the cognitive constructionism content principle to learn domain knowledge through heuristic strategies. Furthermore, they used learning strategies by finding videos on the internet, working with a partner, collaborating with the teachers, and reviewing concepts in the textbooks. One student was inspired by his biology teacher to become a biology teacher as a career.

Instructional Leadership

The teacher participants were asked the interview question, “How would you relate your instructional leadership to the implementation of the CCSS using interdisciplinary units?” Teachers responded with different interpretations depending upon the discipline they taught and the variety of their experiences at WHS. Their perceptions of instructional leadership were developed during the second cycle of descriptive coding, and the following patterns were discovered: implementing CCSS, enacting CCSS in an IU, classroom leadership, and student engagement.

Implementing CCSS. Harvey took an instructional leadership role in the science department by using OnCourse and curriculum resources to help all science teachers implement the CCSS. Harvey explained that he has been “rewriting the OnCourse CCSS for [the] science department…to say…this is what we're gonna cover, or this is what we're going to omit because it's…not heavily focused on the CCSS.” Anne, in English, also viewed sharing lesson plans on OnCourse as an instructional leadership process for implementing the CCSS. Anne explained:

> Yes. The school definitely looks to me for leadership when it comes to the common core standards and using those. Actually, most of the people have access

> to my lesson plans. Even though I have seniors, and for the PARCC you need to cut them down into these smaller sections or smaller units…. I still do it because I am part of this English team and I feel like I have to do the same things that they do. I think I'm definitely a leader when it comes to the common core standards.

The administration expected teachers to use the CCSS as a guide for their lessons. Furthermore, the administration led teachers to use standardized test websites and sample prompts as previously discussed. Jack, one of the science teachers, explained that expectations from WHS administration provided leadership for implementing the CCSS. Jack said, “I'm always trying to get some of these common core standards, in one way or another…because I'm expected to. So… expectations are high.” Lenny, a social studies teacher corroborated this reasoning by stating, “You're assigned different topics and skills to teach, and you teach them.... [CCSS]…was a major change. The skills were very different, and some of the content was different.…So I…roll with it.” Garth, a science teacher, confirmed: “[the] expectations [from the] state science test…You kind of incorporate the common core state standards that's necessary.”

Enacting CCSS in an IU. Instructional leadership practices combined with transformational leadership by school administrators allows teachers to make necessary changes to their teaching methods to improve student achievement (Hallinger, 2003; Leithwood & Sun, 2012). Jack, a science teacher, explained, “I like taking in language arts and I like taking in math whenever I can.” Carrie, an English teacher, and Lenny, a social studies teacher, added other disciplines as presented in their curriculum resources; however, math was not a priority, as Carrie explained:

I think if this question asked the common core with English, I would give myself a four-star rating for instructional leadership. And maybe three stars for science and history disciplinary units. And maybe one star for math, because I kind of avoid it, truthfully.

Brenda in English described the English department's role in enacting the CCSS in an IU by distributing SAT passages to the science and history teachers. Brenda described why by stating:

Instructional leadership…for [the] English department…is we get the material …[and] we're doing the SAT passages…but some of our text is…being used in history…also… in science. We're all working on the same thing, but… it starts with the English aspect. If we don't teach them how to read for the right things, then they're not going to understand how to approach it.

Classroom leadership. Emily in math described instructional leadership as being a leader in the classroom:

I definitely take the lead in the classroom to have the students understand what we're talking about. I …give the lead to the students so that they can figure out concepts by themselves without me…. For example, I…did absolute value and instead of telling them what each part of the function does, I had them explore it …and they were able to change the values and see what happened to the graph. Just being able to put some of that responsibility on them to…use their logic to figure out what's happening made…the lesson…easier, and it helped me…listen to what they were saying and the words they were using.

***Student engagement*.** Emily's example is also evidence of student engagement because Emily described appropriate curricular materials used as an interchange between pairs of students during instruction (Confrey & Krupa, 2010; Vygotsky, 1978). Instructional leadership in the classroom is related to student engagement on activities in the class. Comparisons of classroom observations to teacher interviews were consistent for most participants, and students were engaged in the classes with no off-task behavior, except in two English classes and one math class.

Brenda and Carrie struggled at the beginning of their classes to get students settled and on task for the creative alliteration assignment. Brenda's class is an example of the students' off-task behavior. Brenda stopped giving oral directions at the start of class and told the class, "we don't need…too much talking…This is Friday, let's have a good day. Guys, this is for you, I can't redirect you 10 times." The redirecting 10 times was due to students talking and laughing with each other during Brenda's oral description of the task. Getting them on task took about five minutes. Students laughed and talked over the two students who attempted to give their oral results individually. Brenda said to the class, "Listen…not going to comment in between." Brenda gave the class the same assignment for the weekend to have ready for Monday, and students either read the assigned book or worked on Albert (2018) on their laptop for the remainder of the class.

Fitz, in math, gave the Warm Up question on the Smart Board, and four out of 11 students appeared to be working the question. No students took notes as Fitz wrote solution steps to factoring quadratic equation examples for the remainder of the class. Furthermore, students watched passively without asking questions.

Alternatively, Fitz voiced his perspective of classroom leadership as being a role model for students. Fitz said, “I think there's the aspect of, they are going to copy what you do.... They’re going to imitate not only my work, but my effort I put into the class.” Nate in social studies explained classroom leadership as, “Leading…students through the process of research and developing the skills…to master an AP course…I'm… a guide.” Other teachers expressed different ways of implementing instructional leadership by collaborating with other departmental teachers.

Self-reflection and reflection with other teachers provide an evaluation method for the teachers to improve teaching practices (Osterman & Kottkamp, 2004; Runhaar et al., 2010). These teachers combine their abilities and experiences and perhaps their motivation to try new teaching strategies (Bandura, 1993; Mills, 2003; Runhaar et al., 2010, p. 1155). Emily in math was an example of sharing and reflecting with other teachers within the same department, and this process was echoed by teachers in science (Jack, Karen, and Irving). Emily said it succinctly:

> With…the other math teachers…I…bounce ideas off…one co-teacher and the one power teacher…to get ideas and make sure that what I'm thinking…makes sense to somebody…and it helps…being able to…work together…to create something better.

Mary in social studies viewed instructional leadership as being a Student Council Advisor. For example, Mary explained a charity event sponsored by the student council: “We are running our Giving Tree Program currently for the holiday season. We are reaching out to outside businesses in the community, asking if they would like to make donations. They graciously are.”

Summary of instructional leadership. In this setting of one high school, WHS, most of the teachers were making incremental changes towards teaching IUs using math concepts. This aligns with the literature on how teachers resist changes to their teaching strategies and the change process (Fullan, 2007). All teachers taught the CCSS objectives in their discipline, and the science teachers combined the NGSS with the CCSS.

English, science, and social studies teachers incorporated standardized test items from the PARCC, PSAT, and SAT. Teachers used an interdisciplinary approach by incorporating the test items from other disciplines in their lessons. Jacobs (1989) described this method as “a…curriculum approach that consciously applies methodology and language from more than one discipline to examine a… problem” (Jacobs, 1989, p. 8). However, the approach the teachers used did not include the methodology from the other discipline. It is not the same interdisciplinary method used by the science teachers who demonstrated the interconnectedness of NCTM practices that supported the science standards. Nonetheless, it is an incremental change from teaching a discipline in isolation, and it is a beginning for the change process (Fullan, 2007; Lewin, 1947).

The majority of teachers who viewed themselves as an instructional leader in the classroom demonstrated this leadership when their students were engaged during the class period. Students used CAI and interacted orally or wrote on handouts as the teachers demonstrated how to solve a problem. These teachers monitored student progress by walking around or monitoring students’ work on the teachers’ computer using CAI.

Moreover, most teachers in each discipline viewed themselves as an instructional leader by collaborating with teachers within their department. They shared information and teaching strategies that were successful or not successful or how much time to spend on a unit or lesson. These teachers used self-reflection and reflection with others to improve the teaching strategies of both teachers (Bandura, 1993; Mills, 2003; Osterman & Kottkamp, 2004; Runhaar et al., 2010). Administration at WHS made it possible for teachers to make collaborative decision-making changes known as a second order change (Argyris & Schon, 1974; Leithwood & Poplin, 1992). Lewin (1947) called the first step in making changes unfreezing. The WHS teachers recognized changes that were different from their usual teaching strategies, and the IUs that involve collaboration across the disciplines is a step toward unfreezing (Lewin, 1947). Carrie in English said it best:

> I think this is an important study, and I think it's important for teachers to realize that…education is not isolated into bubbles. It's the whole child, it's the whole brain and we'd be better, the system would be a lot better, if the disciplines were more interrelated, and more relevant. Because, life is interdisciplinary.

Summary of Exploratory Case Study

The first cycle of descriptive coding and second cycle pattern coding led to the four themes that were discovered from the data. The total of 506 incompatible segments of data were coded from teachers' classroom observations, teachers' interviews, field notes, and public documents. Furthermore, 99 exclusive segments of data ware coded using student interviews. Each of the types of data were coded toward implementing the CCSS using IUs at WHS with a focus on mathematics. The theoretical research that IUs help students learn by using their past experiences and making connections across disciplines in addition to the research questions produced reliable information for this study.

The data analysis produced four themes: conceptualize an IU, mathematical concepts in an IU, instructional strategies, and instructional leadership. These four themes discussed in Chapter 4 described the process teachers used to incorporate core disciplines into a lesson, the barriers to this process, the mathematical concepts they incorporated, and their perceptions of instructional leadership. The themes were presented in this study through the data collected and discussed in terms of the core disciplines—English, science, social studies, and math. Furthermore, the data collected from the interviews with the students produced the three themes – conceptualize an IU, mathematical concepts in an IU, and learning strategies.

The majority of the teachers were in the experimentation/reassessment stage, Huberman's third stage. These teachers presented a willingness to use IUs despite the lack of available time to collaborate with teachers from other disciplines or a low self-efficacy in math. Both the teachers and the students espoused the benefits of IUs across the core disciplines, and each group of participants embraced technology for instructional or learning support.

Despite the lack of collaboration among departments about IUs, teachers made incremental changes toward using IUs in their lessons by incorporating standardized test items. Their perception was that this process was a use of an IU. The implications of the research findings, as well as possible areas of change for WHS and the educational leadership, are discussed in Chapter 5.

Chapter 5

Discussion, Implications, and Recommendations

This qualitative case study was designed to understand how high school teachers in the core disciplines of English, math, science, and social studies enacted the Common Core State Standards (CCSS) using interdisciplinary units (IUs). Furthermore, this study was designed to understand how secondary teachers incorporated mathematical concepts and how math teachers used IUs, and to explore ways to adapt the CCSS using IUs. Teachers' beliefs that were produced within themselves and their culture revealed their math self-efficacy, and the barriers they encountered while trying to incorporate IUs were discovered in this study. Specifically, some teachers expressed their lack of self-confidence teaching basic math skills because they believed that people are born with mathematical ability or not. They considered themselves to have been born with language expertise, and they avoided using math whenever possible. Importantly, students' preferred learning structures and teachers' teaching structures did not match each other. Students' preferred learning structures included components of cognitive apprenticeship dimensions and Vygotskian constructivism. Not all teachers' structures included the NCTM principles, teaching IUs, components of cognitive apprenticeship, and Vygotskian constructivism.

This study is organized by the research questions and the themes that were produced from the data analysis that answered them. The importance of using IUs across the core disciplines to support student learning and the perceived barriers that teachers shared with me during interviews are included in this discussion. The implications of the teachers' and students' data concerning teaching strategies and learning strategies, respectively, are discussed and are based upon the theory that students learn concepts better when using various disciplines included in an IU. Furthermore, the importance of educators' membership in professional organizations and of opportunities to share information across the country is also addressed.

The principles of the NCTM (2014) are the foundation of the interconnectedness between cognitive apprenticeship, mathematics education, interdisciplinary theory, and students' cultural experiences. Students' learning strategies and teachers' teaching strategies connect with each other through cognitive apprenticeship and the NCTM principles. The teachers' instructional leadership is discussed in terms of data produced from their implementation of the standards using IUs, sharing information with other teachers, and following administrative directions. Implications for interdisciplinary education for teachers and students and implications for leadership at WHS are also discussed. Recommendations are stated based upon my professional interpretation of the data. This study demonstrates that students at one high school learn better when the cognitive apprenticeship dimensions and the principles of the NCTM (2014) are incorporated into IUs in the secondary disciplines. The findings are discussed in depth and begin on page 157.

This study was based on the theory that "properly designed interdisciplinary units can lessen the fragmentation that too often results" from teaching specific disciplines and not working collaboratively with teachers in other disciplines (Jacobs & Borland, 1986, p. 159). How teachers and students enacted or perceived interdisciplinary units, uses of interdisciplinary units to prepare students for standardized assessments, and challenges to incorporating interdisciplinary units in core courses figure importantly in the data. This study revealed how core curriculum teachers related their instructional leadership to the implementation of the standards using IUs and provides the opportunity for teachers in other schools to justify the implementation of IUs in their individual school. That IUs help students comprehend the content of the disciplines is supported by many research studies and educational thinkers (Andrews, 2011; Anyon, 1980; Dewey, 1902; Eilers & D'Amico, 2012; Hillman, 2014; Jacobs, 1989; Jacobs & Borland, 1986; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Spalding, 2002). This chapter includes a discussion of the implications and recommendations for school leaders supporting the implementation of IUs in a similar context. My findings were consistent, and they support the reasoning for a qualitative case research study as presented by Creswell and Yin (2014). Additionally, this study provided data and data analysis revealing the incorporation of math in IUs from the perspectives of both the teachers and the students in one secondary school. There is very little research about high school core discipline teachers incorporating math in IUs, and the results may serve to support and encourage teachers to use IUs and incorporate mathematical concepts.

Discussion of Major Findings/Answers to Research Questions

The guiding research question addressed in this study was: how do core curriculum teachers teach the CCSS using IUs? Four sub questions asked were as follows:

1. How do core curriculum teachers at one school conceptualize and enact IU lessons?
2. How do core curriculum teachers at one school understand and enact the CCSS?

