**Using Critical Determination in Amplifying Teacher and Principal Voices for Mathematics
Professional Development: A Narrative Inquiry**

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Fulfillment of the Requirements for the Degree of Doctor of Education in Leadership for
Educational Justice

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Abstract

The purpose of this study is to identify the paradigms and practices in mathematics education that shifted as a result of elementary school teacher participation in the California Education Mathematics and Science Professional Learning Initiative (CEMSPLI), Transforming Lives: The Mathematics Leadership Institute professional development program. The purpose of this program was to partner with a school district in Southern California to address historic underachievement within this marginalized community, specifically in mathematics. Through this partnership, the program proved effective in increasing students' learning of mathematics. The Southern California schools who participated in the CEMSPLI grant experienced disproportionately high levels of positive improvement in mathematics achievement in their community, which is composed of predominately lower socio-economic students of color. This dissertation studies and amplifies the voices of teacher and principal participants in the CEMSPLI grant using qualitative, narrative inquiry methods. To complete this study, I interviewed three teachers and three principals who participated in the grant. I analyzed the collected data through the constructed lens of "Critical Determination," and then based on the themes that emerged, I crafted a framework of suggestions for the optimal design of mathematics professional learning programs.

Dedication

This culminating project and the accompanying blood, sweat, and tears associated with achieving completion were only navigable because of the foundation provided by my loving family. My beautiful and loving wife [REDACTED] has been the picture of patience and support, without which my sanity would have long left me during this process. My girls, [REDACTED], have long provided me a purpose to persevere and accomplish more in order to prove to them that anything is possible no matter the obstacle. It's the Jackson 4 against the world! My Grandma [REDACTED], who raised me when she didn't have to, has always been one of my biggest cheerleaders, making me believe I could do anything, even when I doubted. Finally, my mom [REDACTED] and Grandpa [REDACTED], who left us much too early, have always provided me inspiration to cherish and make something of my life in honor of their brief time here. This project is more for all of you than for the fickle world of education.

“In all toil there is profit, but mere talk tends only to poverty.” Proverbs 14:23 ESV

“Therefore we ought to support people like these, that we may be fellow workers for the truth.” 3 John 1:8 ESV

“Do nothing from rivalry or conceit, but in humility count others more significant than yourselves. Let each of you look not only to his own interests, but also to the interests of others.” Philippians 2:3-4 ESV

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Along this long and arduous journey, many people have been instrumental along the path toward successfully completing the seemingly impossible. As will become evident in this work, we as humans long for and gravitate toward those we feel connected to and are motivated beyond our wildest expectations to not let these people down. This fact was what motivated me to complete this work.

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Chapter 1: Introduction

Genesis Story of the California Elementary Mathematics and Science Professional

Learning Initiative (CEMSPLI) in the District Under Consideration

The CEMSPLI Grant began as a grant offered by the California Department of Education as a means of disseminating federal Title II funds for professional learning purposes in 2015 (CDE, 2020). Prior to grant application, applicants needed to establish a four-way partnership between a teacher preparation program at an Institution of Higher Education (IHE), an administrator preparation program within the same IHE, an Arts and Sciences department within the same IHE, and a high-need Local Education Agency (LEA) (CDE, 2020). For the school district in question, the existing relationship that precipitated the grant was between the chair of this dissertation and the LEA's district math strategist. It was because of this relationship that the application for the CEMSPLI grant was completed and approved.

Beyond the four-way partnership explained above, grant applicants were also required to complete an extensive application, which the chair of this dissertation and the district math strategist completed together. The application consisted of eight narrative response sections and fourteen distinct forms that demonstrated everything from the demonstrated need of the LEA to the absence of drugs in the workplaces of the IHE and LEA. To simplify the 59-page application as best I can: the grant was to be used to create a partnership between a high-need LEA (specifically, in this case, an LEA in which marginalized students in grades three through five did not achieve well on the 2015 administration of the California Assessment of Student Performance and Progress (CAASPP) exam in mathematics) and an IHE close to this LEA. The district under consideration and the University through which this dissertation is being completed met the criteria for this grant.

The salient characteristics of this grant were that the target LEA was to recruit ten principals and thirty teachers to participate in the CEMSPLI program from ten elementary schools. These forty participants were to create vertically aligned cohorts composed of third, fourth, and fifth grade teachers and the principal at each of the ten schools. These were the teams that underwent the two-year professional learning program from January 2016 to December 2017. The program consisted of college-like afternoon and evening classes, cohort walkthroughs in their elementary classrooms, and annual report-outs at district events to stakeholders who did not participate in the CEMSPLI program. The emphasis of the training classes was on teaching a comprehensive restructuring of math instructional practices, curriculum, and assessment techniques in the spirit of the Common Core State Standards in Mathematics. This emphasis zeroed in even further to a specific focus on how to best implement the Common Core State Standards for Mathematical Practice (SMP's) as a subset of these CCSS's in mathematics (Kruse, et al., 2017). The university director of this training grant also provided teachers and principals with the research, theory, and practice on the different types of student engagement (academic, social, affective, and cognitive) and observed how the teachers manifested them in their classroom as they worked with students. The district math professional development strategist, district curriculum director, and the university co-director of the grant visited the participating classrooms on a weekly basis to monitor the teachers' progress in delivering the newly acquired strategies for instruction and student engagement.

At the conclusion of this professional learning program, the LEA math strategist and the chair of this dissertation created a report. The focus of this report was on operationalization of the eight Common Core Standards for the Mathematical Practices (SMP's) that will be explained in further detail later in this work. The grant writers developed a rubric that identified varying

pedagogical practices tied to these eight SMP's and used this rubric as a walkthrough tool when conducting class visits of CEMSPLI participant classrooms. The report explained and identified the frequency of these pedagogical practices at the beginning and the end of the two-year CEMSPLI program. This program report focused on what changed in the classrooms as a result of the CEMSPLI program. My work in this dissertation digs deeper by adopting a paradigm of quality rather than quantity for this study. I have worked to understand how and why the CEMSPLI program was so successful in increasing student learning in the ten participating schools by learning what changed in the paradigms and pedagogical practices from the participants who were the closest to the learning.

General Description of the Areas of Concern

Contemporary mathematics education has been undergoing a paradigmatic transformation for the better part of the past decade due to our transition to the Common Core State Standards (CCSS) (Polikoff, 2017). The impetus for this transition was the stagnation of academic achievement for American students as measured by standardized assessments (CAASPP, 2018; Nation's Report Card, 2018; OECD, 2018), coupled with the fact that what sets the American way of life atop the global economic hierarchy is arguably our ability to innovate (Hunt & Wittmann, 2008). Our ability to innovate is theorized to be a direct byproduct of our creativity and abilities to critically problem solve when faced with the challenges, issues, and concerns of contemporary times. These abilities are directly linked to the skills and mindsets gained from high level mathematics education (Hunt & Wittmann, 2008). Furthermore, in a more practical sense, mathematics serves as the academic gatekeeper that prevents many American students from completing post-secondary university studies (Bailey, et al., 2010; Larnell, 2017).

Digging down to the root of this reality leads one to the study of foundational level

mathematics instruction during elementary school. Studies have linked early grade mathematics instructor confidence and competence to high school and college students' mathematical achievements (Hadley & Dorward, 2011; Ramirez, et al., 2018). This confidence and competence—or lack thereof—within the ranks of early education teachers is directly linked to the this generation in educations' the beliefs and mindsets—or paradigms—that have been studied by countless researchers to be reviewed in Chapter 2 (Anderson, et al., 2018; Bamburg, 1994; Bursal, & Paznokas, 2006; Dusek & Joseph, 1983; Dweck, 2006; Eccles & Wigfield, 1985; Good & Brophy, 2003; Guillory Bryant, 2009; Harris & Rosenthal, 1985; Jussim, et al., 1998; Pellegrini & Blatchford, 2000; Pigott & Cowen, 2000; Ramirez, et al., 2018; Raudenbush, 1984; Rosenthal & Jacobson, 1968; Rubie-Davies, 2006; Rubie-Davies, et al., 2006; Rubie-Davies, 2014; Scott-Whelan & Teddlie, 1989; Sudkamp, et al., 2012; Smey-Richman, 1989; Smith, 1980; Waxmon & Padron, 1995). Studying this pivotal time in the education of students and looking to improve the competence and confidence levels of these teachers are logical directions in which to point research efforts, and they guide my work here. Through this study, I have identified concrete tactics that resulted in a boost in teachers' competence and confidence levels in a successful professional learning setting.

The mindsets, confidence and competence levels, and paradigms of education are what guide the daily pedagogical practices of elementary school teachers. These pedagogical practices are critical in creating the conditions for maximum student learning. In the following pages, I examine the interplay between beliefs and practices using the work of multiple researchers (Aguirre & Speer, 2000; Bobis, et al., 2016; Campbell, et al., 2014; Price, 2017) to guide my thoughts and subsequent framework creation. I focused this study on identifying professional development needs that must be met in order to change teacher beliefs and practices.

Continuing in this spirit of identifying areas of concern within the study of math instruction during our era of the Common Core State Standards, the words of Sztajn, et al. (2012) also guide my work. These authors state the following:

A current problem with PD is that available opportunities are frequently fragmented and episodic, including both high and low quality work, strong and weak learning opportunities, generic and content-focused activities, appropriately and poorly focused learning experiences, in part because PD is supported and coordinated through many different types of organizations. (p. 14)

This statement amplifies the importance of my aim to develop a coherent, scalable framework that will shift the paradigms and pedagogy of early mathematics teachers in a manner that will improve student learning. In this project, I addressed this crucial time in the early math education of all students by studying the professional development needs of elementary school teachers in mathematics—through recognizing and amplifying their voices and experiences related to a program that worked. I aim to create a path of clarity and coherence through an otherwise opaque view into the world of mathematical professional development. Many studies have been conducted to gauge the effectiveness of professional development techniques in education (Guskey & Yoon, 2009; Schmidt, 2012; Swars & Chestnutt, 2016; Yoon, et al., 2007). Few have taken on this challenge using the voice of the teacher as the focal point using narrative inquiry methods (Guskey & Yoon, 2009). By studying the voices of teachers in a Southern California community composed primarily of low socio-economic students of color, who achieved disproportionate success on standardized state mathematics achievement tests when compared to similar communities, I aim to shed light on the middle steps between where this community was and where they ended up. Ideally, this information can be added to the knowledge base with

which other communities may attempt similar processes to improve their professional learning efforts.

Problem Statement

In the current, questionable era of educational accountability and standardized testing, measures of educator effectiveness continue to illustrate that students are being left behind in math (CAASPP, 2019; Nation's Report Card, 2018; OECD, 2018). Using data obtained from the California Department of Education (CAASPP, 2019), I created the figures below in order to visually expose the magnitude of this problem in the state of California, San Bernardino County, and the Inland Empire region. In looking through all graphs representative of all math achievement over the last four years at the various levels of the California and Southern California regions, the highest achievement represented shows a data set in which over half the students tested still did not reach the specified standard for achievement (CAASPP, 2019). Though standardized testing is not the panacea of measurements of educational effectiveness, any system where over half of the students fail and is not a system to be celebrated; this figure represents a system in need of study and improvement.