3. How do science, social studies, and English teachers at one school incorporate mathematical concepts when teaching the CCSS?
4. How do the core teachers at one school relate their instructional leadership to the implementation of the CCSS using IUs?

All teachers except Advanced Placement (AP) teachers who relied on the College Board standards, taught the objectives from the CCSS in their observed class, and all teachers had access to technology. All students were issued a laptop, and most students in the observed classes used their laptops. Some teachers conceptualized and used IUs and incorporated mathematical concepts in core disciplines. Moreover, students created an IU and recalled how they used math in their courses using a graphic elicitation handout. Additionally, students discussed their preferred learning strategies and how they studied for tests.

The suggestions for educational leadership, and future directions in the areas of IUs incorporating mathematical concepts are discussed using the discovered themes throughout the following sections. They are:

- Conceptualize an IU – teachers and students
- Mathematical concepts in an IU – teachers and students
- Teachers' instructional strategies
- Students' learning strategies
- Instructional leadership - teachers

Each theme, the implications, and the recommendations are discussed below. The meanings of the findings of this study are presented by the themes, and the meanings are presented both in the context of WHS and the larger forum of interdisciplinary mathematics.

Conceptualize an IU and implications. The theme, conceptualize an IU, addressed the first sub-question, how do core curriculum teachers at one school conceptualize and enact IU lessons? Some teachers incorporated other disciplines into a lesson if the concepts were included in the curriculum resources. An implication of conceptualizing an IU is that it may allow teachers and students opportunities to be involved in new learning experiences. For example, teachers learn techniques from other teachers as they collaborate and observe other teachers involving student ideas, and students may gain encouragement to try new learning strategies.

Furthermore, teams of teachers who develop and clarify concepts within an IU have opportunities to experiment with new teaching practices, reinforce social interactions among the members, and develop an understanding of the importance of each of the various disciplinary concepts in the IU. Teachers who use CAI have opportunities to share technological resources and computer skills with other team members. Teams may present an overview of their IU and results at faculty meetings, and all teachers may have the opportunity to benefit from the team's success as well as difficulties encountered while implementing an IU. These teams of teachers may present to district or national conferences like those of the NCTM, and perhaps create webinars of their IU. Many studies have indicated that teachers in disciplines other than math may appreciate opportunities to learn how to incorporate NCTM practices, and the teachers in this study did the same.

The results of this study indicate that some English teachers did not use math or teach it in their classes due to a perceived lack of planning time or low math self-efficacy. Those teachers were not following the board policy that teachers teach the curriculum using IUs when appropriate. An additional implication is that they deprived their students of the benefits of making interconnections across the English and math curricula. Some teachers may need appropriate training and coaching to learn how to conceptualize an IU and teach the interconnectedness of math with other disciplines.

An implication of these findings is that teachers may need more time for training throughout the year and time to experiment teaching an IU. Because most teachers in the study were in Huberman's (1989) third career stage, experimentation/activism, they may be willing to work with a team of teachers to learn new teaching techniques. Some of the teacher participants from this study may volunteer to learn how to conceptualize an IU. Teachers implementing new instructional techniques need support and encouragement from administrators who understand that failure is a learning process and part of growing professionally (Hallinger, 2003; Leithwood & Sun, 2012). This understanding from administrators is a practice of instructional leadership.

An implication of the training for this group of teachers and district curriculum coaches, a cadre of educators, is that they may become the model for all teachers at WHS to implement IUs and interdisciplinary mathematics. Furthermore, the cadre may present at conferences of the Association of Interdisciplinary Studies and provide the findings of their work to many educators. The cadre may add valuable support to each teacher of the core disciplines and train them about the importance of IUs and what an IU means in theory and in practice.

For example, the English teachers included science and social studies standardized test prompts, and they perceived this process as using an IU. The implication for this lack of understanding about IUs is that students practice evaluating and responding to a test question or prompt; however, they do not experience how to use the science and social studies underlying content and skills to solve real problems. However, the students did understand that an IU may be used for teaching across any disciplines.

The social studies teachers conceptualized an IU and included the English Language Arts (ELA) skills of writing and interpretation as they followed the curriculum resources and assigned tasks from the textbooks. Furthermore, the social studies teachers incorporated standardized test prompts that referred to historical topics. Math concepts incorporated were basic math skills as presented in social studies curriculum resources. English and social studies teachers did not incorporate mathematical concepts beyond basic math skills found in the curriculum resources. An implication is that English and social studies teachers may benefit from collaborating with math teachers and the district math curriculum coach to provide opportunities for modeling the interconnectedness of higher mathematical concepts in ELA and social studies. English, social studies, and other teachers may need to have appropriate training to understand the theory supporting IUs and how to conceptualize and enact an IU.

Math teachers taught mathematical concepts based upon curriculum resources, and one math teacher used real problems in the algebra I class that demonstrated an NCTM practice. Neither math teacher used an IU curriculum approach in the observed classes or discussed their conceptualization of an IU in the interviews. These classroom observations and discussions in interviews revealed that students were taught mathematical concepts and practice skills in isolation. Student participants understood that mathematical concepts are found and used in many disciplines, and they voiced their creativity when they conceptualized an IU.

Another implication is that the NCTM effective mathematics teaching practices may need to be incorporated into math lessons to provide students opportunities to experience 21st century problem-solving techniques (NCTM, 2014). For example, the NCTM (2014) explains a productive belief of teaching mathematics is that students should be "actively involved in making sense of mathematics tasks by using varied strategies and representations, justifying solutions, making connections to prior knowledge or familiar contexts and experiences, and considering the reasoning of others" (p. 11). Furthermore, an implication for students is that they may not relate the problem-solving process of creating solutions when confronted with real problems that require underlying mathematical concepts if they are taught to solve problems by watching and listening to the teacher (Mayer, 2002). Additionally, students perceived that secondary teachers do not collaborate across core disciplines.

Comparison of the teachers' findings revealed that science teachers used curriculum resources and assigned virtual or physical labs as required by the NGSS, CCSS, and their curriculum resources. The mathematical concepts included in class observations consisted of five of the eight NCTM practices, and science teachers' interviews supported the math used in the class observations. This implies that science teachers follow the NGSS, include mathematical concepts that support the science curriculum, and incorporate both ELA skills and references to historical events as warranted. Science teachers used science standardized test prompts and students practiced the ELA skills of writing, interpretation of lab results, and responding appropriately to testing prompts. Science teachers provided the underlying content and skills required for students to create solutions in lab situations, and this is a concept of cognitive apprenticeship. The dimension of content from cognitive apprenticeship includes the concepts of domain knowledge and learning strategies (Collins & Kapur, 2006). Students performing science labs in small groups or virtual Internet labs used domain knowledge to learn "subject matter specific concepts, fact, and procedures" (Collins & Kapur, 2006, p. 112). Additionally, students used learning strategies of working in a group for a common goal that may have helped them implement the new concepts, facts, and procedures in the labs. Therefore, science teachers used some dimensions of cognitive apprenticeship.

Mathematical concepts in an IU and implications. Data from both teachers and students related to the research question about how teachers in science, social studies, and ELA incorporate mathematical concepts when teaching the CCSS produced the theme mathematical concepts in an IU. The findings related to this theme were that most teachers of the core disciplines included the math concepts if the math was included in the curriculum resources. All teachers and students agreed that including math in other disciplines helped students recall math topics and may improve students' math comprehension. An implication may be that the English and social studies teachers teach the discipline's concepts using basic math skills because that is the math found in the curriculum resources. This implies that curriculum resources may need to be updated to include 21st-century interdisciplinary mathematics.

Briefly, the NCTM practices revealed in the data from science teachers included reasoning and problem solving, correct mathematical representations, meaningful math discourse, support struggle in learning math, and elicit student thinking. Teachers in other disciplines may benefit from the experiences of the science teachers because they used IUs by incorporating science, math, ELA, and appropriate Internet resources. All teachers and students espoused the theory that including math in other disciplines helps students' math comprehension. That repetition of the math concepts used in other disciplines reinforces the math topics and helps students retain the concepts from each of the courses is a concept supported by research (Andrews, 2011; Anyon, 1980; Dewey, 1902; Eilers & D'Amico, 2012; Hillman, 2014; Jacobs, 1989; Jacobs & Borland, 1986; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Spalding, 2002). The finding that students recalled math used in all courses implies that teachers in all disciplines may teach basic math skills and that all teachers can be included in training and the development of IUs.

Teaching a discipline in isolation of the other disciplines is not helping students to make connections to new disciplinary concepts by using the students' prior knowledge and skills, which is supported by research. The finding that students were told by their math teacher that they do not do word problems in algebra II implies that the math teacher was not supporting the students' prior knowledge of math content and skills. Math teachers are responsible for helping students understand how to practice solutions to math problems and how to apply mathematical concepts in real situational problems. Connections between courses are made by students, and it is the responsibility of all teachers to develop and encourage students' connections across disciplines. Students' experiences in problem-solving using math in other courses are valuable resources for all teachers.

The purpose of both the NCTM practices and the Common Core State Standards for Math (CCSSM) standards is to improve student learning (CCSS, 2018; NCTM, 2014). In addition to the implications previously mentioned, district curriculum coaches can collaborate with PLC members and demonstrate interdisciplinary mathematics teaching techniques. Teachers need continual support and guidance during their first year of implementing IUs, especially when experimenting with incorporating interdisciplinary mathematics. All educational “stakeholders need to realize our shared goal of ensuring mathematical success for all” (NCTM, 2014, p. vii). *Principles to Actions: Ensuring Mathematical Success for All* is recommended by the NCTM (2014) to help educators understand the five interrelated strands that form proficiency in mathematics: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (p. 7). These effective strands are woven within the eight mathematical practices, and some of the practices were discovered by classroom observations and interviews with teacher participants as they discussed their instructional strategies.

Instructional strategies and implications - teachers and students. The second research question, how do core curriculum teachers at one school understand and enact the CCSS, produced the theme of instructional strategies. Both teachers’ and students’ data were included. The findings mean that concepts of two constructive apprenticeship dimensions, content and methods, were observed or discussed in both teacher and student interviews. Content components were domain knowledge and heuristic strategies, and methods components were scaffolding and articulation (Collins & Kapur, 2006, p. 112).

***NCTM principles and cognitive apprenticeship*.** Each discipline requires similar effective teaching strategies that create a productive environment for students, and teachers focus their attention on the practices that are the most effective. According to the NCTM (2014):

> Research from both cognitive science (Mayer, 2001; Bransford, et al., 2000; National Research Council, 2012) and mathematics education (Donovan & Bransford, 2005; Lester, 2007) supports the characterization of mathematics learning as an active process, in which each student builds his or her own mathematical knowledge from personal experiences, coupled with feedback from peers, teachers and other adults, and themselves. (pp. 8-9)

The interconnectedness between the learning science of cognitive apprenticeship, Vygotskian constructivism, and the theory of learning is detailed through IUs as described above and in the principles of learning that follow. Briefly, the NCTM (2014) principles state students should have experiences "that enable them to engage with challenging tasks… ,connect new learning with prior knowledge…, acquire conceptual [and] procedural knowledge…, construct knowledge socially…, receive descriptive and timely feedback…, [and] develop metacognitive awareness of themselves as learners" (p. 9).

These principles and practices of teaching mathematics using cognitive apprenticeship dimensions and Vygotskian constructivism are possible when the district and school administrators and all teachers understand and agree upon the following effective school mathematics elements for each student: commitment to access and equity, a powerful curriculum, appropriate tools and technology, meaningful and aligned assessment, and a culture of professionalism (NCTM, 2014, p. 59). The meanings of the findings for teachers' instructional strategies and students' learning strategies are incorporated as they relate to interdisciplinary mathematics.

Teachers' instructional strategies that include engaging students in activities that challenge them and support significant learning about applications to real problems of the community, state, nation, or our world provide students opportunities to use their personal interests, prior knowledge, and skills from all disciplines. This type of student engagement is a principle of learning using interdisciplinary mathematics. Teachers using this principle may provide students opportunities to connect new mathematical concepts with their "informal reasoning [about math] and, in the process address preconceptions and misconceptions" (NCTM, 2014, p. 9). Science teachers, as mentioned earlier, demonstrated this principle with students engaged in labs; however, math teachers did not teach a class using this principle or discuss it in the interviews. These findings imply that observed math teachers may need training to help them implement this principle of teaching and guiding students through this learning process. Teachers in each of the core disciplines can benefit from appropriate training using this principle of engaging students in challenging tasks.

The principle of students acquiring "conceptual knowledge as well as procedural knowledge…allows students to organize their knowledge, acquire new knowledge, and transfer and apply knowledge to new situations" (NCTM, 2014, p. 9). This principle addresses how students learn through reading, reflection, trying new ways to solve problems, or working through a model to solve a problem. An implication of the findings from this study is that science teachers practiced this principle of student learning in labs by expecting students to apply their knowledge and conceptual skills to a new experimental situation. English and social studies teachers practiced this principle by expecting students to use classical literature and primary documents to make concepts of these documents relevant to the present. Math teachers in this study demonstrated how to solve specific math problems; however, they expressed that teaching IUs may help students understand the reasons to learn the concepts during the interviews. Math teachers did not practice this principle of allowing students to transfer or apply knowledge to new situations. Math teachers were concerned about procedural knowledge and teaching students how to solve a set of math problems using a procedure the teacher selected. Some math teachers could benefit from appropriate training to allow students to use their creativity, their prior knowledge, and their skills to solve problems.

The NCTM principle of "construct[ing] knowledge socially, through discourse, activity, and interaction related to meaningful problems" (p. 9) is the foundation of Vygotskian constructivism (Vygotsky, 1978). The findings of this study revealed no teachers using Vygotskian constructivism in the classroom; however, most teachers explained in the interviews they preferred group work in their classes. The findings from student participants revealed they preferred learning techniques explained by Vygotsky. For example, students preferred group discussions and interactions with the teacher. This finding means students do not prefer to be lectured to most of the time, and they prefer to be engaged in their classes. Teachers would benefit from appropriate training to implement teaching by involving students in social discourse and activities related to a given problem.

Some English teachers used small groups of students to discuss an issue and report their results orally to the class. These findings mean that English teachers used incremental steps toward implementing student social interaction. The topic students were given required students to use their prior knowledge and interests and relate them to the new knowledge of a short story. This articulation is a dimension of methods, a component of the cognitive apprenticeship dimension. Findings from math and social studies class observations revealed that not all teachers used student social interaction to allow students to collaborate about solving real problems. Teachers and their students could benefit from using the cognitive apprenticeship dimension of sociology to support communication and collaboration among groups of students. For example, appropriate training provides teachers with techniques to implement situational learning activities like creating links to the school website or a community website, and student data revealed students use the Internet on their own and for their assignments, and they enjoy working in small groups. Social discourse among groups of students can provide each student an opportunity to learn from others to accomplish a given task and create a community of practice for projects. This community of practice will reveal to teachers their students' interests, prior knowledge, skills, and problem-solving processes. This process of using students' experiences to solve problems with the guidance of teachers is the cornerstone of IUs and interdisciplinary mathematics (Collins & Kapur, 2006; Jacobs, 1989; NCTM, 2014).

Students' problem-solving processes using concepts from all disciplines may reveal how the students work cooperatively with other students and teachers. Furthermore, as students work within their groups, their intrinsic motivation helps them set personal goals to meet deadlines, use their skills, and help the group find solutions to the given task. The findings of this study revealed that most teachers, including science and English teachers, used the curriculum resources for their discipline along with the suggested mathematical concepts. As teachers demonstrate to the students the teamwork of developing IUs that include interdisciplinary mathematics, students have the opportunity to learn how to collaborate among their community of practice members. In conclusion, students learn how to interact with their group if they are given the opportunity to see teachers work together (Bandura, 1993).

The findings from the math teachers and science teachers indicated that they used the CAI program, ixl.com, as a practice resource for some math and science concepts, respectively. Students who took time to read the corrective notes about their incorrect response to a problem usually selected the remedial links to understand their original mistakes. Students who performed poorly on ixl assignments did not use the prescriptive links, and their scores were not passing grades. These findings regarding ixl imply that student data from ixl can be shared among the math and science teachers through their PLCs. This teacher collaboration across departments provides support for students who performed poorly on ixl assignments through IUs and interdisciplinary mathematics.

A principle of the NCTM (2014) is that students should develop metacognitive awareness, and websites like ixl help them have experiences so that they learn about "themselves as learners, thinkers, and problem solvers, and learn to monitor their learning and performance" (p. 9). Math and science teachers use the reports and data analysis from ixl to guide students to successful problem solving at WHS. The principle of students developing their metacognitive awareness is an interdisciplinary mathematics concept, and this principle is important for each student in each course. For example, students who read a passage in English and cannot explain the main idea of the passage may need to read it again (Collins & Kapur, 2006, p. 112). At WHS, this principle of students' metacognition needs to be discussed by teachers in PLCs. This time provides teachers the opportunity to collaborate about students who need support with monitoring their individual learning and performance.

Another NCTM (2014) principle for supporting students' learning is that students should "receive descriptive and timely feedback so that they can reflect on and revise their work, thinking, and understanding" (p. 9). The findings of this study revealed that not all teachers provided this support for their students. For example, a math teacher asked the class about homework problems assigned the night before, but the teacher did not check their work or discuss any specific problem the students may not have understood. Another math teacher passed back students' papers from the previous day, and the students were instructed how to correct their mistakes. The math teacher demonstrated timely feedback, so students could revise their written work; however, students were not asked to explain their thinking and no time was given for students to reflect upon their mistakes. These findings imply that some math teachers need to commit to appropriate training about the process of providing timely feedback and provide time for students to share the reasoning and thinking skills they used to solve math problems.

All teachers could benefit from collaboration across disciplines and reflection with their peers in their PLCs about their students' efforts to solve problems.

The findings revealed that none of the sequencing dimension concepts: increasing complexity, increasing diversity, and global to local skills of cognitive apprenticeship were observed in classes or discussed in interviews. An implication is that each teacher in the core disciplines can benefit from appropriate training in the sequencing dimension. Another implication is that most teachers followed the lead of the principal of WHS and concentrated on teaching the process of solving released standardized test items. As mentioned earlier in this chapter, teaching to the test is not beneficial if students do not learn the concepts of the disciplines. Additionally, increasing diversity is a practice allowing students to learn basic concepts in a discipline and providing students opportunities to use those concepts in a variety of problem-solving situations. Increasing diversity is also an interdisciplinary mathematics concept because students use a variety of skills and decide which skills to use to solve challenging problems. For example, in mathematics, students may be given problems and they must decide which mathematical concepts to use (Collins & Kapur, 2006, p. 115). This decision-making process may be used by students in all disciplines, and this process is a basic element of students' learning. The lack of the sequencing dimension implies that teachers need appropriate training from qualified instructors to learn how to implement the sequencing dimension components to benefit students.

Furthermore, no teacher used or discussed the concepts of modeling and coaching included in the methods dimension of cognitive apprenticeship. Modeling, coaching, providing time for students to reflect with others, and teachers providing time for students to pose and solve their own problems are concepts of modeling (Collins & Kapur, 2006). Teachers need appropriate PD in the modeling dimension and opportunities to practice the coaching concepts. Moreover, teachers demonstrated domain knowledge both in the observations and interviews. Teachers used a plethora of hands-on activities in the observed classes, and they discussed instructional strategies in the interviews. For example, flash cards mentioned in interviews were the heuristic component of the content dimension (Collins & Kapur, 2006). Handouts were examples of the scaffolding component of the methods dimension, and some teachers used computer displays or Smart Boards for notes.

Two English teachers were observed using articulation, a component of the methods dimension of constructive apprenticeship (Collins & Kapur, 2006). Their students were in small groups, and the groups had to discuss and report their findings on a given topic. Additionally, this process demonstrated the sociology dimension cognitive apprenticeship concept of cooperation because students had to work together to accomplish their goal. Furthermore, each teacher participant mentioned pairs or small groups as an instructional strategy in their interviews, even though this arrangement was not observed in most classes. Most teachers provided students with some components of the cognitive apprenticeship dimension labeled content. Another implication is that teachers who use the content concepts may share their successful experiences and resources with others in their PLCs.

An additional finding was the incorporation of appropriate Internet websites for CAI. Teachers used the provided technological equipment and embraced Internet resources. For example, both science and social studies teachers used scaffolding and critical thinking processes for students' assignments. They used the CAI resources as scaffolding in the science virtual labs, and social studies teachers provided handouts for students to answer questions based upon the textbook through the Google Suite. In both disciplines, students had to analyze the information, produce appropriate graphs, if necessary, and analyze the concepts from their research or findings. English assignments required students to write in a prescribed style and create a story based upon an eighteenth-century short story; however, students had to make it relevant to the present. These teachers used critical thinking when they expected students to analyze or compare topics for findings from labs. Both science and social studies teachers demonstrated an IU by incorporating reading, writing, and analysis in one assignment (Collins & Kapur, 2006; Ennis, 1994). These findings imply that some teachers communicate and collaborate within their departmental meetings about appropriate websites and heuristic strategies for their specific courses. These teachers could share their experiences with others in their PLCs.

As mentioned in Chapter 4, two teachers depended upon the same student to answer oral questions at the beginning of class. One teacher asked lower-order questions based upon the prior day's lesson, and then used the planned CAI activities for students. However, the other teacher depended upon the same student to answer questions throughout the class. The student used the student workbook to respond to the teacher's questions, and all students wrote his responses in their workbook. The student's responses were based on prior knowledge instead of analyzing or evaluating concepts (Tofade et al., 2013, p. 1). These teachers depended upon one student to answer questions, and no communication or collaboration among students occurred. Findings in each math, social studies, and some English classes revealed the same lack of student cooperation. Some teachers may benefit from training about the cognitive apprenticeship component labeled cooperation. Cooperation is a social learning dimension component that teachers use to allow students “to work together to accomplish their goals” (Collins & Kapur, 2006, p. 112). As mentioned earlier, social interaction among students and teachers with the goal of using the concepts and skills of a discipline to solve problems is the foundation of Vygotskian constructivism. Furthermore, social interaction among students is an NCTM (2104) principle of learning that is required for effective mathematics teachers (p. 9).

Learning strategies and implications. Students’ data was used to produce the findings related to the research question about how core curriculum teachers at one school understand and enact the CCSS. As the interviews indicate, students preferred visual notes from computer displays, Smart Board notes, flash cards, pairs/partners, engagement with the teacher, and CAI. Students preferred Vygotskian constructivism and components of the cognitive apprenticeship dimensions. Concepts of the cognitive apprenticeship dimensions content, methods, sequencing, and sociology were the preferred learning strategies for students. This data implies that students preferred to use the cognitive apprenticeship dimension content by using domain knowledge, heuristic strategies, and learning strategies.

Students’ preferred learning strategies included social interaction with other students, interaction with the teacher, and visual resources like using notes form the board or labs to study for a test. Their learning strategies, a component of the content dimension, included using the textbook, their notes, and various Internet resources.

Students created flash cards as a heuristic strategy to learn domain knowledge (Collins & Kapur, 2006). Implications from these findings indicate that students' experiences with using math in other disciplines or courses may be shared with all the students' teachers. Teachers can share students' experiences and begin a collaboration with them through the Google Classroom Suite. This communication can be the beginning of a discussion between students and teachers and about how to incorporate math topics in an IU.

Furthermore, students used Vygotskian constructivism when they explained they prefer to interact socially with other students and the teachers to learn concepts. Students in each observed class used their laptops for assignments, and students discussed how they used various websites to help them with their work. Students recalled using objectives for each day's lesson that were displayed on the board. Students explained the objectives were a guide to follow through their lessons, and some students thought they were easy to understand. They discussed how teachers helped them comprehend the topics and additional activities performed in their classes. This means that students used the standards and objectives in their lessons. Additionally, students preferred to use the cognitive apprenticeship dimensions to learn concepts and skills in their courses. The concepts of the dimension content are methods, sequencing, and sociology, and they are the link between students learning and teachers teaching. As mentioned throughout this chapter, the concepts of the cognitive apprenticeship dimensions that were discovered and those that were not found in this study are the concepts that students prefer to use to learn across all disciplines. An implication of these students' findings is that not all teachers use some concepts of the cognitive apprenticeship dimension. Components of the dimensions of cognitive apprenticeship and Vygotskian constructivism were students' preferred learning structures in this study. The bridge between students' preferred learning structures and teachers' teaching structures consist of the components of cognitive apprenticeship dimensions, Vygotskian constructivism, the NCTM principles, and teaching IUs. However, the concepts of the students' learning structures and the teachers' structures are not equivalent because not all teachers use some concepts of cognitive apprenticeship, Vygotskian constructivism, the NCTM principles and IUs.

Instructional leadership. Teachers related their instructional leadership to implementing the standards using IUs and their leadership in the classroom through the lens of their experiences. For example, science and social studies teachers enacted the standards in an IU as previously mentioned in this chapter. Most teachers perceived instructional leadership as sharing curriculum CAI resources with other teachers, practicing classroom leadership, and following administrative expectations. Findings from administrative meetings with departments and faculty meetings with all teachers revealed that WHS administrators lead teachers by focusing upon instructional discussions. Another implication from the teacher interviews is that school administrators discussed and asked teachers to incorporate released standardized test items in their courses. Additionally, some teachers perceived instructional leadership as following administrative directions to teach the test items, and they did not teach the concepts and skills.

For example, Harvey, a science teacher, used instructional leadership to align the NGSS to the CCSS and shared the alignment with the other teachers on OnCourse (n.d.). Science teachers practiced instructional leadership by enacting the objectives from the standards, and they also shared instructional strategies with other members of the department and assisted teachers new to the science department. IUs were used throughout the science department, and each teacher had most of their students engaged during the observed classes. These teachers valued the administrative expectations that the science standards would be taught, as they discussed in interviews, and they used IUs. Science teachers may share their leadership experiences with educators through professional journal publications and educational conferences.

The social studies teachers taught the objectives from the standards, and they used ELA skills in class and for students' assignments. Basic math concepts were taught as they were encountered in curriculum resources. Therefore, social studies teachers enacted the standards using IUs. The instructional leadership of these teachers was perceived through the lens of their experiences at WHS and in the classroom. Teachers were making the primary historical documents relevant to students and aligning the standards to their curriculum resources. Furthermore, social studies teachers incorporated standardized test items that related to the social studies courses. An implication of these findings is that social studies teachers may be a resource for English and math teachers who need training in developing an IU across disciplines. An additional implication is that math and English teachers can share their expertise in their specific discipline with social studies teachers. This process benefits teachers' instructional strategies and students' learning strategies, and these accomplishments may be a topic for further research.

Implications for Interdisciplinary Education and Students

Teachers with low math self-efficacy may benefit from communicating and collaborating with math teachers as they conceptualize an IU and create a unit in their

PLC (Bandura, 1993; DuFour & Eaker, 1998; Runhar et al., 2010). Additionally, teachers with low math self-efficacy may learn that they do not have to be a math major to incorporate math into an IU. Teaching IUs benefits teachers because common learning goals are addressed, and it is a more efficient way to instruct (College Board, 2018; Jacobs, 1989). Relevance of topics or concepts in a discipline demonstrates a shift from teaching a discipline in isolation to integration of students' experiences and previous knowledge. This is an application of cognitive apprenticeship dimensions and the students' culture (Collins & Kapur, 2006; Vygotsky, 1978). The implications of the findings for students were equivalent to the implications for teachers. Specifically, teachers needed time and appropriate PD for creating IUs, and students benefit by being included in the development of the IUs because they become part of the planning and creative processes (Jacobs & Borland, 1986). Students explained that they would remember more of each discipline that was included in an IU, and this theory is supported by research (Andrews, 2011; Anyon, 1980; Dewey, 1902; Eilers & D'Amico, 2012; Hillman, 2014; Jacobs, 1989; Jacobs & Borland, 1986; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Spalding, 2002).