Figure 1. CAASPP Math Results in the State of California, and Los Angeles, Riverside, and San Bernardino Counties. Created using data retrieved November 1, 2019, from <https://caaspp.cde.ca.gov/sb2018/Search>

Figure 2. CAASPP Math Results in the Top 10 districts in the Inland Empire by enrollment. Created using data retrieved November 1, 2019, from <https://caaspp.cde.ca.gov/sb2018/Search>

Beyond the problem of poor math achievement for all students in this region lies the problem of marginalized students' disproportionately low levels of achievement when compared to more privileged students, including White, Asian-American, and middle to upper class

students. Not only is this gap present at the local and regional levels in Southern California and statewide, but as the below figure illustrates, this fact remains on national tests of achievement as well. On the 2017 administration of the National Assessment of Educational Progress (NAEP) test in mathematics, Black, Hispanic, Pacific Islander, and Native American students scored below average while White, Asian/Pacific Islander Combined, Asian-American, and students of two or more races scored above average (DeBrey, et al., 2019). This demonstrates that an achievement gap in standardized mathematics test scores persists nationwide.

Figure 3. 4th Grade National Assessment of Educational Progress in Mathematics Scaled Scores by Ethnicity. Retrieved March 4, 2019 from <https://nces.ed.gov/pubs2019/2019038.pdf>

This achievement gap mirrors countless inequities that marginalized populations have faced throughout the entirety of US history. Lisa Given (2008) defines marginalization as “the process through which members of some segments of society find themselves out of the mainstream based on their membership in socially meaningful groups” (p. 491). For the purposes of this study, marginalized students are defined as those students out of the mainstream White and Asian-American, middle-class segments of society who historically underachieve academically when compared to these privileged groups. As illustrated clearly in the figures below, White, Asian-American, and middle-class mathematics students achieve at a much higher

rate when compared with poor students, disabled students, and students of color. Though the district under consideration in this paper experienced substantial growth in mathematical achievement, there still exists a substantial disparity between the above defined marginalized student populations and students of more privileged backgrounds.

Figure 4. CAASPP Math Results by Subgroup in the Top 10 districts in the Inland Empire by enrollment. Created using data retrieved November 1, 2019, from <https://caaspp.cde.ca.gov/sb2018/Search>

Figure 5. CAASPP Math Results in the 10 Schools Who Participated in the CEMPSLI Program by Subgroup. Created using data retrieved November 1, 2019, from <https://caaspp.cde.ca.gov/sb2018/Search>

The final figure displayed in this section, displayed below, demonstrates the improvement in math CAASPP test results in the district under consideration after treatment from the CEMSPLI professional development program. In their book titled *The Power of Positive Deviance*, Pascale and Monique (2010) outline the fundamental tenet of their theory that led to my interest in studying this district. They state that Positive Deviance is:

...based on the observation that in every community there are certain individuals or groups whose uncommon behaviors and strategies enable them to find better solutions to problems than their peers, while having access to the same resources and facing similar or worse challenges (p. 7).

Pascale & Monique ultimately posit that the tools and structures necessary to achieve positive results in any collection of people, toward any goal, can be found from within that population. In various areas of interest, they identify problems within a population, identify outliers achieving disproportionately positive results within that population, study the possible causes of this disproportionate success, and then work to scale what is learned from within (Pascale & Monique, 2010). While math CAASPP results are stagnant at the state, county and local district levels, the district under consideration for this work has achieved disproportionately positive results within the same system, with similar resources, and despite encountering similar obstacles to the rest of the state, county, and most local districts. I studied the cause of this disproportionate success and then worked to provide recommendations for future professional learning programs to consider when designing future efforts in much the same way that Pascale and Monique outline.

Figure 6. CAASPP Math Results in the 10 Schools Who Participated in the CEMPSLI Program. Created using data retrieved November 1, 2019, from <https://caaspp.cde.ca.gov/sb2018/Search>

Significance of the Study

Many studies support the notion that the teacher is the most important agent employed within the behemoth education system (Darling-Hammond, 1997; Darling-Hammond & Haselkorn, 2009; Hattie, 2008; Hattie, 2011; Hattie, 2015; McCann, et al., 2012; Stronge & Hindman, 2003). Though principals are a close second in their ability to impact the learning environment from within, teachers rank number one in terms of their impact on the future lives of their students (Adejumo, 2017). This is what led to my decision to study the beliefs and practices of teachers as the critical factors contributing to the mathematical success of their students for this study, while also investigating the perceptions of the second most important agents, the school principals.

With this as a foundation, the next piece of this project builds on the fact that many teachers of elementary school students are not confident in their ability to effectively teach foundational mathematical concepts (Bringard, 2017; Maloney, & Beilock, 2012; Nelson, et al.,

2016; Ramirez, et al., 2018; Schmidt, 2012). This phenomenon is coined by many researchers as “mathematical anxiety,” both on the part of the teacher and on the part of the students in their classes (Bringard, 2017; Bryant, 2009; Bursal & Paznokas, 2009; Maloney, & Beilock, 2012; Nelson, et al., 2016; Ramirez, et al., 2018; Schmidt, 2012). This is because the inevitable side-effect of this mathematical anxiety in teachers is that the students in these teachers’ classes are not exposed to the rigor that is necessary to understand the mathematical concepts on a deep level. They spend less time on mathematical study than students in the classes of more confident teachers and ultimately may develop their own math anxiety later in life (Ramirez et al., 2018).

This phenomenon reinforces the connection between the beliefs of the teacher regarding their own mathematical ability and the pedagogical practices they carry out while teaching math in their classroom. In the Common Core State Standards for Mathematics (CCSSM), there is a paradigm shift from covering more mathematical topics at a very surface level to the idea of diving deeper into less topics so that: “correct answers come from understanding and using mathematics” (Sztajn, et al., 2012, p. 4) rather than from memorizing shortcuts and tricks. The authors of the cited work discuss that the goal of this shift is to move into an era of less topics, using more time, so that the math can be learned at a deeper level, and in their words: “Teaching should be paced to give students time to learn, not paced to cover all the topics.” (Sztajn, et al., 2012, p. 4) This shift further compounds the anxiety of teachers without strong backgrounds in mathematics (Campbell, et al., 2014). These deficiencies in a teacher’s beliefs regarding the most effective way to teach mathematics, and the consequent practices that lead to lower levels of mathematical rigor in their classrooms, can have lasting effects on student performance in higher-level mathematics. These facts reinforce the critical need to develop professional learning strategies that ease teachers’ anxiety and provide all teachers the necessary training to meet

students' needs under these requirements. Whether in the form of pre-service teacher preparation or in-service professional learning programs, the skills to teach within this paradigmatic shift to "less but deeper" need to be nurtured and developed.

As stated previously, students who begin their educational journey with less confident math teachers end up achieving at a lower level when they reach high school and university studies (Ramirez, et al., 2018). This lower level of achievement facilitates the practice of ability-based tracking, which opens up a plethora of questionable discriminatory practices affecting marginalized students (Pekkala Kerr, et al., 2013). Students who are placed in lower level math class tracks because of their lack of advanced mathematical knowledge rarely break free of the lower achievement track and move into the advanced track (Pekkala Kerr, et al., 2013). Further, students of color and students living in poverty are more likely to be placed into these lower ability tracks than their White and Asian-American, middle-class peers (Friedrich, et al., 2015). This fact sheds light on a persistent achievement gap that must be addressed.

This study contributes to addressing this achievement gap by coming up with tangible strategies that positively affect persistent inequities present on various forms of international, national, state, and local standardized tests of mathematical achievement (CAASPP, 2019; Nation's Report Card, 2018; OECD, 2018). Coupled with these described inequities, figures 3, 4, and 5 above demonstrate how students living in poverty and students of color consistently underperform on tests of mathematical achievement compared to White and Asian-American students at the national and local levels (CAASPP, 2019; DeBrey et al., 2019). This persistent achievement gap remains the educational equity and social justice issue of our time yet remains perplexing to solve for the educational researchers and practitioners who routinely attempt to address it in their work.

Not only does this achievement gap persist in the form of standardized test scores but, as stated previously, it persists in the fact that students who are of color and/or living in poverty never make it into the higher levels of math classes (Betts, 2011). Unfortunately, these classes tend to serve as the gatekeepers to high school completion and later university studies (Atanda, 1999). This gatekeeping effect contributes to a lower high school graduation rate as a direct result of poor math achievement, consequent abandonment of university dreams, and a more difficult adult life as a result (Atanda, 1999; Betts, 2011). A high school dropout is 63 times more likely to be incarcerated than a college graduate (Sum, et al., 2009). Not only do students with less education struggle economically, but they are placed at greater risk of losing their rights of liberty and civic involvement in our democratic society.

The logical path that has been laid out to reinforce the significance of this project begins with the fact that many early mathematics teachers experience mathematical anxiety and are consequently unconfident in their abilities to properly teach deep mathematical concepts (Bringard, 2017; Bryant, 2009; Bursal & Paznokas, 2009; Maloney & Beilock, 2012; Nelson, et al., 2016; Ramirez, et al., 2018; Schmidt, 2012). The path continues with the fact that a lack of confidence leads to practices that impede the learning of foundational concepts at a deep level (Campbell, et al., 2014) which result in later math struggles for students in the form of tracking and their own math anxiety (Pekkala Kerr, et al., 2013; Ramirez, et al., 2018). Furthermore, this tracking and lack of mathematical success is disproportionately present in students living in poverty and students of color (Friedrich, et al., 2015). Next, these students end up victims of the gatekeeping effect that higher math achievement has on high school graduation and university matriculation (Atanda, 1999; Betts, 2011). Finally, many of these students who have been left behind by the educational system end up interfacing with the American judicial system (Sum, et

al., 2009) and are stripped of their rights to freedom and the ability to vote and help craft our society. At the end of this path is the rational conclusion that addressing the mathematical beliefs and practices of early mathematics teachers has the potential to steer marginalized students away from both economic and civic hardship.

This is not at all meant to trivialize the myriad other efforts needed to create a more equitable educational system, free from the persistent, oppressive mechanisms of discrimination. This work is merely meant to contribute a small kernel of new knowledge to be placed upon the mountain of previously established knowledge in educational equity pursuits. By focusing this work down the path of math instruction, I hope to create the mildest of ripples in creating a more equitable path forward for students in a gatekeeper course. Perhaps this knowledge can be applied to more aspects of the educational system in future work. By finishing this study and completing my doctoral studies, three magical letters will follow my name and unlock a newfound level of influence with which I can attempt to attack many of the other, seemingly infinite patterns of social injustice present in the American educational system.

What follows is a conceptual map that helps graphically represent what guides this work:

Conceptual Framework

Figure 7. Conceptual Framework

This graphic represents that the theories of Critical Pedagogy (Aronowitz, 2010; Freire, 1970; Giroux, 2010) and Self-Determination (Deci, 2017; Deci, Olafsen, et al., 2017; Pink, 2009) were used to create Critical Determination, the mindset and theoretical framework that guided this work. This mindset was reinforced by the teacher professional development framework of Darling-Hammond, et al. (2017) and the professional development specific to math in the era of Common Core State Standards of Sztajn, et al. (2012). I used this lens to examine the shift in paradigms (Boaler, William, et al., 2000; Boaler, 2005; Boaler, 2013; Boaler, 2015; Boaler & Sengupta-Irving, 2016) and pedagogy (Boaler, 2015; Kruse, Schlosser, & Bostic, 2017; Swars & Chestnutt, 2016) that occurred as a result of teacher and principal participation in the CEMSPLI professional learning program. From this analysis came the eight themes of Accountability and Purpose, Autonomy / Team False Dichotomy, Humble Reflection, Self-Efficacy, Cognitive Rigor, Encouragement and Productive Struggle, Inquiry Techniques, and Modeling. What follows is a bit more unpacking of the foundational theories that created Critical Determination.

Critical Pedagogy as formed from the work of Freire (1970), Giroux (2010), and Aronowitz (2015), along with Self-Determination Theory as crafted in the works of Ryan and Deci (2017), Pink (2009), and Deci, Olafsen, et al., (2017) create the lens of Critical Determination through which this study was conducted. I would define Critical Determination as: the lens of not merely viewing but acting upon the world from a mindset of criticality toward the mechanisms of oppression, inequity, and injustice, in a partnering fashion that humanizes all people in bolstering their autonomy, competence, and purpose through relatedness to each other and a cause bigger than themselves. The researchers who come before me in helping to construct this definition view the purpose of education and roots of human motivation as much more than assessment driven, economically based endeavors. Richard Schaul via Freire (2018) states that:

Education either functions as an instrument that is used to facilitate the integration of the younger generation into the logic of the present system and bring about conformity to it, or it becomes the practice of freedom, the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world (p. 34).

These words on the practice of freedom and what Freire calls “humanization” (1970) drove my decision to frame this work in the lens of Critical Determination while using methods of narrative inquiry to answer my research questions.

The ultimate purpose of education, whether of adults or children, according to these researchers, is to create a dialogue with which to reflect upon and impact one’s world (Freire, 1970). Freire (1970) states that: “One cannot expect positive results from an educational or political action program which fails to respect the particular view of the world held by the people.” (p. 95) In pursuit of understanding how and why the CEMSPLI program worked with this study, I chose to reinforce the voices of the learners through a critical dialogue to identify promising further steps in designing mathematics professional development programs.

While co-creating the knowledge that addresses my research questions, I also lean on the tenets of intrinsic motivation and Self-Determination Theory as laid out by the above-mentioned researchers (Ryan & Deci, 2017; Pink, 2009; Deci, et al., 2017). These researchers propose that there are three basic tenets comprising the roots of human motivation. Ryan and Deci (2017) and Deci, et al. (2017) call these the psychological needs of feeling competence, autonomy, and relatedness. Pink (2009) similarly calls these the psychological needs of feeling autonomy, mastery, and purpose. A thorough unpacking of these concepts is conducted in Chapter 2 in order to create the mental model that meshes with Critical Pedagogy in underlying this study.

These two overarching theories create the base upon which to place the specific theory of professional development guidelines for teachers (Darling-Hammond, et al., 2017) and mathematical professional development best practices (Sztajn, et al., 2012) in order to funnel toward specific answers to the research questions guiding this study. This theoretical foundation used to frame the emergent themes was created using these core characteristics of Critical Pedagogy and Self-Determination along with the use of Darling-Hammond, et al.'s (2017) best practices in teacher professional development and Sztajn, et al.'s (2012) nine element theory of effective mathematical professional development in an era of common core state standards. By examining the paradigms and pedagogy of the teacher and principal participants in this study through the lenses of Critical Determination, as built upon Critical Pedagogy and Self-Determination and reinforced by the elements of effective professional development programs, I aim to create a link between nebulous theory and specific recommendations that can guide future mathematical professional learning program design efforts.

During the literature review, I focus on how humans learn, looking specifically at nuances of adult learning theory using the work of Hussain and Haladu (2013), Ihejirika (2013), Ihejirika and Onyenemezu (2012), Merriam (2018), Paiko (1997), and Ukpong (2000). I use the specific elements of adult learning theory as extricated from these generalized human learning theories to focus on how adults learn related to their stage of cognitive development. All of these theories are studied through the constructed lens of Critical Determination in order to better understand what changes the beliefs and practices of adults when they learn new knowledge.

From this understanding, I intend to link to the work of Darling-Hammond, et al. (2017) and Sztajn, et al.'s (2012) nine-element framework of what works in teacher professional development directly to math teachers. I then align participant responses and emergent themes to

these elements and the constructed elements of Critical Determination. This framework, along with the methods of narrative inquiry, guided the data analysis efforts to identify the elements of the CEMSPLI program that the study participants felt were the most beneficial in achieving their disproportionately positive results. Once I establish a link between the themes and consistencies found in the interviews and the defining elements of Darling-Hammond, et al.'s (2017) and Sztajn, et al.'s (2012), I then propose a framework of suggestions for the design of future foundational mathematics professional development efforts. While the Sztajn, et al. (2012) nine-element framework is explained at length in Chapter 2 of this work, what follows is a figure introducing the nine elements and a brief elaboration of each.

Recommendation	Elaboration
1: Emphasize the Substance of CCSSM Professional Development	Professional development provides opportunities for practicing mathematics teachers to engage with both the CCSSM content and the CCSSM practices in a focused and integrated way.
2: Create and Adapt Materials for Use in Professional Development Aligned With CCSSM	Professional development materials are needed that explicitly address the mathematics content and practices of the CCSSM and provide vivid images of teaching and learning that are consistent with CCSSM.
3: Design CCSSM Professional Development Based on Features That Support Teacher Learning	Professional development takes into account existing knowledge about effective ways to organize learning experiences for teachers of mathematics.
4: Build Coherent Programs of Professional Development Aligned With the CCSSM	Programs of professional development provide a continuous and coherent set of experiences in which practicing mathematics teachers engage over an extended period of time.
5: Prepare and Use Knowledgeable Facilitators for Professional Development Aligned With the CCSSM	Professional development uses expert facilitation to ensure teacher learning of CCSSM at scale.
6: Provide CCSSM Professional Development Tailored to Key Role Groups, in Addition to Teachers	Strong programs of professional development target a variety of role groups within the education system and attend to the professional needs of each group as the system builds capacity at all levels.
7: Educate Stakeholders About the CCSSM	Members of the general public need to be apprised on how the CCSSM will impact instruction and learning in our nation's classrooms.
8: Continuously Assess CCSSM Professional Development	Professional development programs are regularly assessed to provide formative information for program improvement and revision and to establish the effectiveness of the programs.
9: Create CCSSM Professional Development Consortia	Professional development consortia are needed to oversee and improve the role professional development plays in successful implementation of the CCSSM.

Figure 8. 9 Recommendations for Math PD. Adapted from "Scaling Up Professional Development in an Era of Common State Standards." Retrieved March 2, 2019, from <https://journals.sagepub.com/doi/abs/10.1177/0022487112473838>

Adding to the Knowledge

I expand upon Critical Determination in Chapter 2, where I outline how the underlying theories of Critical Pedagogy defined in the work of Aronowitz (2015), Freire (1970), and Giroux (2010) lay the foundation of what it is to partner with learners to interrogate our world and work in a democratic fashion to deconstruct the mechanisms of oppression. The work of Deci, et al. (2017), Pink (2011) and Ryan and Deci (2017) is also expanded upon further in

Chapter 2, where the defining elements of Self-Determination Theory—as connected to what motivates human behavior—are unpacked so that the previously mentioned definition of Critical Determination can be better understood. How this lens contributed to knowledge at the completion of this study is in the criticality I held toward best professional practices during the study and in the examination of what worked best in the CEMSPLI program from the perspectives of teachers and principals.. One can endlessly debate the inequities present in over emphasizing the measurement student learning through standardized testing, specifically in mathematics, or one can notice the reality that mathematical knowledge these students in this community were expected to gain was better gained after their teachers and principals participated in the CEMSPLI program. Whether this knowledge is truly the most important knowledge that these students should obtain for a more prosperous and joyous future can be debated in a different project at a different time. The fact remains that these students in this underprivileged community learned more after the professional educators guiding their education learned from this program. This study sheds light on tangible, actionable reasons for how and why they learned as connected to all previously mentioned theorists (Aronowitz, 2015; Darling-Hammond, 2017; Deci, et al., 2017; Freire, 1970; Giroux, 2010; Pink, 2011; Ryan & Deci, 2017; Sztajn, 2012). Eight themes emerged, which are expanded upon further later in this work. I include a thorough explanation for how they emerged and how they connect to the theories of these previously mentioned scholars, so that the recommendations made may build upon existing knowledge in professional development design. I make these specific recommendations in the recommendations and staff development sections of Chapter 1, and later during the implications section of Chapter 5.

Research Questions

Three research questions guide this project. Those three questions are:

1. What professional learning practices do participating teachers and principals in the California Elementary Mathematics and Science Professional Learning Initiative Grant perceive led to disproportionately high math achievement in a community of impoverished and disenfranchised students?
2. What themes emerge when listening to teacher and principal voices related to shifts in teacher paradigms and/or teacher practices?
3. What recommendations can be made for mathematical professional learning programs to improve future mathematics professional learning offerings?

The purpose of these questions is to provide the avenue to understanding the specific paradigms and pedagogical practices in mathematics that changed among these teachers and principals and led to such positive results. Emergent themes from the interviews guided the creation of specific recommendations which could inform the design of future mathematics professional development programs in marginalized communities. Using the lens of Critical Determination via operationalizing elements of the theories of Critical Pedagogy and Self-Determination, analyzing participant responses for emergent themes helps shed light on practical steps to be taken in real communities, with real students in need of best instructional practices, as a result of powerfully effective professional development programs. These questions are significant to helping to add to the knowledge base in education because they help identify clear and coherent elements of effective mathematics instruction professional learning programs. These elements may ultimately guide the design of similar math professional learning efforts in other marginalized communities. The answers to these questions became clearer due to the inquiry methods that are further explained in Chapter 3 of this work. The stories that emerge were

powerful tools with which to inspire real change in the design and implementation of mathematics instructional professional development programs in many other communities.

Definition of Terms

- Autonomy – The literal translation of autonomy is regulation by the self. Authors expand upon this to include the psychological need for a person to have control over their own destiny (Deci, et al., 2017; Pink, 2009; Ryan & Deci, 2017).
- CEMSPLI – California Education Mathematics and Science Professional Learning Initiative. This is the acronym used to describe the professional learning program central to this study.
- Competence – As used in this work, this is the psychological need to feel challenged and like one is contributing by getting better at something that matters (Deci, et al., 2017; Ryan & Deci, 2017).
- Critical Determination – As created from Critical Pedagogy and Self-Determination theories: Critical Determination is the lens of not merely viewing but acting upon the world from a mindset of criticality toward the mechanisms of oppression, inequity, and injustice, in a partnering fashion that humanizes all people in bolstering their autonomy, competence, and purpose through relatedness to each other and a cause bigger than themselves.
- Critical Pedagogy – The foundation for this concept was set by Freire in his seminal work *Pedagogy of the Oppressed* and has since been expanded and mushroomed into a strand of theory studied by multitudes of scholars. In a sentence, Critical Pedagogy is the praxis of educational professionals toward a liberation from and reconstruction of the mechanisms of oppression toward a more equitable, democratic world (Aronowitz, 2015;

Freire, 1970; Giroux, 2010).

- Intrinsic Motivation – Being moved to action because an activity is inherently interesting or enjoyable (Deci, et al., 2017; Pink, 2009; Ryan & Deci, 2017).
- Mastery – The psychological need to improve one’s skills and abilities in activities that intrinsically matter to that person (Pink, 2009).
- Motivation – The essence of what moves a person to action (Deci et al., 2017; Pink, 2009; Ryan & Deci, 2017).
- Narrative Inquiry – The study of experience understood narratively by undergoing recursive and iterative methods of capturing stories from participants, analyzing and theming these stories, then reporting out the results of this process (Clandinin, 2016; Conle, 2010; Connelly & Clandinin, 1990; Connelly, Clandinin, Green, et al., 2006; Cresswell & Poth, 2017).
- Pedagogy – The instructional efforts that one undergoes while practicing the art of teaching that ultimately result in student learning (Boaler, 2015; Kruse, Schlosser, & Bostic, 2017; Swars & Chestnutt, 2016).
- Paradigm – The mindsets and beliefs that one harbors regarding how the world around them operates and how their actions fit and interact within that world (Boaler, et al., 2000; Boaler, 2005; Boaler, 2013; Boaler, 2015; Boaler & Sengupta-Irving, 2016).
- Professional Development – Structured professional learning that changes teachers’ paradigms and pedagogy and ultimately results in increased student learning (Darling – Hammond, et al., 2017; Sztajn, et al., 2012).
- Purpose – The psychological need to feel a connection between one’s actions and something bigger than oneself individually (Pink, 2009).