Collins and Kapur (2006) explained that there are four dimensions needed for any learning environment: content, methods, sequence, and sociology (p. 111-112). These are broad dimensions and teachers and students referred to components of these dimensions as discussed earlier in this study. Students and teachers are valuable resources for each other. An implication is that students could provide their teachers with activities that help them learn and study; therefore, teachers can adjust their instructional strategies to complement their current students' learning strategies (Jacobs & Borland, 1986).

Implications for Leadership

Implications of the findings indicate that science teachers may be the leaders in PLCs at WHS. Many of the science teachers were in the third career stage, experimentation/reassessment (Huberman, 1989). An implication of this finding is that teachers in this stage are willing to experiment, assess, and reflect upon new teaching strategies. English teachers perceived instructional leadership through their experiences of implementing the CCSS and teaching the standards using their curriculum resources and standardized testing items. Furthermore, they shared their lesson plans with other teachers through OnCourse. The English teachers shared science and social studies standardized test items with teachers in those departments, and their perceptions were that this was a use of IUs. Additionally, their leadership perspective of initiating the sharing of the test items was practicing instructional leadership and using IUs. However, according to Jacobs (1989), this practice is simply a sharing of test items and not practicing effective teaching techniques using an IU. As mentioned earlier, implications from this study revealed that some teachers could benefit from appropriate training in the theory and implementation of IUs.

Administrators at WHS expected teachers to teach the standards and align their standards to standardized tests. All interviewed teachers taught the standards for their courses. Some teachers discussed during interviews that teaching standardized test items that were not labeled as their specific discipline as an example of teaching an IU. For example, English teachers perceived teaching standardized test items from science and history test items as enacting the CCSS in an IU. However, this is not an example of an IU, as previously discussed. The concepts and skills of science and history being assessed were not addressed in test items only. Appropriate training can correct this problem, and district curriculum coaches and school administrators are the key to listening and collaborating with teachers for solutions.

Recommendations

As a professional interpreting the data, I am making recommendations that may be appropriate for the governing bodies of the New Jersey General Assembly, the WCPSDBOE, and WHS administrators and teachers. Funding should be available to provide curriculum coaches or lead teacher positions in the disciplines of English and math in grades K-12 in the Wonder City Public School District. A curriculum coach in each discipline is ideal, but this may not be realistic. WCPSD has a math coach position, and federal funds may provide money to hire an English curriculum coach. Curriculum coaches may research and visit high schools in New Jersey with similar district situations that use IUs across the core disciplines. The STEM and STEAM schools mentioned in the literature review of this study may be a starting point for coaches and administrators for this research, and they may discover recent incorporation of IUs across all core disciplines in high schools. Curriculum coaches can create an IU model for teachers at WHS with teacher and student input. A master schedule should be available for WHS that includes regularly scheduled PLC time throughout the year for core curricula teachers to communicate and collaborate with the curriculum coaches and with each other. The curriculum coaches can present examples from the schools they found and demonstrate the teaching strategies that include the objectives from each discipline. WHS administrators and curriculum coaches could collaborate with the administrations at the schools practicing IUs and discover possible funding sources for staff and appropriate curriculum instructional resources.

Department heads should provide time during departmental meetings for teachers to share and reflect upon their teaching strategies. Teachers may ask administrators or curriculum coaches to visit a class, observe them and their students, and provide constructive feedback about oral questioning or any strategy that teachers use to support and improve student learning. Most interviewed teachers at WHS were in Huberman's (1989) second, third, or fourth career stages, and they may be ready for suggestions to improve instructional strategies. Students should be included as participants as teachers begin the process of creating an IU. Teachers can allow their students to brainstorm ideas for IUs that are aligned to the standards, and the courses that should be included. The results of the students' participation may be shared by teachers with their PLC team. Jacobs and Borland (1986) explained that involving students and aligning topics to the standards are key components in developing an IU.

Students continue to be assessed on national and state standardized tests not only in ELA but math as well. It would be valuable for the district superintendent and the WCPSDBOE to include math as an important discipline in the policy of IUs. Furthermore, the School Improvement Plan for the district may include math as part of the incorporation of IUs. School administrators may add a platform of including math within all core disciplines as a part of their instructional leadership efforts. The research in this study demonstrates that teachers espoused that students may comprehend concepts from each discipline longer. This may impact the scores on standardized tests, and this may be a topic for future research.

It would be critical for school administrators to use time during department head meetings to address IUs and allow department heads time to collaborate among themselves about how to incorporate math across disciplines. Department heads may relay those results to the teachers during departmental meetings for further study in teachers' PLCs. Curriculum coaches may meet with administrators and department chairs, and later with teachers in the departments to support and provide expertise about incorporating math in an IU. Ideas and suggestions may be shared as teachers meet with their PLCs, and coaches may share technological resources with teachers.

Recommendations for teachers. It would be valuable for math teachers to collaborate with curriculum coaches to provide practical applications of mathematical concepts to teachers in other disciplines. Students are a valuable resource because they are required to use math concepts to solve real problems. Involving students in both the research phase and the implementation phase of the IUs and allowing them to be creative using mathematical concepts across disciplines may support teachers' and coaches' research of IUs.

Science teachers may share their instructional strategies about grouping students for productive work as they assigned work for students to complete during and outside of class using Google Suite and virtual labs. Curriculum coaches may research teaching activities that include cognitive apprenticeship dimensions and Vygotskian constructivism and share them with teachers. Teachers should share these activities with students to make students part of the planning process. Teachers may discuss the planned activities with their PLC members, implement them in their classes, and reflect with their PLC afterwards to share feedback and support for any necessary changes. This professional reflection is supported by Osterman and Kottkamp (2004). As a result, teachers may practice the sociology concept of cooperation and learn from each other. Math teachers may work with the math coach and research critical thinking assignments for students, how students can make math relevant to their experiences, and analyze students' solutions for accuracy. School administrators may take suggestions for PD from department heads, curriculum coaches, and teachers to create appropriate PD.

It would behoove teachers to include smaller group activities, so students may learn from each other using Vygotskian constructivism. Smaller groups may allow teachers to interact with more students during a class period as opposed to seating students in rows. Teachers may share strategies in their PLCs or in their departmental meetings to get students back on task as they transition from one activity to another. Additionally, teachers may establish a classroom culture that includes students' suggestions and that support the students' learning strategies. The use of small groups for learning core disciplines using math in a secondary school may be a topic for further research.

Teachers should be provided with appropriate training to understand the theory of using IUs across disciplines using the standards, objectives, and appropriate models of instructional strategies. Opportunities for science teachers to share their teaching strategies and how they collaborated with each other during convenient times at school could be shared with other teachers through PLCs. Their experiences may be a basis for developing a platform to include math beyond basic skills in other disciplines.

Administrators at WHS may address the issue of not using appropriate IUs with each department and address any barriers the teachers perceive to teaching IUs. School administrators should provide time and appropriate training for the cadre of teachers to conceptualize and experiment with IUs to include interdisciplinary mathematics in their classes with support from the curriculum coaches. WHS administrators may need to change the master schedule to provide teachers with common planning time to communicate and collaborate across the disciplines and departments. School administrators may lead the teachers to teach the objectives of the standards and not focus only on standardized test items.

At least one teacher from each of the core disciplines may volunteer to accompany coaches for visits to districts with similar situations where teaching IUs is practiced and acclaimed in New Jersey high schools. Additionally, these educators may become a cadre ready for appropriate training in conceptualizing, implementing, and experimenting with IUs that include interdisciplinary mathematics. Funding should be provided for travel and appropriate curriculum resources that teachers may use to include interdisciplinary mathematics in each discipline. Additionally, the cadre of teachers should be provided time to reflect with each other and the curriculum coaches throughout the year as they make any necessary changes to improve IUs. School administrators should allow all teachers to experiment with IUs following the model from the cadre of educators. Leithwood and Poplin (1992) explained that transformational leaders are administrators who provide all teachers opportunities to give each student unique learning strategies. WHS administrators may become transformational leaders by focusing upon instruction of the concepts and skills in a discipline and allowing teachers to discuss their experiences teaching the IUs in PLCs.

Technology and professional organizations. PLCs may be given time to collaborate in face-to-face groups and real time Internet discussions. For example, Google Groups is an application of the Google Suite available to teachers, and teachers should be given appropriate training in these Internet resources. Funding should be provided for CAI programs to implement IUs with interdisciplinary mathematics. Funding should be provided for curriculum coaches to visit secondary schools in New Jersey that use IUs with an emphasis on interdisciplinary mathematics, and the curriculum coaches may share their findings and resources with the administrators and teachers at WHS. It may be advantageous that the cadre presents at an ASCD conference and share their work through educational journals like the *Journal of Interdisciplinary Studies in Education*, and their articles may be available to many educators.

Funding should be provided for math teachers to become annual members of the NCTM and attend NCTM conferences. Time should be provided for the math teachers to share their knowledge they gain at these conferences within the math department and in their PLCs. Administrators may provide math teachers time to work together to conceptualize an IU based upon the NCTM math practices and the NCTM beliefs of teaching and learning mathematics (NCTM, 2014). Funding should be provided for current technology, appropriate websites, and appropriate training for math teachers to learn how to teach using the interconnectedness of each discipline. Furthermore, school administrators will find it advantageous to continue to focus upon IUs with interdisciplinary mathematics during faculty meetings, their walk-through short teacher observations, and formal teacher observations. Administrators may include discussions with the teachers during the pre-observation and post-observation sessions of formal teacher observations about the interrelatedness of math across all disciplines.

Funding should be provided for all teachers and coaches to join professional organizations. For example, the NCTM organization membership provides member access to resources, research, and with the Internet resources available, a connection to many high school teachers (NCTM, n.d.). Furthermore, the membership provides access to all NCTM journals, including the *Mathematics Teacher for Grades 8-14* (NCTM, n.d.). The membership may benefit members by providing access to educational trends and tested, effective practices. These services include webinars and webcasts on a variety of mathematical teaching strategies that are ready for math teachers to experiment with in their classes (NCTM, n.d.). The math coach may research the plethora of topics and discuss the findings with the math teachers, and they may collaborate upon the best strategies to use in an IU. Math teachers and coaches may collaborate with members of their PLC about how to implement interdisciplinary mathematics. Additionally, funding should be available for purchasing a copy of *Principles to Actions: Ensuring Mathematical Success for All* for secondary teachers, curriculum coaches, board members, and district and school educators. WHS administrators may provide planning time for groups of teachers to prepare presentations at educational conferences and collaborate about publishing articles in educational journals.

Curriculum coaches may use the professional organizations' references to investigate the sizes of the current classes at WHS and compare the class size to the class size recommended by educational researchers. This research may address students' preferred learning strategy of interacting with the teacher, and smaller classes may allow teachers to have more individual personal interactions with students. Funding should be provided for updated student laptops and resources for teachers to create a learning environment in which students engage in situated learning and communities of practice over the Internet. Administrators may provide time for teacher training to learn how to implement instructional leadership skills and new teaching techniques, as well as collaborate and reflect with each other within their PLCs, make changes, and try the modified technique again. Funding should also be provided for websites designed to allow groups of students to solve real simulated problems.

Funding should be provided for English teachers to implement ixl.com practice lessons into their program of studies. Time should be provided by school administrators for English teachers to collaborate with teachers in all disciplines, perhaps in PLCs, to provide support skills through ixl for students not performing well in their courses. Curriculum coaches may investigate websites that have the monitoring, diagnostic, and remedial components that may be appropriate for students not performing well with ixl and offer these websites to teachers as an alternative to ixl. All teachers of core disciplines should have appropriate training and appropriate websites that provide high quality CAI for students to guide themselves through problem solving practices and develop their metacognitive awareness. Curriculum coaches may investigate companies that specialize in curriculum and student self-monitoring, and they may support teachers in their efforts to implement the resources.

Funding should be provided for smaller class sizes. For example, smaller class sizes may allow teachers opportunities to provide students the concepts of the methods dimension and perhaps improve student performance in the classroom and on standardized tests. This research is supported by Akerhielm, (1995) and she cautions that family background affects the performance of students. Over 68% of WHS students live in a low socioeconomic status community. The household of low-income families may not be conducive to children receiving proper nutrition or having a quiet place to study, and many students deal with the stress of being left at home alone in a rough or violent neighborhood (Dahl & Lochner, 2012).

Funding should be provided for instructors and resources to train teachers how to implement the cognitive apprenticeship dimensions. Time should be provided by administrators over the period of at least one year so that teachers may collaborate with trainers and with each other periodically as they develop effective teaching practices across all disciplines. Additionally, all math teachers and their students may benefit from incorporating the NCTM principles of effective mathematics teaching as they develop teaching strategies under the umbrella of cognitive apprenticeship. Teachers who use strategies from cognitive apprenticeship dimensions may share their experiences with others through PLCs and departmental meetings.

Limitations

I interviewed teachers during their planning period or other convenient times, and I interviewed students for half of one class period in my classroom privately. I deliberately selected participants who teach core courses, and these parameters were due to the school class schedule. This was not a causal study (Yin, 2014), and I did not answer the question of why teachers chose to teach interdisciplinary units. Moreover, there may be limited transfer of my qualitative case study from WHS to other high schools.

Summary

This study examined the teachers' perspectives of teaching IUs that included mathematical concepts, and it provides a different perspective than the current research because it focused upon incorporating math across the core disciplines. Furthermore, this study includes the perceptions from interviewed students about IUs and how they recalled mathematical concepts that were incorporated across disciplines. This study revealed that the bridge between the instructional strategies of the teachers and the learning strategies of the students emanates from constructive apprenticeship and Vygotskian constructivism, and IUs may support the dimensions of constructive apprenticeship (Collins & Kapur, 2006; Vygotsky, 1978). The bridge between students' preferred learning structures and teachers' teaching structures consist of the components of cognitive apprenticeship dimensions, Vygotskian constructivism, the NCTM principles, and teaching IUs. However, the concepts of the students' learning structures and the teachers' structures are not equivalent because not all teachers use some concepts of cognitive apprenticeship, Vygotskian constructivism, the NCTM principles, and IUs.

Jacobs and Borland (1986) state there are four necessary steps to develop an interdisciplinary unit:

> select a topic, brainstorm associations, formulate guiding questions, and design and implement activities. First, the topic should be of interest to the teachers, students, and be appropriate for the curricula. Second, teachers use brainstorming techniques to incorporate each of the disciplines for the selected topic. Students may become participants in the brainstorming process following the teachers' methods. (pp. 161-162)

Students and teachers are valuable resources for each other, and the communication and collaboration among the students in the creative process support constructive apprenticeship. Collins and Kapur (2006) listed the four dimensions that are necessary for any learning environment: content, methods, sequence, and sociology (p. 111-112). The connection between teachers' desires to make disciplinary subjects relevant to students and showing students applications of the basic material in courses is an underlying concept of IUs (Kember, Ho, & Hong, 2008, p. 249).

This approach to instructional strategies is the theory of using IUs to relate students' experiences and prior knowledge to the disciplinary standards and objectives (Andrews, 2011; Anyon, 1980; Dewey, 1902; Eilers & D'Amico, 2012; Hillman, 2014; Jacobs, 1989; Jacobs & Borland, 1986; Partnership for 21st Century Skills, 2002; Songer & Kali, 2006; Spalding, 2002). This may be a platform for teachers in all disciplines to discuss and create plans for IUs in PLCs. Most of the core disciplinary teacher participants created lessons and instructional strategies to make their content relevant to students. Furthermore, appropriate PD may be required to support teachers in their efforts to create IUs because student learning is the reason for the existence of schools, teachers, administrators, and boards of education.

Students are our future, and teachers and administrators are preparing today's students for successful citizenship and possible future leadership. The low socioeconomic status of most of the students at WHS is not an excuse for denying them the opportunity to become creative and self-confident in solving math problems, as discovered by Anyon (1980). Mathematics is found in all disciplines at the secondary level, and knowledge of math found in the higher-level math courses opens doors to colleges for students. This opportunity should be available for all students who have the intellect and capability to attend and graduate from college, not just the students from wealthy families. Every student deserves the opportunity to become better skilled for employment and survival, and to learn their unique life skills.

The significance of this study is drawn from the social justice issue of teaching students how to use math and creative problem-solving techniques across the core disciplines. Anyon (1980) discussed the social reproduction of communities and schools after a five-year qualitative study as she inquired about staff members teaching mathematics. Anyon (1980) discovered schools in affluent communities provided planning time for teachers to create interdisciplinary units, and the students earned more autonomy in the classroom. Additionally, Anyon found that teachers in schools in lower socioeconomic communities taught rote, repetitive methods in math, and the students were not encouraged or rewarded for thinking creatively to solve math problems. The results of Anyon's study was an inspiration for this study to be performed at Wonder High School (WHS) because, according to the 2016 New Jersey School Performance Report, over 68% of the students are on free or reduced lunch, and as a result, the community at large is a lower socioeconomic group according to stated guidelines. All students deserve equal opportunities for a quality education. This current study was a collaborative effort between myself and teachers of core subjects at WHS. This study and the results will hopefully create positive results for teachers and students at WHS.

Students are the reason for educators to use their instructional leadership and to model communication and collaboration with members of the PLCs. Students learn from the actions of educators, and if we model cooperation with each other and our students, then we are using appropriate instructional leadership. Teachers guide students and challenge them to work for their goals and fulfill their dreams. School administrators and the board of education may provide and support policies that allow teachers to be creative in their PLCs and use IUs. The impact on policy should be from the classroom up to administrators and then to the board of education for discussion of future classroom policies. This bottom to top process allows teachers and their students to have a voice in preparing all students for their futures (DuFour & Eaker, 1998).

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Appendix A

Interview Protocol Teachers

1. How many years have you been teaching?
    a. How long have you been at WHS?
    b. What courses do you teach this year?
    c. What are the names of the courses you teach?
2. What have been your primary teaching strategies over the years?
3. What experiences have you had with teaching the CCSS? How do you feel about teaching the CCSS in your discipline?
4. How do you determine which disciplines to incorporate in interdisciplinary units?
5. How do you conceptualize an interdisciplinary unit?
6. How do you enact the CCSS in interdisciplinary units?
7. How do you incorporate mathematical concepts into your CCSS lessons? What topics do you find are easy to incorporate mathematical concepts?
8. How do you incorporate mathematical concepts into your interdisciplinary units?
9. How would you describe the effect on students’ math comprehension based on integrating other disciplines?
10. How would you relate your instructional leadership to the implementation of the CCSS using interdisciplinary units?

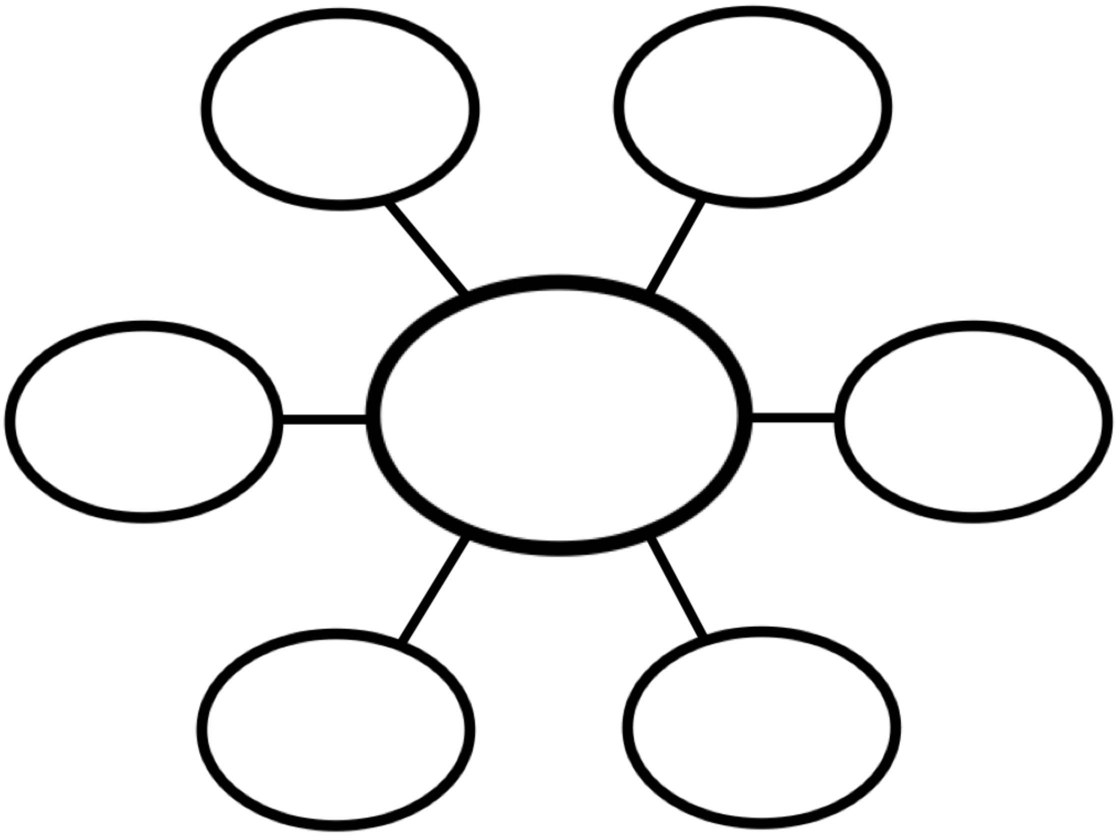
Appendix B

Interview Protocol Students

1. How many years have you attended WHS?
    a. How long have you lived in Wonder City?
    b. What courses are your favorites this year?
    c. What are the topics you like best?
2. What have been your primary studying strategies over the years?
3. What experiences have you had with working with the CCSS? How do you feel about learning the topics of the CCSS in your classes?
4. What do you think of when you hear the phrase, an interdisciplinary unit?
5. What experiences have you had with interdisciplinary units?
6. How have you incorporated objectives from the CCSS into interdisciplinary units? What courses have been combined in the units?
7. What mathematical topics have been combined in other subjects?
8. How do you incorporate mathematical concepts into your other subjects?
9. How would you describe the effect on your math comprehension based on integrating other disciplines? What math topics were easy to recall based on your experiences with interdisciplinary units?
10. How would you create an interdisciplinary unit? What subjects would you use?

Appendix C

Graphic Elicitation



Appendix D

A Model for Interdisciplinary Units and Descriptions

1. Determine the Standards Based Curriculum Objectives

2. Agree upon a Primary Essential Question

3. Divide the overall concept of the essential question into parts directly related to individual academic subjects.

4. Collaborate and communicate among team members to identify and assign roles and responsibilities and agree upon a team leader.

5. Identify any adjustments to relevant topics and timelines as the school year progresses.

6. Introduce the topic to each class of students by asking an essential question or sub-question directly related to the subject. Make the question relevant to students.

7. Develop formative and summative assessments and create the culminating project for students to use interdisciplinary content.

8. Write individual subject lesson plans and note required materials. Save the plans for future interdisciplinary units and any necessary modifications as the year progresses.

9. After the unit is completed, reflect personally and among team members. Discuss and record successes of the project and where improvements may need to be made.

Appendix E

Methods Matrix

Research Questions	Data Source	Data Source	Data Source	Data Source
How do core curriculum teachers at one high school teach the CCSS using interdisciplinary units?	Document Analysis Literature Review	Teacher Interviews Field Notes Student Interviews	Analytic Memos Observe teachers teaching	Graphic Elicitations
How do core curriculum teachers at one school conceptualize and enact interdisciplinary unit lessons?	Teacher Interviews Field Notes	Analytic Memos Observe teachers teaching	Graphic Elicitations	Literature Review Student interviews
How do core curriculum teachers at one school understand and enact the CCSS?	Teacher Interviews Field Notes	Analytic Memos Observe teachers teaching	Graphic Elicitations Student interviews	Literature Review
How do science, social studies, and ELA teachers at one school incorporate mathematical concepts when teaching the CCSS?	Teacher Interviews Field Notes	Analytic Memos Observe teachers teaching	Graphic Elicitations Student interviews	Literature Review
How do the core teachers at one school relate their instructional leadership to the implementation of the CCSS using interdisciplinary units?	Teacher Interviews Field Notes	Analytic Memos	Literature Review	

Appendix F

Observation Tool

Teacher:	Observer:	Date:

Please indicate whether the following is true and provide observations to support your assessments.

Question	**Observed (+/□)**	**Notes**
1. Is the lesson objective clearly posted?		
2. Is the lesson objective clearly articulated and student friendly?		
3. Are instructional methods appropriately aligned to lesson objectives?		
4. Does teacher assess student understanding (formally/informally) and is assessment aligned to lesson objectives?		
5. Are classroom rules and procedures clear, specific, consistent, and evident?		

Next Steps & Summary

Appendix G

First Cycle of Descriptive Codes - Teachers

Primary teaching strategies	Hands on	Lecture	Groups/pairs	Critical reading/writing
	Standardized tests	Teach standards	CCSS code posted	Warm up/do now
	Handout-paper	Objective posted	Differentiate instruction	Oral questioning
	Student engagement	CCSS students need for college	Positive emotions	Analyze/ analysis
Barriers	Negative emotions	Not enough time		
Instructional leadership	Relate instructional leadership to implementing CCSS	Enact the CCSS in an IU	Classroom leadership	Administrative expectations
	Student engagement			
Determine disciplines to incorporate into an IU	Curriculum Resources-Textbook	Science & Math	English & Social Studies	Social Studies & Math & English
Conceptualize an IU	Curriculum Resources-Textbook	CCSS Objectives		
Incorporate mathematical concepts in an IU	NCTM practices 1-8	Topics easy to incorporate with mathematical concepts	Analysis-Analyze	Not enough time
	Math self-efficacy			
Effect on students' math	Positive - all participants			

comprehension based on IU				
Modeling	English - reading/ writing and conceptual understanding of the text	Science – reasoning in a computer simulation and self-regulated learning	Social studies - reading comprehension and making primary documents relevant	
Cognitive apprenticeship	Content	Domain knowledge	Heuristic strategies	Student flash cards
	Computer assisted instruction (CAI)	Scaffolding		
	Methods	Science and social studies		
	Articulation	English		
	Inspiring teacher			
Vygotskian constructivism	Groups, pairs, partners	English, science, social studies		

Appendix H

First Cycle Descriptive Codes Reduced into Second Cycle Pattern Codes - Teachers

Instructional strategies	Hands on
	Lecture
	Groups/pairs
	Critical reading/writing
	Standardized tests
	Teach standards
	CCSS code posted
	Warm up/do now
	Handout-paper
	Objective posted
	Differentiate instruction
	Oral questioning
	Student engagement
	CCSS students need for college
	Positive emotions
Critical thinking	Analyze/analysis
Barriers	Negative emotions
	Not enough time
Instructional leadership	Relate instructional leadership to implementing CCSS
	Enact the CCSS in an IU
	Classroom leadership

	Administrative expectations
	Student engagement
Determine disciplines in an IU	Curriculum resources-textbook
	Science & math
	English & social studies
	Social studies, math, & English
Conceptualize IU	Curriculum resources-textbook
	CCSS objectives
Incorporate math in IU	NCTM practices 1-8
	Topics easy to include with mathematical concepts
	Analysis/analyze
	Not enough time
	Math self-efficacy
Effect on students' math comprehension	Positive – all participants
Cognitive apprenticeship	Modeling
	English-reading/writing and conceptual understand of the text
	Science-reasoning in a computer simulation and self-regulated learning
	Social studies-reading comprehension and making primary documents relevant
	Content
	Domain knowledge
	Heuristic strategies
	Student flash cards

	Learning strategies
	Computer assisted instruction (CAI)
	English, science, social studies
	Relate CCSS objective to students
	Methods
	Scaffolding
	Handouts
	Science and social studies
	Articulation
	Inspiring teacher
Vygotskian constructivism	Groups, pairs, partners
	English, science, social studies