- Relatedness – The psychological need to feel connected to other human beings through shared experiences and actions (Deci, et al., 2017; Ryan & Deci, 2017).
- Self Determination – The psychological theory that humans are more powerfully motivated through the intrinsic needs to feel autonomy, competence / mastery, and purpose / relatedness than they are through extrinsic methods, such as punishment or reward systems (Deci, et al., 2017; Pink, 2009; Ryan & Deci, 2017).

Recommendations

I will introduce my recommendations for the world of academia now and then discuss them more thoroughly in Chapters 4 and 5, alongside a more thorough explanation of the results and implications of this work. The eight themes of Accountability and Purpose, Autonomy / Team False Dichotomy, Cognitive Rigor, Encouragement and Productive Struggle, Humble Reflection, Inquiry Techniques, Modeling, and Self-Efficacy emerged as the themes of how and why the CEMSPLI program so effectively improved students' learning of mathematics, according to study participants. These themes guided my creation of a framework of suggestions to be reflected upon when designing math professional learning programs. This framework, explained succinctly, makes the case for the need to establish a trusting team foundation as the first step to any professional learning program. From this team dynamic, the first catalyst for change of humble reflection can safely happen among participants in the program. Once these conditions leading to the establishment of a trusting team that humbly reflects upon their beliefs and practices have been created, then the notion of accountability can be factored in. This is not the typical paradigm of accountability in education today, as represented by high stakes standardized testing and the dehumanization of teachers. This is an idea of accountability to self-mastery and to a purpose larger than our own selfish desires in the spirit of the components of

competence / mastery and purpose / relatedness that characterize Critical Determination. This accountability leads to receptivity to the specific techniques that follow in changing the paradigms and pedagogy that result in improved student learning. These techniques of inquiry that result in deep cognitive rigor must be wrapped in the efforts of encouragement to productively struggle from the team, the facilitator, and from any leaders present within the professional learning program, so that perseverance can lead to breakthroughs in learning. Teachers' breakthroughs then accompany the most important outcome of this study, and that is to develop efficacy on the part of the professional learner so that they may in turn work to develop efficacy in the students they teach. For a deeper discussion regarding the structure of these suggestions, see the implications section of Chapter 5.

Staff Development

The results of this study drive the recommendation that the staff most in need of understanding these implications are those that make decisions around professional learning program design and implementation. In much the same spirit that this study suggests the framework of creating a better math professional learning program, any efforts of staff development using this new knowledge must come from a foundation of trust and reflection on the part of the information disseminator and learner. Those most in need of this new information—school administrators and professional learning facilitators—tend to be very successful professionals who may hold onto their existing beliefs and practices strongly because these beliefs and practices have helped them achieve success over the course of their career. To open these professionals up to the importance of this framework will require finesse and a thorough development of the foundations of trust and teamwork. This foundation cannot be undervalued or overstated. From these conditions of trust and team, the further building blocks of

humble reflection and the other six themes as mentioned above can be constructed, ultimately leading to improved student learning. This professional learning program should be built into the overall professional learning goals of whatever academic institution it is implemented in and should not be a single workshop. Program designers should space sessions closely enough that all concepts are absorbed but not forgotten, and programs should span the course of more than a year so that participants understand that these concepts are foundational and not just the latest educational fad. This program could be specific to mathematics content, or as I will argue further in this paper, can include any professional learning program.

Organization of the Study

The method of inquiry that amplified the voice of participating teachers and principals was a narrative inquiry approach. I dialogued with study participants in the Freirean sense and worked to objectively record and consequently communicate their perspective every step along the way. Bruner (2008) and Neuhauser (2010) both demonstrate that humans learn better through the power of story when compared to recitation and memorization of facts and figures. Furthermore, Conle (2010) emphasizes that a narrative inquiry approach focuses on the study of a lived experience. Conle (2010) also states that narrative inquiry is a rhetorical exercise based on the art of persuasion best served to study personal experiences rooted in practice and not easily named. Finally, Connelly, Clandinin, Green, Camilli, and Elmore (2006) along with Connelly and Clandinin (1990) discuss that narrative inquiry is a method to study human experience that is powerful because humans are storytelling organisms who individually and socially lead storied lives. This lived experience and what was learned from the powerful story that resulted were the underlying purposes of this inquiry. I worked diligently to craft a powerful story from the data gathered through dialogue and the resultant themes obtained in this study.

Using this powerful story, I endeavored to persuade action toward improving mathematical professional development outcomes for elementary school teachers so that future generations of math students can experience the same amount of success as the population being studied in this work.

Conclusion

To zero in on and address early mathematics education, I have worked to make the case that to the biggest impact derives from a focus on elementary level teachers' paradigms and pedagogical practices in teaching math. Addressing the beliefs and consequent actions of elementary school teachers regarding mathematics instruction has the potential to create lasting, tangible, positive effects on student achievement (Hadley & Dorward, 2011; Ramirez, et al., 2018). With a lack of clarity regarding how to best change these beliefs and consequent practices (Antoniou, et al., 2015; Baumfeld, 2007; Bell & Odom, 2012; Bernhardt, 2015; Birman, et al., 2000; Borko, 2004; Boyle, et al., 2004; Buczynski & Hansen, 2010; Desimone et al., 2002; Evans, 2014; Garet, et al., 2001; Guskey, 2000; Guskey, 2002; Guskey 2014; Guskey & Yoon, 2009; Hill, et al., 2013; Hirsh, 2012; Jaquith, 2013; Jita & Mokhele, 2014; Joyce & Calhoun, 2010; Kazempour, 2009; Kazempour & Amirshokoohi, 2014; Kennedy, 2005; Reeves, 2010; Yoon, et al., 2007), my decision for this study was to focus specifically on a professional learning program that proved effective in improving student mathematical achievement in a lower socioeconomic community of color at a much greater rate than surrounding communities with similar demographics. I conducted an analysis through the lens of Critical Determination—as built upon the theories of Critical Pedagogy and Self-Determination Theory—of what teachers and administrators felt was the most beneficial in the California Elementary Mathematics and Science Professional Learning Initiative Grant. In this analysis, I used the voices of three

teachers and three administrators. I explored and established a link between these thoughts and previously developed theories of professional learning for teachers (Darling-Hammond, et al., 2017) and theories of optimal professional learning for common core mathematics (Sztajn et al., 2012). This underlying work led to the creation of a coherent framework of recommendations for professional learning program design, specific to elementary level mathematics instruction, but that can also possibly be used in any content area. Perhaps these ideas can be scaled and used in other disadvantaged communities, in order to contribute to the creation of a more equitable education system by shrinking achievement gaps for marginalized populations in mathematics.

Chapter 2: Literature Review

Historical Background

The purpose of math.

Simon Sinek champions the idea that people do not support what you do before they can support why it is done (Sinek, 2009). In this spirit, I begin my study of mathematics education literature by exploring strong supportive evidence for why math is studied in the education system. The strands of justification for the study of mathematics that I explore involve how it helps to develop and strengthen the brain (Arsalidou, et al., 2018; Boaler, 2015; Evans, et al., 2015; Peters & DeSmedt, 2018), the economic gains attained through higher levels of mathematical education (Carnevale, et al., 2015; Hanushek & Woessmann; 2010; Hanushek, Peterson, et al., 2013; Hunt & Wittman, 2008; Jackson, 2017; Rindermann, 2007; Symonds, et al., 2011), and the link between mathematical thinking and innovation through creative thinking (Atkinson & Mayo, 2010; Kerr, et al., 2018; Kruse, et al., 2017; Reynolds, et al., 2002).

With new advances in brain scan technology over the last few years, the field of neuroscience is unlocking new insights into how the brain develops, operates, and strengthens. This has consequently unlocked many insights into how the study of mathematics impacts the human brain. Leading mathematics education researcher and practitioner Jo Boaler (2015) has identified problem solving regions of the brain that are fired only through the study of mathematics rather than any other academic discipline. Venturing further into the details of brain research, Evans, et al. (2015) have discovered that mathematical thought and practices fire the same brain regions that are fired during high level decision making and attentional processes. From this, one can conclude that to study math strengthens students' decision-making and attention-holding abilities. Venturing further, Peters and DeSmedt (2018) discuss how

mathematical study recruits interconnected brain regions such as the prefrontal, posterior parietal, occipital-temporal, and hippocampal regions. Finally—going as far into this work as I felt was appropriate, since I am an educational researcher rather than a brain science researcher—Arsalidou, et al. (2018) discuss that the inferior parietal lobule, precuneus, frontal (superior and medial frontal gyri) cortices, insula, and claustrum light up and activate while mathematics is being studied. Suffice to say that the study of mathematics strengthens regions of the brain that would otherwise go unexercised.

This ability to strengthen the brain by studying mathematics may prove to be a very powerful intrinsic motivator to many who enjoy improving themselves in any regard. However, in the American capitalist system, there prove to also be extrinsic motivators for the study of mathematics in the form of economic rewards to be gained through higher math education. In conducting my own research using the National Education Longitudinal Study of 2002 data set, I found significant positive correlations between math and future life success. In running tests using the independent variables of highest math class taken in high school and the number of math classes taken in high school, I found a positive correlational effect on the dependent variable of 2011 reported earnings (Jackson, 2017). The higher the math class or number of classes taken in sequence correlated with later life earnings for these students. A favorite expression in the world of quantitative research is that correlation does not imply causation, but this correlation cannot be ignored, nonetheless.

In addition to my own original research, the positive correlation between various measurements of intelligence and economic prosperity has been scientifically argued in the work of many researchers (Hanushek & Woessmann; 2010; Hanushek, Peterson, et al., 2013; Hunt & Wittman, 2008; Rindermann, 2007; Symonds, et al., 2011). This conclusion that higher

intelligence correlates to higher earnings would seemingly be intuitive but has also been buttressed by cited research. Finally, remaining in this economic strand of thought, in studying the economic value of various college majors, Carnevale, et al. (2015) concluded that the average college graduate earns around one million more dollars over the course of a lifetime than an individual that does not graduate college. This becomes very relevant to my later discussion outlining the college gatekeeping effects of mathematical study and how it acts as an insurmountable obstacle to many who pursue higher education.

Perhaps because of these previously mentioned benefits of mathematical study, in recent years a trend in education has been to focus on strengthening curricular offerings in what has been coined as STEM, or Science, Technology, Engineering and Mathematics. Atkinson and Mayo (2010) discuss the positive correlation between STEM study and a mindset of innovation. It has been argued (Feldman, et al., 2016) that the key to American economic prosperity in the global marketplace—despite having a tremendous population disadvantage when compared with China and India—is in this free American spirit to innovate and produce high quality products. To find a method of strengthening our ability to innovate would prove valuable in strengthening our ability to prosper as a people. With their work linking mathematical and innovative thinking, Feldman, et al. (2016) help to illuminate yet another compelling reason to reinforce why the study of mathematics in any education system is beneficial to the holistic good of a community.