Appendix I

First Cycle of Descriptive Codes - Students

Primary learning strategies	Flashcards 8/8	Partners 1/8	Standardized tests 1/8	Objective posted in classroom 6/8
	CAI 2/8	Student engagement with the teacher 1/8	Positive emotions 8/8	
Determine core disciplines to incorporate into an IU	Math, Science, & English 1/8	Math, Science & Social Studies 6/8		
Conceptualize an IU	Math & Science 2/8	Math, Science, & Social Studies 3/8	Math & Social Studies 1/8	Lab, Mini lessons 1/8
Incorporate mathematical concepts in an IU	Science – percent, ratios, squares, square root 3/8	Spanish – quantity 2/8	Measurement 1/8	Forensics 1/8
Effect on students' math comprehension based on an IU	All participants agreed 8/8			
Mathematical topics easy to recall in other disciplines	Exponents – Science 1/8	Formulas – Science 1/8	Point slope – Science & Social Studies 1/8	Basic mathematical operations 2/8
	Measurements – Science 1/8	Graphing – Science 1/8		
Cognitive apprenticeship	Content 8/8	Domain knowledge 2/8	Heuristic strategies 8/8	Student flash cards 8/8

	Learning strategies	Computer assisted instruction (CAI) 2/8	Visual learning- Smart Board 1/8	Teacher interaction 1/8
	Biology teacher inspires student 1/8			
Vygotskian constructivism	Partners 1/8			

Appendix J

First Cycle Descriptive Codes Reduced into Second Cycle Pattern Codes - Students

Learning strategies	Flash cards
	Pairs/partner
	Standardized tests
	Objective posted
	CAI
	Student engagement with the teacher
	Positive emotions
Determine disciplines in an IU	Math, science & English
	Math, science, & social studies
Conceptualize IU	Math & science
	Math, science & social studies
	Math & social studies
	Lab, Mini lessons
Effect on students' math comprehension based on IU	All participants agreed
Incorporate math in IU	Science- percent, ratios, squares, square root
	Spanish - quantity
	Math self-efficacy
	Forensics
	Mathematical topics easy to recall in other disciplines
	Exponents

	Formulas
	Point slope – Science & Social Studies
	Basic Mathematical operations
	Measurements
	Graphing - Science
Cognitive apprenticeship	Content
	Domain knowledge
	Heuristic strategies – student flash cards
	Learning strategies
	Computer assisted instruction (CAI)
	Visual learning- Smart Board
	Teacher interaction
	Inspiring teacher – biology teacher inspired student
Vygotskian constructivism	Pairs/partners

Appendix K

Handout Used in Observed Classes

HIGH SCHOOL LAB REPORT FORMAT

REQUIRED LAB REPORT FORMAT

Cover Page: Title, Course, Instructor, Name, Date.
Or a Formal Heading (per instructor)

I. Purpose: A brief statement of the purpose or objective of the experiment. What are you trying to determine by performing the experiment? You can usually copy these from the lab information provided in class.

II. Materials: You should include a **bulleted** list of all lab equipment you need to perform this lab.

III. Procedures: Write the steps of your procedure so that anyone reading your report, even a non-science person, can easily duplicate your data with a set of instructions. Do not use paragraph format. Use numbered list. Do not use we, I, our group….. Use imperative mood such as Place, Prepare, Measure. Do not repeat step1, step2…. Just the number.

IV. Data and Observations: Separate page(s)
Organize your data table(s) so that:

It includes a title
Data table columns and rows include labels
Data table columns and rows include units
It includes several trials
Observations should include as much detail as possible.

Graphs: (if applicable): Always create representations of your data in graphical form. Graphs must have the following:

Unless done on a computer, all graphs must be drawn on graph paper.
The graph (not just the axes) should cover at least 75% of the page. Teeny-tiny graphs are unacceptable.
Coordinate axes must be a straight edge.
Each axis must have a clear label followed by the units of the labeled quantity in parenthesis.
The scale used on each axis must be clearly stated and easy to read.
All plotted points must be small and made clear and easy to read.
Write a title above each graph. The title should <u>not</u> be a repeat of the axis labels. It should clearly differentiate the graph from any others. For example, "Graph

Appendix L

Code Book

First Cycle Descriptive Codes- Teachers	Description	Example
Primary teaching strategies	Teachers discuss and practice in class observations their teaching strategies that include hands-on activities.	“I teach British Literature, so I think it's really very important that I do that literature with the students’ hands on. My experience is that you ask them to read by themselves, they're not going to do it because it's so difficult to understand, and it requires quite a bit of guidance and explanation. What I try to do is, with the literature, I do it with them and we do it together. We read it together. We discuss it.”
Lecture	Each teacher lectured for part of the observed classes to give directions, introduce the warm up activity, or close the lesson.	“All right, we’re factoring, so we’re doing the opposite of the product of two binomials. If second signs are positive, then both the same.”
Groups/pairs	Teacher discussion or class observations revealed the espoused belief that students learn from each other in groups or pairs.	“The main thing in my class, as far as strategies and stuff goes, I love to have the kids working together in groups at all times, especially in science. Regardless of whether they're doing a lab or not, they're always in groups, and they're collaborating on the stuff that we're doing in class.”

Critical reading/writing	Teacher discussion or class observations revealed use of critical reading/writing in English.	“My primary teaching strategies are always critical reading and writing strategies, they're always related to those processes.”
Standardized tests	Teachers discussed how they use test items in science, social studies, and English classes.	“This year we looked at our results from the PARCC last year. And we identified five or six of the standards on which we were particularly low. We broke those down into key concepts and understandings and those have become our objectives for our lessons.”
Teach standards	Teachers discussed how they use the CCSS and curriculum resources to teach the standards. Class observations revealed objectives displayed in the classroom.	“In a History class, it lends itself as well to a lot of writing. Not only reading- but writing. Kids say all the time, ‘This is a history class, why do we have to write an essay?’ I say, ‘Because it's what you do in history class now. It's not the years of dates and facts. It's 2017, and this is how we learn.’”
CCSS code posted	Most teachers displayed the code of the objective in the class.	Science - The objective was written on the front chalkboard – HSLS 1-4- Enzymes.
Warm up/do now	Teachers used an activity at the start of the class as discovered from class observations.	“Warm Up is factor the quadratic expression $x^2 - 12x + 32$.”
Handout-paper	Teachers used paper handouts in social studies, science, English, and math classes.	All students participated in their group at the lab station. Students filled out the tables on the handout after finding results of experiments.

Objective posted	Teachers discussed how the objectives were always posted in the room, and class observations verified this practice.	Describe the similarities and differences between isotopes and a single element.
Differentiate instruction	A science teacher discussed how he used differentiation to form groups.	“I try to I guess differentiate with all of them. I mean, you know, the differentiated instruction, right, we talk about all the time, but it's always not the easiest thing to implement. A lot of the time a lot of the stuff that I give, as far as even like assignments for the most part, when we start something, I may be like, "Hey. Here's 10 problems. I want each of you guys to pick three or four. Read through all of them, and pick the ones that you think you can do, and then circle the ones that you think are more challenging." Then as a class we'll kind of see, because usually you have a lot of the kids will pick the different ones, you know, ‘I think these ones are harder for this reason.’”
Oral questioning	Teachers used oral questioning in observed classes as part of the introduction to a lesson, clarifying directions, and directing student attention to the task at hand.	“On the calculator, we’re still getting volume bigger than surface area. Divide the volume by the surface area. Do you see what’s happening?”
Student engagement	Most students were engaged in the activity in all observed classes.	“On your chart, where you mark the colors. Potency can get altered. The strength, capability of doing its chemical reaction. Look at your bag. Did it change color? Is it absent or present?”

CCSS students need for college	Teachers discussed how their discipline is important for students to perform well in college.	"These standards, this is what they need to know. This is what they need to know in college."
Positive emotions	Teachers discussed they felt positively about the standards, and how they embraced them.	"I pretty much took them under my wing, so to speak, and really worked hard in incorporating them and making sure that the students understood the material that I was putting forth in terms of the standards, because again, like I said, when I was college, it resonated with me that those were all the things that I needed to know, and I felt if I taught those standards that the students would be much better off. Yes, I'm a lover of the standards."
Analyze/analysis	Teachers discussed and were observed using the critical thinking terms, providing paper handouts or CAI instructions that required analysis.	Determine central ideas or themes of a text and analyze their development. Summarize key ideas and details. NJSLS A.R2, R3, W1, W2
Barriers	Teachers addressed few frustrations to teaching the standards.	"The standards are very cut and dry. They, now more than ever, are very, shall we say, particular. With College English 3, with the documents that I teach as part of American Literature, I feel that some of them are being cut out because the core curriculum content standards only want certain ones to be taught. I think the kids are losing out on that from not having the benefit of having a few more documents to see it over the course of the period of literature itself."

Negative emotions	Teachers addressed few negative feelings about teaching the standards as compared to the standards taught prior to 2010.	"I think they're a good guideline to helping students become successful in their education, but I do sometimes feel that they can inhibit the teacher's ability to give a little bit more, because they can be so rigid in what they want the kids to learn about and how they want them to learn about it."
Not enough time	Teachers discussed frustrations about time to teach the standards.	"However, some of them just don't work with what we are doing. I find that it lacks. I also don't teach every single strand. There's not enough time for that. But I do try to line them up as best as I can with the books we use, with the information that we're giving out in class."
Instructional leadership	Teachers discussed how their leadership was used to assist other teachers with lessons based upon the standards and sharing on OnCourse.	"The school definitely looks to me for leadership when it comes to the common core standards and using those. Actually, most of the people have access to my lesson plans. Even though I have seniors, and for the PARCC you need to cut them down into these smaller sections or smaller units."
Relate instructional leadership to implementing CCSS	An English teacher discussed using instructional leadership by collaborating across disciplines in one interview.	"I really do enjoy interacting with teachers from other disciplines. I really do, and sharing out. Mary and I are very, very close, and since she teaches history, she shares many things that she's teaching in US History with me that I'm able to easily pull into my revolutionary period of literature that I'm teaching in College English 3."
Enact the CCSS in an IU	Teachers discussed instructional leadership in terms of enacting the standards using an IU.	"Oh, I find it easy to enact the CCSS in these interdisciplinary units because I think it's kind of,

		the CCSS is kind of crafted for you to be interdisciplinary.”
Classroom leadership	Teachers were observed as the leaders in their classes, and they discussed its importance.	“I think there's the aspect of, they are going to copy what you do. Whether it's how I organize my notes on the board, or just the work I put in in the class. If they feel like I don't know what I'm doing, or I'm just doing busy work, doing the bare minimum to get through the subject myself, I think that's going to reflect on how they feel about me and the class. Then they're going to do the same. They're going to imitate not only my work, but my effort I put into the class.”
Administrative expectations	Teachers discussed how administrators’ expectations supported enacting the CCSS.	“So, and expectations are high. You know, science and math teachers, we step up.”
Student engagement	Teachers discussed their classroom leadership by involving students in the learning process and high student engagement was observed in most classes.	“Again, in a course like the AP course, I'm generally a guide as far as my job is to lead them through it rather than throwing at them directly on an everyday basis, because they have to develop the specific skill set that the AP wants them to develop. And they need to get a lot of the content on their own, because a lot of what we have to concentrate on in class is the content plus the skill development, which is writing and analysis and all those things that the College Boards are looking for.”
Determine disciplines to incorporate into an IU	Teachers discussed IUs as assigning standardized test items from other disciplines. One science teacher, Jack, addressed	“Well usually, it's science-based texts or history-based texts because those are what students will see on the PARCC and on the SAT. On the SAT, there's only one literary text. On the

	each of the core disciplines in his explanation.	PARCC it's one-third literary, it's two-thirds informational. And one of those would be science related, some kind of science text and some kind of history text. Those are normally the interdisciplinary things that we would do. Primary documents for history and processes for science, getting them to summarize those things." Jack: "I have, since I've been teaching seventh grade, ninth grade, tenth, eleventh, twelfth, I have always focused on interdisciplinary units. I just think it makes my job easier. And I think it's far more interesting and I think it has more of an impact when I can get language arts and math into it. But I've done it so long that it's just something that I do."
Curriculum resources - textbook	Teachers discussed their reliance on textbooks, CAI, and internet resources, and these practices were observed in classrooms.	"I follow the common core standards, but also I'm a real big textbook lover. I feel that there's already somebody who's probably making way more money than I am a year, and there's a collaboration of maybe 20 people with doctorates that created that textbook, so I trust in them. It's not always right. I don't always agree with it, but I do follow that. That's how I come up with what I'm doing."
Science and math	Science teachers used a plethora of mathematical concepts in observed classes, and they discussed the interdisciplinary components.	"Like biology, when we talk about genetics, a lot of that's based on probability, so that's very easy to introduce the concept of probability, what it means in terms of not just the numbers, but what it means in

		terms of the concept itself. So, you have an X percent of chance of your kids being carriers or have a disease or not have a disease, so things like that with genetics, we do a lot of that. For the AP Bio, we do use a lot of statistical analysis to see how their data compares to the other students in the class. Also, how with standard percent error, how it could technically differ with an entire bigger population."
English & Social Studies	Teachers reflected on how they included topics from other core disciplines.	"That, to me, is on a week-to-week basis when I do my lesson plans. For example, I'm teaching right now, in College English 3, the period of revolution. Therefore, without a doubt, I'm going to incorporate history standards into that."
Social Studies & Math & English	References from social studies teachers who include reading and writing of essays and the mathematical concepts included in their curriculum resources.	"Yeah, we just went over the 16th Amendment and how in 1913, the 16th Amendment just put income tax on the American people. I said, 'If you guys go out and you work ... Anybody with jobs? Anybody work? Oh, yeah, I work, I work. I go, Well, check your paycheck. Do you ever notice, you might gross $100, but you bring home $85, why? What's the money being used for?"
Conceptualize an IU	Reflection upon experiences and difficulty of teaching an IU from the perspective of an English teacher.	"Well, it starts with the key concepts that we want our students to be able to master. And then for eleventh grade common core is working. The common core specifies for the eleventh-grade curriculum that certain primary documents,

		those what are they called? Foundational documents, like the Federalists papers, the Declaration of Independence, the Preamble to the Constitution, those are part of the curriculum. For an interdisciplinary unit, I would look towards those, those documents to be texts, the center of it. For science, it's kind of just how it presents itself."
Curriculum Resources – Textbook	Reflection of conceptualizing an IU reveals sources for teaching core disciplines.	"The textbook is good that we use because of, in each chapter there's always maps. Graphs and charts. So, I find it easiest to incorporate those things in each chapter."
CCSS Objectives	Teachers reflected upon teaching the standards and using curriculum resources as the resources aligned to the objectives.	"I've converted to trying to make my plans on a unit basis rather than just like on a day-to-day or weekly basis. I have tried to take into consideration more the entire unit, and really have paid attention to where can I incorporate interdisciplinary units. Specifically, where can I incorporate graph chart analysis, and reading comprehension, word usage, things that are going to pop up on the PARCC, the SAT, the PSAT."
Incorporate mathematical concepts in an IU	Teachers voiced frustration to incorporation of mathematical concepts.	"English, I'd say, I don't. There are no mathematical concepts, really, unless it lends itself to the material that we're reading. Same with the interdisciplinary units. I don't really tie any math, I wouldn't say, unless we're reading about it, then we would."

NCTM practices 1-8	Science teachers discussed and used five of the eight practices.	"I mean science and math usually go hand in hand, so it's a lot; it's fairly seamless to incorporate math into pretty much any science concept, so it lends itself to it like I said. Again, a lot of this stuff is statistical analysis, so things like average, mean, mode, things like that can even go from an entry-level course all up to AP."
Topics easy to incorporate with mathematical concepts	References to using math in science classes as observed and discussed.	"A lot of the mathematical concepts are used in a lab setting, so as previously stated, whether it's taking a measurement of something or finding a percentage, determining the fraction, which then leads to the percentage. Most of the mathematical concepts are done during the lab portions of the curriculum for biology."
Analysis-Analyze	Teachers used analysis or analyze in observed classes and discussed the importance of this critical thinking process.	"They're in a lab, so they'll receive data. They're required to put that into some type of chart. With that chart full of data, they're then asked to provide some type of visual image, so whether it's creating a line graph or a bar graph, they have to be able to take that data and apply it to graphing skills. They do receive data charts, and they have to basically analyze on it. That's one of the things that our school has been working on because of PARCC testing. The higher levels of PARCC, the PSATS, are having students analyzing graphs and answering questions of that graph. Our district has now put into place that we practice that more often

		in the classroom setting, as well."
Not enough time	Reflections led teachers to conclude that their courses must come first and no time to incorporate other disciplines.	"As I said before, I go through them. I know the English ones very well. I will say that I'm still a rookie with getting to know the standards for math or science. It's more time-consuming to go through and say, 'Yeah, this one will work,' but it's still worth it in the end so that if I am bringing the two together, the lesson is always more well-rounded. I would agree that maybe I just need more time to spend learning all the standards because it could take a long time to get them all down and just know, 'Oh, wow, that matches up this one.'"
Math self-efficacy	References of lack of confidence in math.	"It would probably just be, because I am terrible at math myself, I have severe math anxiety, it would be basic math sense. I might would hand back a test and say figure out your average or each correct answer is worth four points, subtract two points for each incorrect answer and have them do those math facts themselves. Other than that, I'm bad at it, so I don't feel confident infusing what I'm not good at. I wish I were more confident in my math abilities."
Effect on students' math comprehension based on IU	All teachers agreed that students who encounter math concepts across disciplines may retain more of the math skills.	"I think it's certainly beneficial to a student's math comprehension to have math practice into other disciplines. I think the more practice the better."

Positive – all participants	Reflections upon the type of math students encountered in the teachers' courses.	"I said to somebody, '538's the number, what's 2/3 of 538?' I could see a couple of them thinking it right in their head. 56 percent, right? What is that number? They might not have had it exact, but they knew it was going to be more than half. Things like that, I find that kids get pretty easily. I'm not doing algebraic equations here. I think, they do, they get it.
Modeling	Observation of an English teacher using a classic eighteenth century story and modeling orally the assignment for students to write their interpretation based upon their experiences.	"In Massachusetts in prison, and mother and baby…letter A…publicly shamed…Hester refused to identify the child's father. They're assuming you know- what happens when you assume. Roger Chillingworth, as missing husband. Daughter – Pearl …live outside the community. Eventually discover that Arthur Dimmesdale was the father, had an affair. Dies, leaves money to Paarl and Hester. They move to London. Return wearing the scarlet letter. Put yourself there. Can't write a narrative unless you put yourself there. Show up on Thanksgiving Day, after on Black Friday. Your shopping list is going to be different from your other shopping lists. Agenda…what's your deal, what's your game? Are you going to be the one who says stop…she has to wear that letter all the days of her life? Or do

		you speak up and the crowd beats you up?”
English – reading/writing and conceptual understanding of the text	Observed class reveals English teacher assigning classic story and students are expected to write their conclusion based upon their culture and experiences.	“I give you literary license... characters, settlement…morals. At the end of our story, you’re the boss…see where your sense of compassion is. No? Yes? Check back with you in about five more minutes.”
Science – reasoning in a computer simulation and self-regulated learning	A science teacher, Harvey, assigned a virtual lab and expected students to generate data, analyze it, and produce appropriate graphs.	The virtual lab was complete with graphs, data, and an interactive program for student responses. Students worked individually on their laptop on a virtual lab about stickleback evolution. Students were required to graph data, there is a link for students to review different types of graphs. There is an experiment with three components on the CAI program: Analyze Fish from Lakes, Analyze Fossil Fish, and Pelvic Asymmetry. A notebook is the lab manual. Students created line graphs and used them on Google Docs or Microsoft Excel.
Social studies – reading comprehension and making primary	Teachers discussed making standards relate to or relevant to students, and this is a concept of both cognitive apprenticeship and IUs. Students write and use reasoning based upon their	“It’s difficult for students sometimes to learn about something that happened in 1500's. In order to grasp their interest, I try to tie in something that can relate today, or something relatively new information I could try to pull

documents relevant	experiences and prior knowledge.	in. I use a lot of, 'Well, what would you do if you were in their shoes? We did the Declaration of Independence, and I had the kids write their own Declaration of Independence. What are you breaking away from? I try to spin it to make it personal."
Cognitive apprenticeship	Teachers demonstrated expert knowledge of their discipline in the observed classes.	"The unhealthy Chesapeake - write four to five bullets to support that statement. Importance of tobacco economy in Chesapeake - indentured servants and head right system."
Content	Classroom observations revealed that most teachers understood the content of their discipline and how to encourage student participation.	"Keep your notebooks out. We finished the isotopes Tuesday. Isotopes on the spectrogram of a transition metal. Calculate the average molar masses from the experiment and show your work."
Domain knowledge	Classroom observations revealed that most teachers used specific concepts and procedures of their field.	"Use mm and find the radius and calculate the surface area and volume and find their ratio. Why do this?"
Heuristic strategies	Classroom observations revealed that most teachers used specific handouts or word processing directions from Google Suite for students to accomplish the tasks.	Jack, a science teacher, gave each student a handout with directions to enter data from the lab on Google Classroom.
Student flash cards	Teacher discussion and classroom observations showed	"Okay. I have, for the past couple years, done Cornell notes. I also do standard,

	many activities for students to be successful on assignments.	traditional hierarchy notes. I do power points. I also post whatever I can for the students to have access to it. And I like taking in language arts and I like taking in math whenever I can.”
Computer assisted instruction (CAI)	Classroom observations and interviews with teachers proved a plethora of CAI applications.	“I always try to use some form of technology. I like to use, for science sometimes the classes, it's difficult to conduct a lab. So where I see trends going today, it's more students are being expected, not necessarily to know content, you have to have a certain amount of content, but a lot of it is analytical skills, and the virtual labs, they give them data. There is something to say about conducting a lab, but a lot of the tests, whether it's AP or some of the SAT exams, they're geared towards taking data and analyzing it, so the virtual labs do get them some of the limited exposure to how to do the techniques, but it's more that I can fine tune questions to analyze or have them demonstrate whether they can analyze data or not.”
Scaffolding	Classroom observations and teacher interviews produced uses of scaffolding, a component of the dimension methods.	“Student analysis on the handout. Students see what happens to the rate of reaction when the temperature goes too high. Students also discover what happens to the enzyme when the temperature is set too hot.”
Methods	Classroom observations showed a variety of using specific questions or suggestions for	Carrie, an English teacher, addressed the class: “Today we’re sharing- share it out. One thing in your life for each

	students to develop expertise of the topics.	category. Never works, coffee maker, computer, batteries - but don't throw it away. Why do you keep batteries that don't work? You have to figure it out. All right. SOAPST – Tone part by looking at choice. How he feels about the subject. Who's the speaker?"
Science and social studies	Science and social studies teachers used handouts, different types of notetaking, and all teacher participants used CAI to assist student development of expertise.	Irving, a science teacher, explained the method of groups: "I choose the groups, and I make sure certain kids are where they are. Sometimes it's based off of their academic level, like high, middle, low, those kinds of things, or there may be another thing where, Hey. I know these two really work well together, and this person usually gets the stuff, and they like to teach other people, so I'll kind of put them around the kids that are struggling a little more.
Articulation	English teachers were observed asking students to respond orally to address a problem that supported the literature assignment.	Carrie, an English teacher, gave an oral assignment to the class as they worked in pairs or groups of three. "To make it more relevant to you…Baker classifies [shown on dry erase board] Things that break down Things that get lost Things that don't work."
English	English teachers demonstrated articulation by asking students to discuss a problem that related to the reading assignment from the preceding day.	Brenda said to the class, "Once a week be creative. Only use 20 words or phrases for the rest of your life, what would they be? Think about your family

		members, what you care about, and food, choose wisely. What do you do on a regular basis? Real world situations. You have a limited ability to communicate. Think about what words we use throughout a regular day that we don't need…too much talking."
Inspiring teacher	A science teacher, Jack, was honored by being named the teacher of the year for WHS.	"Well let me give you an example of this past week. We are calculating percent efficiency of glycolysis. And then aerobic respiration. One is two, one is 39, and then I want them to do a percent difference and discuss why is it we wouldn't be able to survive on anaerobic, the two, and why we need the 38. But I also like them to take a look at 39 percent and what they're concept is to how does that impact them? It's only 39 percent efficient. What's going on inside of us? And how do they feel about that? Anyway, it's just interesting to get some, you know, are we gonna die? So, I tell them, it's not great, but here we are, so 39% is working. So, it's very easy and the book does help a lot in incorporating this kind of stuff."
Vygotskian constructivism	All teacher participants explained they used groups or pairs of students for them to learn from each other and allow	"I do a lot of IXL on the computer for the students. I do a lot of whiteboard activities with the students so I can see their answers right away. A lot of station activities where they're

	the teacher to discover the students' thinking processes.	moving around, partner work, and then just normal lecture. I just did absolute value and instead of telling them what each part of the function does, I had them explore it using an activity and they were able to change the values and see what happened to the graph. Just being able to put some of that responsibility on them to kind of use their logic to figure out what's happening made one, the lesson go a lot easier, and it helped me take a step back and listen to what they were saying and the words they were using."
Groups, pairs, partners	Classroom observations and teacher interviews resulted in references to grouping students to share ideas, or solutions to help each other.	"In the English world, we read a lot, a lot of text. We do outside reading novels. Then, we do a lot of articles informational text. Trying to get them ready for the college experience. Everything's pretty much hands-on, but I'd say, group work, partner work, whole class instruction's the best strategy for that."
English, science, social studies	Classroom observations and teacher interviews resulted in students working in pairs or small groups to work on an assignment.	"I use several different strategies with teaching history because it lends itself to many, many different strategies. For example, warm ups. We do one every day, and they're done differently every day. Sometimes the warmup itself can be definitions. It can be put yourself in the place. It can be recalling facts. The way I strategize it is, I have the kids pair share, partner pair share. Sometimes I have them write a line, write something underneath what someone said. Sometimes I just pass them up

		and I just do a quiet collection, I'll ask for volunteers to raise their hands."

Second Cycle Pattern Codes-Teachers	Description	First Cycle Descriptive Codes - Teachers
Conceptualize an IU	How teachers perceived an IU from their experiences teaching the standards. Incremental steps of teaching standardized test items related to other disciplines and using the standards as a guide were the two references to teaching an IU. Little effort from the teachers is due to inappropriate PD and models that include the core disciplines with recent technological advances. Time was a barrier for the processes of communication and collaboration across disciplines, and this led to frustration by teachers.	Curriculum resources CCSS objectives Critical thinking-analyze/analysis Barriers Negative emotions Determine disciplines in an IU Student engagement Curriculum resources-textbook Science & math English & social studies Social studies, math, & English
Mathematical concepts in an IU	How and what mathematical concepts were included in an IU. Most teachers included the math concepts from curriculum resources, and their perception from their experiences was that this was all the math that was	Incorporate math in an IU NCTM practices 1-8 Topics easy to include with mathematical concepts

	necessary. Teachers who had a strong math self-efficacy incorporated the math skills in lessons. Teachers with low math self-efficacy avoided math in their lessons even though it was used in the curriculum resources. Despite the view that there was not enough time or personal mathematical expertise, teachers espoused the belief that math incorporated into other disciplines benefited students' math comprehension.	Analysis/analyze Not enough time Math self-efficacy Effect on students' math comprehension Positive – all participants
Instructional strategies	How teachers perceived the instructional strategies they used to enact the adopted standards. Teacher participants viewed teaching standards and objectives from their experiences that formed their perception of using a variety of teaching strategies. Their level of acceptance of the standards was considered and their indications of the changes they made after the standards were adopted led to the emerged theme of instructional strategies.	Hands-on Lecture Groups/pairs Critical reading/writing Standardized tests Teacher standards CCSS code posted Warm up/do now Handout-paper Objective posted Differentiate instruction Oral questioning Student engagement CCSS students need for college Positive emotions Cognitive apprenticeship

		Modeling English-reading/writing and conceptual understanding of the text Science-reasoning in a computer simulation and self-regulated learning Social studies-reading comprehension and making primary documents relevant Content Domain knowledge Heuristic strategies Student flash cards Learning strategies Computer assisted instruction (CAI) English, science, and social studies Relate CCSS objective to students Methods Scaffolding Handouts Science and social studies Articulation Inspiring teacher

		Vygotskian constructivism Groups, pairs, partners English, science, social studies
Instructional leadership	How teachers' perceptions through their experiences with the adopted curriculum and using IUs defined their instructional leadership. This was the fifth year of teaching the standards in English, science, and social studies. This was the fourth year of teaching the math standards. Instructional leadership was valued as sharing among teachers of the same department. Teachers voiced frustration at not having time to collaborate with teachers across disciplines and not enough time to plan IUs. Teachers demonstrated classroom leadership during the observed classes, and they valued administrative instructional expectations.	Related instructional leadership to implementing CCSS Enact the CCSS in an IU Classroom leadership Administrative expectations

First Cycle Descriptive Codes - Students	**Description**	**Examples**
Primary learning strategies	Students discussed their primary studying strategies, which became their primary learning	"I like the writing. My primary studying strategies over the years. I like writing out notes, like flashcards."

	strategies, throughout the interview.	
Flash cards	Students used the heuristic strategy of creating and using flash cards in most of their courses.	"My primary study strategies over the years are note cards, I like index cards and flip them over, and my mom helps me with them. And so, yeah that's what I've been using for a while."
Pairs/partners	Students enjoyed working with another student to share ideas and possible solutions to assignments. This is a Vygotskian constructivism concept of sharing ideas.	"Me, making note cards and reading them, or study with a partner if I could find one."
Standardized tests	Students related their experiences of using standardized test items in class.	"Right now, I'm in English, actually. We're doing the RST to help for the test we're doing, I think the SAT."
Objective posted	Students were comfortable with the standard objectives posted in the classroom. Most students understood the value and importance of the objectives.	"Just like having them up in the classroom? I think it helps us prepare for what we'll be learning about that day. I think it's helpful, because before class starts, I like to prepare for what we're gonna be learning for. I like to mentally prepare."
CAI	Students used CAI to research and understand concepts from their courses.	"For the studying strategy, I've been using flash cards and watching videos on YouTube. If I'm doing bad in something, something else."