Finally, in line with this link to innovation, researchers have pointed their efforts toward identifying a link between entrepreneurial characteristics and the newly defined Standards for the Mathematics Practice (Kerr, et al., 2018; Reynolds, et al., 2002; Kruse, et al., 2017). All of these researchers identified connections between entrepreneurial characteristics (strong teamwork mindsets, tolerance for risk taking, and higher levels of self-efficacy) and the eight standards of

mathematical practice (making sense of problems and persevering in solving them, reasoning abstractly and quantitatively, constructing viable arguments and critiquing the reasoning of others, modeling with mathematics, using appropriate tools strategically, attending to precision, looking for and making use of structure, and looking for and expressing regularity in repeated reasoning). These researchers help build my argument on a strong foundation that the study of mathematics brings more benefit to the learner than the narrow view of learning algorithms and mathematical formulae.

As presented in this subsection of work, the “why” behind a continued emphasis on mathematical education has been sturdily established both from an intrinsic and extrinsic motivation mindset. The study of math has clear links to brain development and strengthening, both individual and community economic prosperity, and higher levels of innovation and entrepreneurial prowess. Unfortunately, the justification for this need to study math in its current state has been constructed by and is primarily composed of the voice of the dominant white male culture, which has long held the privileged and dominant voice in the creation of our education system. This undoubtedly is a compelling reason why a perpetual achievement gap exists in the academic study of mathematics between White and Asian-American students and their Black and Brown peers.

A history of achievement gaps.

An unfortunate fact that has perpetuated for decades, if not centuries, in education is that students of color consistently score lower on various standardized tests and tests of intelligence and that they graduate at lower rates than students of European decent (Jencks & Philips, 2011). Sustained high mathematical achievement has proven an elusive target to reach over the past few decades for all students in America (CAASPP, 2019; Nation’s Report Card, 2018; OECD, 2018).

However, these problems tend to be the most persistent within low socioeconomic communities of color (Achievement Gap Initiative, 2019). Seeing as the American population is growing the most rapidly within the demographics that tend to achieve the lowest scores on these standardized assessments, real work must be done to address either the misalignment of these measurements that define academic success or the mechanisms necessary to help more students reach higher levels of achievement on these measurements. Critically analyzing and addressing the mechanisms of standardized testing that define academic achievement worldwide would be far beyond the scope of this project; therefore, I turn my attention toward working within the current measurements of success so that marginalized student can achieve more equitable outcomes on standardized assessments. Perhaps in later work, methods of reconstructing the inequitable system will be further pursued from other angles.

A possible area of inquiry as to why these gaps persist is in the phenomenon known as ability-based tracking. Particularly in the area of mathematics, this phenomenon persists and is unfortunately used to keep impoverished students and/or students of color disproportionately placed in lower levels of mathematics courses (Boaler, 2013; Dustmann, et al., 2017; Pekkala, et al., 2013; Wang, et al., 2013; Zevenbergen, 2003). For my purposes, I now discuss the systemic tracking mechanisms in place that tend to perpetuate what Anyon (1980) refers to as “the hidden curriculum of work.” As Anyon states, there is a tendency in our education system to unconsciously adjust our curricular offerings based on the community that a school serves. Unfortunately, this tailoring is in inverse relationship to what is necessary to open opportunities and disrupt cycles of poverty, which is what many disenfranchised communities need. Lower socio-economic communities tend to have more course offerings along the vocational education and lower cognitive rigor trajectory, while more affluent communities enjoy the wider range of

high rigor and enrichment offerings such as Advanced Placement and technology courses (Anyon, 1980). Impoverished communities composed primarily of people of color experience these same phenomena when it comes to ability-based tracking, specifically in mathematics class placement (Achievement Gap Initiative, 2019).

Ability-based tracking is the practice of placing students into varying levels of a curriculum based on previous standardized test achievement or on past course success, among other more subjective criteria (Betts, 2011). More impoverished students of color—who would benefit from belief in their ability to rise to a higher expectation of academic rigor—are more often tracked into remedial or slower paced academic courses, specifically in mathematics, than are students in more affluent white communities (Betts, 2011). Whether this practice is helpful or detrimental to the future academic success of students regarding mathematical achievement can be argued from many directions (Betts, 2011; Duflo, et al., 2011; Pekkala Kerr, et al., 2013). For example, positive impacts have been identified for high and low achieving students in all curricular areas with no impact for middling students (Duflo, et al., 2011). Also, high-achieving peer influence has been experimentally identified as being beneficial to previously low achieving, low-income students (Pekkala Kerr, et al., 2013). Perhaps the most interesting finding, and useful for my purposes, regarding ability-based tracking is the theory that teacher expectations are influenced by and positively correlate to the tracking level of their students (Betts, 2011). According to the research of Betts (2011), a potentially negative side effect of ability-based tracking is that teachers of students on the varying ability level tracks tend to harbor beliefs about the ability of those students that coincided with what level they were tracked into. Lower tracked students had teachers who held lower expectations for their ability to learn in that setting, while students tracked into the more rigorous courses enjoyed the benefit of

teachers who believed in their abilities and held them to a more rigorous standard (Betts, 2011). The troublesome aspect of this is in the self-fulfilling prophecy effect as developed in the work of Rosenthal and Jacobson (1968), which concludes that many of our neediest students experience lower levels of learning because of low teacher expectations.

Holding low expectations for students tracked into lower rigor classes contradicts volumes of research that illustrate and reinforce the importance of teachers maintaining high expectations for learning for students of all ability levels. A multitude of studies and reports have supported that belief in all students' ability to learn at high levels has a positive impact on learning; therefore, maintaining high expectations at all times for all learners is of critical importance (Bamburg, 1994; Dusek & Joseph, 1983; Harris & Rosenthal, 1985; Pigott & Cowen, 2000; Raudenbush, 1984; Rosenthal & Jacobson, 1968; Rubie-Davies, 2006; Rubie-Davies, et al., 2006; Rubie-Davies, 2014; Scott-Whelan & Teddlie, 1989; Smey-Richman, 1989; Smith, 1980; Sudkamp, et al., 2012; Waxmon & Padron, 1995). Exposing and addressing the inequitable practice of ability-based tracking may prove a promising mechanism for building a more equitable education system. These achievement gap phenomena unfortunately have real life consequences for those on the deficient side of the gap. As previously mentioned, the inability to find success in high level math classes leads to many later negative gatekeeping effects that impede these students' abilities to complete higher education.

Math as a gatekeeper course.

A virtual mountain of research has concluded that mathematics has historically served as an unofficial gatekeeper to higher education entrance and later completion (Atanda, 1999; Gaertner, et al., 2014; Martin, et al., 2011; Riley, 1997). Overall, a student's inability to be successful in higher math courses such as Algebra 2, Trigonometry, Calculus, etc., has been a

roadblock to that student's ability to matriculate to four-year university studies (Atanda, 1999; Riley, 1997). Further, Algebra 2, which is similar to Integrated Math 3 from the integrated mathematical strands as developed in our era of Common Core State Standards, has been identified as a powerful indicator of four-year university entrance and later success (Gaertner, et al., 2014). This conclusion also helps to reinforce the need to eliminate any ability-based tracking efforts in high school that would hinder a student from ever successfully completing Algebra 2 / Integrated Math 3.

Another pivotal relationship exists between high levels of math achievement and later higher education success, and therefore life success. Many researchers have studied the relationship between math achievement and the concept known as the "cooling out" phenomenon in education, or COPE. This "cooling out" period describes the period from when a student is accepted to and begins college, to when that student withdraws from their studies prematurely without earning their degree. Many researchers have determined that a substantial number of students who prematurely withdraw from undergraduate studies before they earn a degree do so because of a negative interaction with mathematics, in which failure was accepted as final and resilience was exhausted (Larnell, 2017; Martin, et al., 2011; Wang, et al., 2017; Xu & Dadgar, 2018). Because of previous math struggles, these students are forced into remedial math classes upon their entry to post-secondary studies that do not count toward their eventual graduation but do take a substantial amount of time and tuition money to complete. Working through these remedial classes leads to frustration, and the student eventually gives up on their dream of obtaining a college degree. Only three to four of every twenty students referred to remedial mathematics course enrollment at the community college level ever graduate college (Bailey, et al., 2010).

While successfully completing Algebra 2 / Integrated Math 3 and more advanced math classes have been found to be critically important to university entrance and success, opponents of these findings lean on the argument that students need not enter college for life success and therefore need not persist in higher mathematical achievement (Gaertner, et al., 2014). As stated previously, the rebuttal to this argument is that a college graduate will earn an average of one million more dollars over a lifetime than a high school graduate (Carnevale, et al., 2015). While money may not be the ultimate motivator to many students as they embark on their college or career pursuits, it is the ethical obligation of educational professionals to provide all students with all necessary information to make an informed decision on how to best proceed with their lives beyond high school. We must be the advocates that convey this information to students and faculty alike so that every decision regarding the pursuit of higher-level mathematics courses can be as informed as possible. Students deserve the opportunity to make an informed decision on whether to take higher level math classes of knowing their potential benefit to their future life success. To effectively inform and advocate for students, we must change the educator actions of maintaining low expectations through ability-based tracking practices. The work of many researchers reinforces the point that the first step to changing the actions of individuals is to change their thoughts or paradigms with which they view their world (Boaler, et al., 2000; Boaler, 2005; Boaler, 2013; Boaler, 2015; Boaler & Sengupta-Irving, 2016).

Math paradigms.

A buzz-phrase of contemporary education leadership theory is the phrase “growth mindset,” which is based on the work of Carol Dweck and her book *Mindset: The New Psychology of Success* (2006). Jo Boaler, a contemporary of Carol Dweck, has expended much effort to uncover the power of positive growth mindsets held specifically by mathematics

instructors in influencing and reinforcing positive academic outcomes for their students (Boaler, et al., 2000; Boaler, 2005; Boaler, 2013; Boaler, 2015; Boaler & Sengupta-Irving, 2016). In her book *Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages and Innovative Teaching*, Boaler extensively examines the many methods of establishing, nurturing, and strengthening a paradigm of high expectations for all learners of mathematics. Suffice to say that multitudes of psychological researchers tracing back to Bob Rosenthal and Lenore Jacobson's work out of Stanford (Rosenthal & Jacobson, 1968) have demonstrated the positive effects of believing in the high academic achievement capabilities of all students (Anderson, et al., 2018; Bamburg, 1994; Dusek & Joseph, 1983; Dweck, 2006; Eccles & Wigfield, 1985; Good & Brophy, 2003; Harris & Rosenthal, 1985; Jussim, et al., 1998; Pellegrini & Blatchford, 2000; Pigott & Cowen, 2000; Raudenbush, 1984; Rubie-Davies, 2006; Rubie-Davies, et al., 2006; Rubie-Davies, 2014; Scott-Whelan & Teddlie, 1989; Sudkamp, et al., 2012; Smey-Richman, 1989; Smith, 1980; Waxmon & Padron, 1995). To focus energy on how to best foster these beliefs and paradigms of high expectations within instructors of mathematics is of obvious value based on the conclusions of these researchers. Once these paradigms or beliefs can be disrupted and changed to a positive belief in the learning abilities of all students, then we can begin the task of disrupting and changing the actions we carry out in the mathematics learning environment.

Math practices.