Student engagement with the teacher	Students preferred help from the teachers during class.	“I'm a visual learner, so having things taught to me on the board, Smart Board, things being drawn out to me. I need the teacher to interact with me for me to fully understand something. Being one with the teacher, I guess.”
Positive emotions	Students’ perceptions of the standards were positive due to their experiences in each course. Teachers explained the objectives and sometimes used the codes from the standards.	“The experiences I've had, I think, they're pretty good. I always stick by them. They're pretty easy to comprehend and go about. I feel like the teachers go about it really well. And help the students understand more with it.”
Determine core disciplines in an IU	Students used the graphic elicitation to focus and reflect upon the courses they would include to create an IU. Students focused upon core disciplines they wrote on their graphic elicitation.	“I think math could be incorporated into social studies, because you need to know the years that certain subjects take place in. Obviously, like we were discussing earlier, science, because of measurements. You need to know about how to measure.”
Math, science & English	Students explained how they would incorporate math in other courses based upon their experiences in school.	“AP History - No. Science -Yes. English - Yes. In Science, I mean in Biology, I've used math like adding and subtracted and dividing stuff. We have used how to measure stuff. We've used a ruler and stuff.”
Math, science & social studies	Students relied on their experiences to relate math	“Mathematical topics have been. Well with science, we use it a lot for formulas to help us figure out how

	and other disciplines in an IU.	many carbons are in something, and other kinds of things like that, to help us figure out our hypothesis as well as other parts to our experiments and stuff. Yeah. So, we use it to help us see when something was created, or something happened, like a war. Or if we want to see how long ago that was, we do that kind of thing. Point, yeah, point slope. We used that to figure out certain ways to plot the points and with graphs in science and history that we have done."
Conceptualize an IU	Students used their experiences to conceptualize an IU from any courses in school or projects out of school.	"Like any of the classes? Probably photography, art, something like that. Definitely fitness, if you're trying to gain weight or lose weight. Put science again. Could I pick things out of school? All right. Probably like landscape, that's one. Anything like social media, something like that, with keeping tasks of phone numbers, or any coding that requires with that."
Math & science	Students matched math and science in most interviews.	"Okay. So math I think for science, I would use it as helping us determine certain parts of, if we were doing something with yeast and carbs, or glucose which we just did an experiment with that. We had to do an equation of how we, how many carbons we put it, I keep saying carbons. How many

		yeast particles we put in, how many glucose particles we put in, and see that kind of thing.”
Math, science & social studies	Students included at least three disciplines in an IU.	“Math connected to Modern Science, Biology and History, INS (Integrated Natural Science).”
Math & social studies	Students perceived math was used in social studies but not much in ELA.	“I mean yeah, sometimes. I see it mostly in science, it's like, history we use it a lot with timelines and seeing ages of things and that kind of thing. Language I feel like I don't see it a lot. But it is in there sometimes. And it helps with, if you're trying to figure out the year something's made or whatever, it helps out.”
Lab, Mini lessons	Students responded more to the disciplines they would include in an IU than to how they would design an IU.	“I don't really know how that would happen. I'd put all mini lessons I guess. Like a lab or something.”
Incorporate mathematical concepts in an IU	Students made no response or explained how they used math outside of school for studying or learning strategies. Students referred to other disciplines, and not in math classes.	“How do I incorporate them? Maybe I can like set an example for myself, like give like, explain, set myself a situation, a certain situation that I would have to like, for instance, I could say like two molecules. Like giving carbohydrates, or something like that.”
Science – percent, ratios, squares, square root	Students recalled how basic math skills and algebra I concepts were used in science class based	“Science. Probably...let's see. I can't think of any off the top of my head. Percents or ratios Yeah, definitely that, and squares,

	upon their experiences this year.	square root of something that's very small, like a microscopic cell, or something like that.”
Spanish – quantity	Students recalled using Spanish words for quantity and numbers.	“Mathematical, other subjects. I want to say Spanish. Yeah, numbers in Spanish, different, like how to describe the quantity of something in Spanish.”
Measurement	Students explained measurement was using in art, science, and social studies based upon this year’s courses and their graphic elicitation. Specific measuring devices were not recalled.	“Measurements in art.”
Forensics	Students related practical uses of math in forensics as taught by the science teachers.	“We use math in forensics. Where we just did blood splatter. We were trying to find the angles of where it drops from and we were doing a lab on that. “
Effect on students’ math comprehension based on IU	Each student gave an example of using math in other courses based upon their experiences in classes this year.	“I feel like using it with other classes helps me do better in math because it helps me not think that I'm not going to use this ever in life. 'Cause that's what a lot of students think, oh I'm just doing this just to get through school, and I think it helps me because I'm like, I know that I could use this in the future, and it helps me realize, put me in situations where I am using it.”

All participants agreed	Students agreed that using math in other disciplines improved their math comprehension of the specific math skills that were incorporated.	“Yeah. Yeah, I think learning math helps me with, in sports marketing for example, I just know how to do the math because of my math classes.”
Mathematical topics easy to recall in other disciplines	Students gave a plethora of math concepts they recalled easily from other courses this year. Students used their graphic elicitation to focus their thoughts and comments.	“I know I take sports marketing. Fourth period. We do revenue. And the math of that. Like, increase profit and then decrease, I forget. Yeah, expenses. We use it in sport marketing. We usually have a math problem on the tests and quizzes.”
Exponents	Students remembered using exponents in science and recalled the correct math term after being asked probing questions.	“Exponents. Deal a lot of codes, especially with biology. There are a lot you've gotta learn.”
Formulas	Students recalled some formulas used in other disciplines this year. Probing questions in the interviews helped students recall the names of the formulas.	“Definitely slope, we used a lot in science for doing graphs or whatever we might need to do. And there's a lot of, I can't think of the word of it right now, it was one of the formulas.”
Point-slope science & social studies	Students recalled using formulas in science and history from plotting points on a graph.	“Point, yeah, point slope. We used that to figure out certain ways to plot the points and with graphs in science and history that we have done.”
Basic mathematical operations	Students recalled the basic math skills as easy to recall	“I would say just simple math: adding, subtracting, division, all those.”

	from use in other disciplines.	
Measurements-Science	Measurement was mentioned by students in courses they were taking this year.	“Oh, yeah. Because we, during labs in biology, we need to know the measurements to know how much of something we need to combine with another, and we need to know the days and time of when we do things, when we experiment.”
Graphing-science	Students recalled graphing in their classes, and they did not elaborate after probing questions were asked during the interviews.	“Yeah, like graphs and stuff in science class and stuff like that.”
Cognitive apprenticeship	Components of the content and methods dimensions were discovered as students discussed how and why they learned in their various courses.	“I want to make code. I want to speak with math, and have that language in. It's basically you talking to a computer to do something, and that's how I see it. With coding, you can make anything you want, basically. You can make a new app on your phone, or you can make a new phone, or you can make anything you want out of your brain, which is like the new art in this era of time. “
Content	Students referred to two concepts in this dimension of cognitive apprenticeship.	“I think we do that by, I don't know how to word it. Okay. I feel like I help, I do it by I write it out, I write out everything I have to do, and then I figure out what kinds of different

		things I have to incorporate in doing the problem, whatever class it might be. And then most of the time there is math involved.”
Domain knowledge	Students referred to using notes and spend time individually reviewing and studying for tests or quizzes.	“I like to do the strategy where you learn it the day, study it the next day, and then study it before the quiz. That's how I learn best. “
Heuristic strategies	Students referred to writing out their notes and explaining this is one favorite strategy to learn.	“I like the writing. My primary studying strategies over the years. I like writing out note, like flashcards.”
Student flash cards	Each student recalled creating flash cards or note cards as heuristic strategies to learn.	“Me, making note cards and reading them, or study with a partner if I could find one.”
Learning strategies	Students recalled preferred learning strategies by naming the specific activity or source for content knowledge of their courses.	“For the studying strategy, I've been using flash cards and watching videos on YouTube. If I'm doing bad in something, something else.”
Computer assisted instruction	Students in each of the observed classes used laptops for the classroom assignments or to complete an assignment after class. Students recalled how they used computer programs in the past.	“I don't really use it for Honors biology, but in the past, courses I've taken, have been more like art, but it's on the computer, visual art and stuff like that.”
Visual learning – Smart Board	Students referred to being visual learners by creating	“I'm a visual learner, so having things taught to me on the board, Smart Board,

	heuristic and learning strategies.	things being drawn out to me."
Teacher interaction	Teacher support in the classroom is important to the students.	"I need the teacher to interact with me for me to fully understand something. Being one with the teacher, I guess."
Biology teacher inspires student	Teacher inspiration is a component of the cognitive apprenticeship dimension. Student #3 referred to the teacher as a response to the question about the favorite subject this year.	"Favorite, I would have to say biology. Mostly because Mr. B (Jack) is just an amazing teacher, and biology's one of my favorite subjects. I just want to go into it in the future."
Vygotskian constructivism	Students referred to working with the teacher or other students.	"I need the teacher to interact with me for me to fully understand something. Being one with the teacher, I guess."
Partners	Students referred to working with a partner for studying and learning strategies	"Me, making note cards and reading them, or study with a partner if I could find one."

Second Cycle Pattern Codes - Students	**Description**	**First Cycle Descriptive Codes - Students**
Conceptualize an IU	How students would conceptualize and create an IU. The graphic elicitation was used for students to write the disciplines they would use in an IU. Student creativity included a variety of courses and their directions were to	Determine disciplines in an IU Math, science & English Math, science, & social studies Conceptualize an IU

	have math as part of the IU. One student offered the mini lessons as a way to use an IU.	Math & science Math, science, & social studies Math & social studies Lab, mini lessons
Mathematical concepts in an IU	Mathematical concepts students recalled from courses, not a math class, this year. Students recalled various courses that included math basic skills and some algebra I concepts. Students with good communication skills and high math self-efficacy responded well and succinctly in the interview. These students recalled the type of math, formula names, and other mathematical terminology.	Incorporate math in IU Science-percent, ratios, squares, square root Spanish-quantity Math self-efficacy Forensics Mathematical topics easy to recall in other disciplines Exponents Formulas Point slope-Science & social studies Basic mathematical operations Measurements Graphing-science Effect on students' math comprehension based on IU All participants agreed

Learning strategies	What students explained as their primary strategies to study and learn. Discoveries were made from both teacher and student data analysis that produced the same codes. For example, cognitive apprenticeship and a reference to Vygotskian constructivism were unexpected from both groups of participants. Students embraced the standards and respected their teachers.	Flash cards Pairs/partner Standardized tests Objective posted CAI Student engagement with the teacher Positive emotions Cognitive apprenticeship Content Domain knowledge Heuristic strategies-student flash cards Learning strategies Computer assisted instruction (CAI) Visual learning-Smart Board Teacher interaction Inspiring teacher-biology teacher inspired student Vygotskian constructivism Pairs/partners

Appendix M

Teacher Survey

Directions: Please use the scale below to rate your agreement (or disagreement) with each of the following statements about teaching mathematical concepts.

1. The mathematics content in the observed lesson was significant and worthwhile.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

2. The content of the observed lesson increased the students' interest in mathematics.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

3. The content of the observed lesson helped students learn mathematical concepts.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

4. The content of the observed lesson helped students learn mathematical procedures.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

5. The content of the observed lesson helped develop students' computational skills.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

6. The content of the observed lesson helped students solve problems.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

7. The content of the observed lesson helped students reason mathematically.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

8. The content of the observed lesson helped students learn how mathematical ideas connect with one another.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

9. The content of the observed lesson helped students prepare for further study in mathematics.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

10. The content of the observed lesson helped students understand the logical structure of mathematics.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

11. The content of the observed lesson helped students learn about the history and nature of mathematics.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

12. The content of the observed lesson helped students learn to explain ideas in mathematics effectively.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

13. The content of the observed lesson helped students learn how to apply mathematics in business and industry.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

14. The content of the observed lesson helped students perform computations with speed and accuracy.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

15. The content of the observed lesson helped prepare students for standardized tests.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

16. The content of the observed lesson helped students make appropriate connections to other areas of mathematics, or other disciplines, or to real-world contexts.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***

17. The content of the observed lesson provided students opportunities to apply or generalize skills and concepts to other areas of mathematics, other disciplines, and/or real-life situations.

1	2	3	4	5
Strongly Disagree	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***