Though the world has changed tremendously over the last century, the methods used to educate our population have not changed nearly as rapidly. Our world has shifted to a very fluid and ever-changing environment of constant, iterative adjustment of learning based on inquiry and adaptability with the help of technology. Unfortunately, the majority of math classrooms in

the American educational system remain stuck in the pedagogical practices of the early 20th century. Students attend most schools in boxed classrooms, sitting in desks arranged in rows, to take notes on algorithmic mathematical practices as dispensed by the all-knowing teacher (Boaler, 2015). This occurs while the same students leave the school building to learn other pursuits intrinsically interesting to them in a more naturally occurring manner through exploration of their surroundings. Most of this exploration admittedly comes in the form of virtual exploration with the use of electronic devices ushered in by the cell phone revolution. However, this inquiry, exploration, and play has been the primary method of learning for the human species for the vast majority of our existence before the advent of our current factory production-based model (Aldrich, 2010).

The era of the Common Core State Standards, CCSS, and the SMP's has ushered in a new attempt at shifting these archaic practices of what Freire (1970) would categorize as The Banking Model of Education to a more partnering approach of inquiry and autonomy-based learning (Swars & Chestnutt, 2016). In an attempt to systematize the Freirean (1970) Problem Posing model into a coherent framework, the CCSS and specifically SMP initiative have introduced a bridge between the growth paradigms mentioned previously and the necessary practices to regain a state of play and exploration in the mathematics classroom (Swars & Chestnutt, 2016). The eight SMP's in their final form are: 1. make sense of problems and persevere in solving them, 2. reason abstractly and quantitatively, 3. construct viable arguments and critique the reasoning of others, 4. model with mathematics, 5. use appropriate tools strategically, 6. attend to precision, 7. look for and make use of structure, and 8. look for and express regularity in repeated reasoning (Kruse, et al., 2017). Rather than rigidly prescribing what math concepts and topics to cover in the traditional model of curriculum mapping and

pacing guides, the SMP's focus more on general habits of mind using math topics as the backdrop for these efforts. Any person who has interacted with such a large conglomerate of human beings as the American education system is composed of can undoubtedly attest to the systemic inertia present in the beliefs and practices of these human beings. So, where does one begin when identifying what works best in changing the above-mentioned paradigms, beliefs, and archaic practices so that the negative gatekeeper effects of mathematical study that disproportionately oppress impoverished students of color can be placated? This is indeed the crux of the research questions I hope begin answering in this work.

Theory Relevant to Research Questions

Compare and contrast human learning theories.

To lay the theoretical foundation needed to answer the first two research questions, I now explore varying theories of human learning in order to tie the teacher and principal perceptions of effective professional development practices to previously established conclusions of empirical research. The two broad umbrellas of behaviorism (Boghossian, 2006; Ferreira, 2018; McCleod, 2003) and constructivism (Boghossian, 2006; Ferreira, 2018; Grennan Brooks & Brooks, 1999; Liu & Matthews, 2005; McCleod, 2003; Prakash, 2010; Vygotsky, 1980) provide the broad, over-arching learning theories. Out of these I now work to extract more nuanced elements of cognitivism (Ferreira, 2018; Huitt, 2009; McCleod, 2003), design-based research learning theory (Barab & Squire, 2004), humanism (Huitt, 2009), social learning theory (Bandura, 1977; Grusec, 1992), and cognitive learning theory (Sincero, 2011), of which the strands of social cognitive and cognitive behavioral theories derive to help in explaining the themes identified through my inquiry.

To give a thorough description of all research surrounding the various human learning

theories throughout the history of social science would require a length of discussion outside the scope of this project. Focusing on the foundational theories of human learning brings my discussion to behaviorism and constructivism. Using the work of Boghossian (2006), Ferreira (2018), and McCleod (2003) I now describe elements of behaviorism, and using the work of Boghossian (2006), Ferreira (2018), Grennan Brooks and Brooks (1999), Liu and Matthews (2005), McCleod (2003), Prakash (2010), and Vygotsky (1980) I describe elements of constructivism. Some of the fundamental elements that define the behaviorist approach according to Boghossian (2006), Ferreira (2018), and McCleod (2003) are that valid knowledge is publicly observable, a single reality that exists external to individual perspective, acquired from outside sources, and achieved when learners undergo conditioning while learning. Learning in this style consists of a heavily lecture based pedagogical approach. In essence this theory of learning consists of very external elements to the learner and espouses a reliance on conditioning the learner using inalienable, axiomatic truths, which the learner is not meant to question.

In a divergence from this extrinsic paradigm of learning, the work of psychologists such as Vygotsky (Rieber & Carton, 1987) and Bruner ushered in a fresh, intrinsic, perspective of human learning in which the learner is more involved in the creation of knowledge as opposed to being a passive recipient of conditioning (Ferreira, 2018). Ferreira (2018), Grennan Brooks and Brooks (1999), Liu and Matthews (2005), McCleod (2003) Prakash (2010), and Vygotsky (1980) define some fundamental elements of constructivist learning theory by the following traits: learning is constructed as opposed to found, learners construct their own knowledge, no one has an epistemically privileged viewpoint, there are multiple realities constructed by individuals, the human mind does not copy outside reality but instead constructs its own from within, and finally learning is characterized by a much more autonomy driven, partnering pedagogical approach in

line with the work of Adams (2006), Bandura (1977), Bandura (1991), Bandura (1999), Bandura (2001), Freire (1970), John-Steiner and Mahn (1996), Martin (2004), Schunk (1989), Schunk (2012), Schunk and DiBenedetto (2016), Watson (2001), Wood and Bandura (1989), and Zimmerman (1990). The essence of constructivist learning theory is that the learner is an autonomous agent in the learning process who creates new knowledge by interacting with present, external information.

Now that I have discussed the broader theories of behaviorism and constructivism, I transition to explore more detailed and nuanced theories of how humans learn. At about the time the computer began gaining prominence in the mid 1950's, the rise of a different strain of learning theories, in addition to the traditional behaviorist and constructivist paradigms, began to gain prominence among psychology scholars (Ferreira, 2018). The first of these offshoots that I discuss is the learning theory known as cognitivism. As stated by McLeod (2003) "A cognitivist views the learning process as an internal and active mental process, which develops within a learner, increased mental capacity and skills in order to learn better" (p. 38). Essentially, cognitivism theorizes that humans learn via stimuli that internally restructures existing knowledge and blends it with the new knowledge gained. In the cognitivist paradigm, learning occurs via the construction of a bridge between existing schema and the new learning objectives of any new knowledge to be gained. This description lends itself nicely to categorizing cognitivism as a subset of constructivist theory. What sets cognitivism apart as a more detailed description of how humans learn is the emphasis on cognitive schema and subtle interactions with outside stimuli (McLeod, 2003).

Next in the line of more nuanced theories of learning is a theory that spans the boundary from pure theory and pontification to a more practical, iterative, experimental approach to

obtaining knowledge. This theory is known as design-based research learning theory. Barab and Squire (2004) discuss three distinct identifying characteristics of design-based research theories. First, design-based research methods embrace the messiness of learning and use the context surrounding human learning as a critical source of inquiry rather than an extraneous byproduct (Barab & Squire, 2004). Next, Barab and Squire (2004) discuss the flexible nature of design-based research methods in which methods are revised, multiple dependent variables are present, and the social interactions within the learning environment are investigated. Finally, a critical characteristic of design-based research is that profiles and descriptive theories are developed to capture the design in practice as the learning is happening (Barab & Squire, 2004). Essentially, design-based research theory embraces the messiness of the learning process and works to dynamically and iteratively capture and explain the nuances of learning as they are happening.

Transitioning to my next learning theory takes me to the work of Maslow in the 1960's. This is the work that opened the dialogue around a more holistic theory of learning brought through his humanistic learning theory (Huitt, 2009). The first defining characteristic of humanism that separates it from previously mentioned theories is the assertion that humans operate with inherent values and guiding morals that are innate to each individual (Huitt, 2009). This deviates from all previously mentioned theories in that these values are innate and not a result of extrinsic conditioning or intrinsic knowledge creation. Huitt (2009) also discusses that the act of learning is a personal act meant to fulfill the full potential of the learner, and how it is necessary to investigate the learner as a whole, especially how they develop over the course of their lifespan. Critical elements of understanding humanistic learning theory are the focus on studying the self, goals, and motivations of the learner with the desired result of developing a self-actualized, autonomous learner (Huitt, 2009).

Next in my line of examined learning theories is Bandura's social learning theory (Bandura, 1977; Grusec, 1992). This theory of learning is widely known as the bridge between the behaviorist and constructivist theories of human learning (McCleod, 2016). This bridge is built through Bandura's (1977) discussion of the connectedness of observational learning and what he calls "mediational processes." In the spirit of behaviorism, the learner observes their environment and takes in extrinsic information, while in the spirit of constructivism, the learner bridges this external stimulus with the mediational process of thinking about how to respond to this stimulus in the creation of new knowledge. The four mediational processes that Bandura focuses on are attention, retention, reproduction, and motivation (McCleod, 2016). These four processes are used to describe the four phases of response to an observation by the learner who is deciding how to respond to what they have observed through their behavior. While Bandura's social learning theory has opened up the possibility of explaining more complex human behaviors, it is very limited in explaining the most complex of human behaviors, namely in the form of thoughts and feelings, or paradigms (McCleod, 2016). Because of this, Bandura (2001) amended this theory while renaming it, and dug even deeper in developing the next and final learning theory that I use to lay the theoretical foundation of how humans learn.

While social learning theory introduces the meta-cognitive processes associated with learning in the spirit of previously defined elements of behaviorism and constructivism, the next and final theory presented here focuses on the complex interplay of this cognition with behavioristic outside conditioners. This final strand of learning theory is Bandura's (2001) cognitive learning theory, of which social cognitive theory and behavioral cognitive theory are the two sub strands. The fundamental premise of cognitive learning theory rests on the seemingly over-simplified idea of using the brain to think and therefore learn. Similarly to humanism, social

cognitive theory emphasizes the interwoven nature of extrinsic, intrinsic, and environmental factors that impact learning (Bandura, 2001). Bandura also discusses the interplay of the three variables of behavioral, environmental, and personal factors in the learning process. In this theory, the optimal learning environment involves the learner displaying the proper behaviors, the environment being ripe for learning, and the learner having a personal mindset receptive to optimizing their learning. While social cognitive theory emphasizes the study of the social aspects of learning, behavioral cognitive theory emphasizes the behavioral traits associated with human learning. Beck (2019) discusses the cognitive triad of the self, the world / environment, and the future. Beck discusses the fact that learners tend to form self-concepts that affect their behaviors and consequently their levels of learning. This self-concept can easily be traced to the self-fulfilling prophecy (Rosenthal & Jacobson, 1968) and expectations work (Rubie-Davies, 2006; Rubie-Davies, et al., 2006; Rubie-Davies, 2014) previously mentioned in this work. As Beck (2019) discusses, the conditions for optimal learning are when the cognitive triad are in a positive state. What is becoming evident through my investigation to this point, within the science of human learning, is that many theories abound that repurpose similar ideas with different vocabulary. An acute example in this situation is that what Beck (2019) calls the cognitive triad as connected with self-concept, Carol Dweck (2006) calls growth mindset. Having laid the foundation of how human beings learn as theorized by iconic psychologists through the ages, I now turn my energy toward a more focused theory of specific elements of adult learning as subsets of the previously presented general human learning theories.

Adult learning theories.

While cognitive psychologists have focused on how human beings learn for over a hundred years, adult learning has only been a distinct area of psychological study since the

middle of the 20th century (Merriam, 2018). To frame my investigation of how adults learn best, I now use the work of Sharan B. Merriam (2018) to present the three foundational theories of adult learning, the social and political contexts in which adults learn, and cutting edge theories on holistic approaches to adult learning. I discuss elements of all of these areas now so that I can later link themes identified through my inquiry to these theories in my attempt to add to the literature of understanding how adults learn best, specifically for teachers of foundational mathematics.

I now begin my investigation of adult learning theories by focusing on what are consistently considered the three foundational theories of adult learning. Researcher Malcolm Knowles has been working at the tip of the spear of these theories from the beginning (1975; 1980; 1984). The three foundational areas of human learning according to Knowles, as presented in the work of Merriam (2018), are andragogy, self-directed learning, and transformational learning.

The foundational theory that Knowles refers to as andragogy can also be referred to simply as the art or science of teaching adults as defined by the Merriam Webster dictionary. In her work, Merriam (2018) identifies six identifying elements of andragogy specific to adult learners. These elements are that learners:

- move from a developmental stage of dependency on the teacher or facilitator as a child to a more independent, self-driven paradigm of learning as an adult.
- draw on an increasing amount of life experiences as they age to aid in learning.
- are ready to learn when their social or life roles change.
- are problem centered and want to apply new learning immediately.
- are motivated intrinsically to learn rather than by extrinsic rewards.

- need to know and agree with the reason for learning something new.

Using these 6 identifying elements of adult learning, the Teaching Excellence in Adult Literacy or TEAL Center outlines six implications for practice when planning and facilitating adult learning experiences (Staff, 2011). These six implications are:

- The facilitator should work to set a cooperative climate for learning.
- The facilitator should work to determine the learner's specific needs and interests.
- Learning objectives should be developed based on these identified needs, interests, and skill levels.
- Sequential activities should be designed around these needs, interests, and skill levels to best meet learning objectives.
- The facilitator should work collaboratively with adult learners when determining methods, materials, and resources used in meeting learning objectives.
- Finally, the facilitator of adult learning experiences should reflect on the quality of the learning taking place, adjust efforts as necessary, and redesign future learning experiences based on continued need or interest.

Along with this foundational theory of adult learning known as andragogy, Merriam (2018) next presents Knowles' (1975) second foundational theory of adult learning, which is the theory of self-directed learning or SDL. The TEAL Center staff define SDL as the "process in which individuals take the initiative, without the help of others in planning, carrying out, and evaluating their own learning experiences" (Staff, 2011, p. 1-2). Using this definition, the TEAL Center suggests the following nine implications for practice when facilitating adult learning. Facilitators should help the adult learner to:

- Conduct a self-assessment of skills and needs to determine learning objectives.

- Identify the entry point for a learning experience.
- Match appropriate resources and methods to the learning objective.
- Establish a learning plan in which goals, strategies, and evaluation criteria are delineated.
- Develop strategies for decision making and self-evaluation of learning effectiveness.
- Develop positive attitudes and independence regarding SDL.
- Reflect on what is learned.

The facilitators should:

- Encourage and support learners throughout the process and highlight areas of their growing thought processes and strategies along the learning journey.
- Offer multiple options as evidence of successful learning.

The final foundational theory of adult learning that I consider using the work of Mezirow (2000) via Merriam (2018) and the TEAL Center staff (2011) is the theory of transformational learning. The foundational theory of transformational learning introduces the concept, which is unpacked further later in this work, that adult learning is better explained using context rather than when broken down into isolated cognitive elements. Merriam (2018) explains that transformational learning in adults is learning that shifts the learner's mindset and worldview, otherwise known as perspective transformation, while accomplishing more focused, curricular goals such as reading and writing. Transformational learning theory focuses on the cognitive processes of meaning making (Merriam, 2018). Merriam frames her discussion of transformational learning theory using the following ten phases of meaning as defined in the work of Mezirow (2000):

- A disorienting dilemma is encountered.
- A self-examination with feelings of fear, anger, guilt, and shame is conducted.
- A critical assessment of assumptions is conducted.
- A recognition that one's discontent and the process of transformation are shared is present.
- An exploration of options for new roles, relationships, and actions is carried out.
- A course of action is planned.
- The knowledge and skills needed to implement this plan are acquired.
- New roles are provisionally tried.
- Competence and self-confidence in the newly acquired roles and relationships is built in the learner.
- A reintegration into one's life on the basis of conditions dictated by one's new perspective is completed.

Again, using these defining elements, the TEAL Center Staff (2011) suggest the following three implications for practice when facilitating adult learning experiences:

- Work to create a climate that promotes transformative learning by exhibiting the personal characteristics of trust, empathy, caring, and authenticity while providing timely feedback and employing activities that promote student-autonomy in a collaborative manner.
- Know your students and the types of learning activities that most appeal to their preferences and needs.
- Develop and implement learning activities that explore and expose differing points of view, even to the extent where the facilitator presents as an equal peer in

the activity.

I now transition from foundational theories of adult learning into what Merriam (2018) describes as the political and social contexts of adult learning. Merriam posits that studying the context of adult learning is as important as identifying the characteristics of and the necessary cognitive processes to ensure learning. She breaks her contextual discussion of adult learning theory into the two categories of critical social science perspectives and situated cognition / contextual learning theory (Merriam, 2018).

Beginning with the critical social science perspective of adult learning, Merriam states that the fundamental premise of this strand of theory examines who holds power and how the powerful shape society. She also presents the notion that the context where learning takes place matters and it is important to challenge the inequities present in the learning environment (Merriam, 2018). She develops her conversation of the critical social science perspective of adult learning around the seven learning tasks embedded in a critical theory of learning as first developed by Brookfield (2005). These seven learning tasks are as follows:

- Challenging ideology
- Contesting hegemony
- Unmasking power
- Overcoming alienation
- Learning liberation
- Reclaiming reason
- Practicing democracy

Beyond this discussion of the critical social science perspective of adult learning, Merriam (2018) next discusses what she describes as situated cognition or contextual learning

theory as a strand of her political and social contexts of adult learning. She states that adult learning is a function of the people involved in the learning activity, the tools employed in the learning environment, and the activities designed to reach the learning objectives. Merriam (2018) discusses that this strand of theory building is where the genesis of professional learning communities and what she calls “communities of practice” originated. Investigating the notion that humans learn in community is a fundamental tenet of situated cognition, otherwise known as contextual learning theory. While this strand does not come with a list of specific elements, the core premise of it is that the context in which adults learn is as worthy of inquiry as, if not more than, the separable elements of the characteristics and cognitive processes employed in adult learning.

The final strand of adult learning theory that I choose to investigate is the newest in the fledgling study of adult learning theories. Merriam (2018) calls this strand of theory “holistic approaches” to adult learning. In describing this strand of adult learning theory, Merriam (2018) delicately describes it as the strand of thought that deviates greatly from traditional western ideology that describes the act of learning and brain development as fundamentally separate from body processes. Under the holistic approach to adult learning, the synergistic interaction of emotions, spirit, and body, of which the mind is not disconnected, are under consideration when working to understand how adults learn (Merriam, 2018). She states that under this guise there exists an interconnected dependence and contribution of each in the process of learning that must be considered (Merriam, 2018). Similar to the critical social science perspective, there is not a clearly delineated list of elements that she presents. However, she does state that under the holistic approach, adult learning theory learning is communal, predominantly lifelong and informal, and holistic in nature by encompassing the above-mentioned aspects of humanness

(Merriam, 2018).

Selecting a methodology.

Now that I have presented elements of how humans—specifically adults—learn best, my next task is to determine how to best answer the research questions related to what led to the robust learning of the adult professionals in this study. The first decision that I made was whether to attack these questions from a quantitative or qualitative paradigm. The critical aspect that led to making this decision is the fact that the perception of participants is of the most critical interest to me in this work. Because of this, the decision was made to approach my inquiry through a qualitative lens. The next question that I addressed was which qualitative path to take in order best study and shed light on my research questions. To best answer this I used the work of Cresswell and Poth (2017) in their book *Qualitative Inquiry & Research Design: Choosing Among Five Approaches*. The five approaches that I considered were narrative inquiry, phenomenology, grounded theory, ethnography, and case study. In the following paragraphs I briefly describe the defining characteristics of each of these five and support the case for why I chose to use a narrative inquiry approach.

The first of the five qualitative approaches to inquiry that I focus on is grounded theory research. According to Cresswell and Poth (2017), the grounded theory approach to research focuses on an “action that has distinct steps or phases that occur over time” (p. 83). The aim of the researcher using this approach is to develop a theory as a result of the extensive work taken on using this method (Cresswell & Poth, 2017). In developing this theory, what Cresswell and Poth (2017) refer to as “memoing” takes on an added level of importance as a means for the researcher to refine their thoughts to formulate the process that is emerging. A hallmark of this approach is that the researcher collects data from a substantial number of participants, in the

range of 20 to 60, and iteratively analyzes it against previously collected data in developing the theory (Cresswell & Poth, 2017). Cresswell and Poth (2017) use the terms “move toward saturation” (p. 88) to describe the level of depth necessary for a substantive theory to emerge. Again, because of the extensive nature of the grounded theory approach to qualitative inquiry, and the large number of participants needed to sufficiently develop a theory, I chose not to adopt this method to answer my research questions.

Second of the five qualitative approaches is the approach of ethnographic research. According to Cresswell and Poth (2017) the fundamental interest of an ethnographer is to “describe and interpret the shared and learned patterns of values, behaviors, beliefs, and language of a culture-sharing group” (Cresswell & Poth, 2017, p. 90). The researcher using this approach uses existing theory to focus his or her efforts on finding the complex and complete description of the working patterns of a culture sharing group (Cresswell & Poth, 2017). These efforts require extensive fieldwork and observations of the patterns and ideational systems as they are carried out (Cresswell & Poth, 2017). Yet again, the limiter to this type of qualitative inquiry is the extensive nature of the fieldwork and the seminal point that to answer my research question requires me to study situation that has already passed. Because of these limiters, I did not use ethnographic research to answer my research questions.

With two approaches down, I come to methods three and four of the five that I choose to examine for the purposes of this work. Next in line to discuss is case study research. According to Cresswell and Poth (2017), what distinguishes case study research from the rest of the approaches herein examined is that “case study research involves the study of a case (or cases) within a real-life, contemporary context or setting” (p. 96). Further “Case study research is defined as a qualitative approach in which the investigator explores a real-life, contemporary

bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information” (Cresswell & Poth, 2017, p. 96). Cresswell and Poth (2017) also explain that case study researchers focus on in-progress, real-life cases in order to gather information in real time. Cresswell and Poth deem a case worthy of study if it falls into the parameters used to bound a system. Though this qualitative approach was under consideration using the multiple-case approach, ultimately the limiter again is that my research questions endeavor to explain and develop new knowledge from events that have already taken place.

Next, I lay out the defining characteristics, procedures, and challenges associated with conducting phenomenological research. I begin this by describing some of the essential elements that define phenomenological research. According to Cresswell and Poth (2017) the most effective of their five qualitative approaches to “describe the essence of a lived phenomenon” (p.67) is phenomenological research. Further, phenomenological research is best used to describe the “common meaning for several individuals,” (Cresswell & Poth, 2017, p. 75), while discerning what “all participants have in common,” (Cresswell & Poth, 2017, p. 75) in order to “reduce individual experiences with a phenomenon to a description of the universal essence” (Cresswell & Poth, 2017, p. 75). Cresswell and Poth (2017) also discuss that four philosophical perspectives are emphasized in phenomenology. These four perspectives are a return to the traditional tasks of philosophy, a philosophy without presuppositions, the intentionality of consciousness, and the refusal of the subject-object dichotomy (Cresswell & Poth, 2017, p. 75). Additional features of phenomenology include a focus on a single concept, heterogeneous groups ranging from three to four up to ten to fifteen under consideration, a focus on the subjective experiences of a phenomenon by individuals and objective experiences of something in common

with other people experiencing this phenomenon, a bracketing out of the research by the researcher, the use of interviews of individuals who have experienced the phenomenon to collect data, systematic data analysis procedures that move from narrow units of analysis to broader units and finally to detailed descriptions that summarize the “what” and “how” of participant experiences, and a descriptive passage incorporating this what and how into a synthesis that culminates in the essence of the phenomenon being studied (Cresswell & Poth, 2017, p. 75).

Cresswell and Poth (2017) next discuss two approaches to phenomenology in their discussion of hermeneutical and transcendental or psychological phenomenological research methods. Defining hermeneutical phenomenology involves what Cresswell and Poth describe as the “dynamic interplay among six research activities” (p. 77). These are loosely stated as turning toward a phenomenon which is 1. an abiding concern that 2. seriously interests the researcher, in which 3. essential themes are reflected on, so that 4. the nature of the lived experience can be determined in order to 5. Describe the phenomenon while 6. maintaining a strong yet balanced relation to the topic (Cresswell & Poth, 2017, p. 75). As Cresswell and Poth (2017) state: “transcendental or psychological phenomenology is focused less on the interpretations of the researcher and more on a description of the experiences of participants” (p. 78). This makes the bracketing out of the researcher of the utmost importance when conducting transcendental phenomenological research. Beyond this bracketing though, Cresswell and Poth (2017) describe that this strand of qualitative inquiry consists of identifying a phenomenon, bracketing out one’s experiences, and collecting data from several participants who have experienced the phenomenon being studied. Once this is complete, the researcher then completes a description of the what and how of the phenomenon (Cresswell & Poth, 2017, p. 75).

The final qualitative approach that I investigate is narrative research. The primary

purpose of narrative research is to tell the individual story of the subjects being studied. The stories that are collected tell of the individual experiences of participants in a specific place or situation and focus on descriptions of “physical, emotional, and social situations” (Cresswell & Poth, 2017, p. 69). Data can be gathered in the form of interviews, observations, documents, or pictures. Data can then be analyzed thematically, structurally, or dialogically, focusing on values, plot, significance, or character mapping and time (Cresswell & Poth, 2017). The stories that are written to describe these narratives contain turning points, specific tensions, or interruptions in which meaning is made “related to similarities, differences, change, or coherence” (Cresswell & Poth, 2017, p. 69). According to Cresswell and Poth (2017) this path of inquiry requires the researcher to select “one or more individuals who have stories or life experiences to tell and spend considerable time with them gathering their stories” (p. 71). The hope through my efforts was to identify themes among the responses that weave together a cohesive framework tied to the previously mentioned theories of learning with specifics of what is currently known to work in professional learning programs.

Current Empirical Literature Relevant to Research Questions

Self-determination and human motivation.

To explore the literature related to the variables within my research questions, I begin by studying what motivates human beings to want to learn and change their ways of thinking. Deci and Ryan (2008a) and Deci, et al. (2017) present the core tenets of what they call Self-Determination Theory, SDT, throughout their work on human motivation. The three core elements that define SDT are that humans are driven by and best motivated by the feelings of autonomy, competency, and relatedness (Deci & Ryan, 2008a; Deci & Ryan, 2008b; Deci, et al., 2017). Autonomy is feeling a sense of control over one’s own destiny, competency is feeling

valuable and productive in any given task, and relatedness to the surrounding community within which the task(s) are being completed. Deci and Ryan (2008a) discuss the presence and reinforcement of intrinsic versus extrinsic life goals as motivators for human behaviors and changes. In their work, they routinely find that humans are more powerfully motivated by intrinsic factors than by extrinsic reward systems (Deci & Ryan, 2008a; Deci, et al., 2017; Ryan & Deci, 2008). In their study titled *A Self Determination Approach to Psychotherapy: The Motivational Basis for Effective Change* (Ryan & Deci, 2008), the authors discuss characteristics of effective change promotion in individuals. They state the importance of awareness promotion, the importance of challenging introjects and external regulations, attention paid to need related goal contents, the basic needs of SDT as outlined above, and the need for a focus on process over outcome when promoting change in human beings (Ryan & Deci, 2008).

Building upon this work, researcher and author Daniel Pink dives deeper down the path of human motivation in his book *Drive* (Pink, 2011). He uses the work of many other researchers, including Deci and Ryan, to lay out what drives human behavior in detail. In this work, Pink similarly outlines three tenets of human motivation in the forms of autonomy, mastery, and purpose (Pink, 2011). He makes the argument that all humans are driven by needing a sense of autonomy or control over their existence in order to put forth their best effort when doing work (Pink, 2011). Similar to Deci and Ryan's notion of competency, Pink also talks about the needs that humans have to master a skill or set of skills in order to feel like they are making progress and getting better at something that matters (Pink, 2011). Finally, again similar to Deci and Ryan's relatedness, Pink talks about the human need for a purpose, or a yearning to do something in the service of a goal or cause larger than ourselves.

Transitioning from a focus on individual change motivation to organizational change

motivation, Deci, Olafsen, and Ryan (2017) repurpose the ideas of intrinsic versus extrinsic motivation into the concepts of autonomous versus controlled motivations within an organization. Through their work they have been able to show that “autonomous motivation but not controlled motivation of employees promotes both high quality performance and employee wellness” (Deci, Olafsen, et al., 2017, p. 38). They buttress this argument back to the fundamental tenets of SDT: that the concepts of autonomy, competency, and relatedness are the foundational human needs of employees within an organization that produce the highest quality performance (Deci, Olafsen, et al., 2017). This high-quality performance is measured in the form of profitability, while employees also maintain the highest levels of wellness (Deci, Olafsen, et al., 2017). Since this work has reinforced the benefit of autonomous motivation, the field of research into leadership characteristics that promote this environment has blossomed over the last few years (Deci, Olafsen, et al., 2017).

One of these specific leadership styles is transformational leadership, which is by definition tied to the ideas of human motivation. First coined by James Downtown (1973), transformational leaders work to change systems through the building of relationships and rapport with followers, so that they may inspire these followers to take up the cause of organizational change autonomously through their work (Spahr, 2015). According to Spahr, transformational leaders work to change the system, solve challenges by finding experiences that illustrate the ineffectiveness of old ways, work to know what has to change, and maximize their teams’ capacity and capabilities. These leaders promote the previously mentioned human needs for autonomy, competency/mastery, and relatedness/purpose by creating the conditions for risk taking among their followers where honest mistakes are embraced as a part of the innovation process (Spahr, 2015). According to Spahr, the benefits of this leadership style are that these

leaders are excellent at communicating new ideas, maintain a good balance between short term vision and long term goals, do well at building strong coalitions and instilling mutual trust, and have integrity and high emotional intelligence in the form of empathy for others. Spahr's drawbacks to transformational leadership are that transformational leaders are ineffective in initial stages or ad-hoc situations, require an existing structure that needs to be fixed, and do not work well in bureaucratic situations. The best fit for transformational leadership is in institutions that are outdated and require serious retooling (Spahr, 2015). The case can be made that the current state of the American public education system fits this description.

Critical pedagogy and professional development paradigms.

Using the foundational elements of human motivation and transformational leadership as the anchoring points in designing the most effective professional learning environment, I now narrow my focus to what works best in designing professional development programs. Using the lens of Freire (1970) and Bourdieu (1977) I first begin the conversation of what works in mathematical professional development programs by amplifying the voice of the teacher in the design and planning of said programs. In Bayar's 2014 work titled *The Components of Effective Professional Development Activities in terms of Teachers' Perspective*, six defining characteristics of effective professional development programs according to teachers are presented. These six defining characteristics are: 1.) the content presented is matched to teacher needs, 2.) this content is also matched to the needs of the school, 3.) teachers are involved in the design and planning of the professional development program, 4.) the pedagogy of the program allows for active participation of the teachers being trained, 5.) the program creates the conditions for long term engagement of the teachers, and 6.) the professional development program is facilitated by high quality instructors (Bayar, 2014). In this same vein, Chval, Abell,

Pareja, Musikul, and Ritzka (2008) present five defining characteristics of effective professional development in their work titled *Science and Mathematics Teachers' Experiences, Needs, and Expectations Regarding Professional Development*. The five defining characteristics are: 1.) 60 hours of professional development appears to be the hinge-point of effectiveness that must be reached to be the most effective, 2.) the program builds community with participants, 3.) the content is designed to build knowledge, 4.) the content is learner-centered, and 5.) the content is assessment-centered in that it assesses teachers' thinking and understanding (Chval, et al., 2008).

Coupled with this amplification of teacher voice in identifying best practices in designing and implementing professional development programs is the work of many researchers empirically identifying the necessary characteristics of these programs. Darling-Hammond, et al. (2017) creates and presents a seven-element framework of effective professional learning programs that is built into the framework of this study. She suggests that effective professional learning programs:

- Are Content Focused
- Incorporate Active Learning
- Support Collaboration
- Use Models of Effective Practice
- Provide Coaching and Expert Support
- Offer Feedback and Reflection
- Are of Sustained Duration

Further, Guskey (2014) presents the seemingly intuitive concept of working backward from desired student outcomes through five defining characteristics of the most effective professional development programs. Those five defining characteristics are:

- Determining what the desired student outcomes are.
- Determining what new teacher practices must be carried out to reach these outcomes.
- Identifying what organizational support is needed for teachers to learn and implement these practices.
- Defining what new knowledge and skills must teachers learn.
- Determining and designing the optimal professional learning activities needed for teachers to learn the required knowledge and skills.

Joining the work of Guskey (2014), is the work of Desimone, Porter, Garet, Yoon, and Birman (2002) in communicating another six defining characteristics of effective professional development programs. These six defining features are broken down into structural features and core features in which there are three of each defining characteristic (Desimone, et al., 2002).

The structural features include:

- reform type which the authors define as a longer-term type of professional development such as study groups, mentorships, committees, or task forces, as opposed to workshops, courses, or conferences.
- Duration of the professional development, in particular longer in terms of contact hours and span of time of the program as effective characteristics.
- Collective participation of teachers within a school, department, or grade level, as opposed to many different teachers from many different schools.

The core characteristics of effective professional development are described as:

- Active learning, in which teacher participants are given opportunities to actively engage in the analysis of teaching and learning.

- Coherence in the program in that the experiences incorporated are consistent with teachers' goals, as well as state standards and assessments, and that the experiences encourage professional collaboration and communication among teachers.
- Content-focused in that it focuses on deepening the content knowledge of the participating teachers in mathematics.

Drilling down even more specifically for the purposes of my study, I have identified two studies that identify nine math professional development best practices specific to the Common Core State Standards in Mathematics (Marrongelle, et al., 2013; Sztajn, et al., 2012). These nine best practices specific to teaching mathematics in the era of Common Core State Standards have been presented earlier in this work. The hope through this study is to identify themes in the responses from participants in the California Elementary Mathematics and Science Professional Learning Initiative professional development program that may or may not align to these nine recommendations, the seven elements of Darling-Hammond, et al.'s best professional development practices for teachers, and the defining characteristics of Critical Determination (Aronowitz, 2015; Freire, 1970; Giroux, 2010; Deci, et al., 2017; Pink, 2011; Ryan & Deci, 2017).

Focusing in even further for the purposes of my study, I now present the work of multiple researchers who undertook narrative studies to identify professional development best practices specific to mathematics. Metz and Simmitt (2015) and Preciado Babb, Metz, and Marcotte (2013) have blazed the trail that I now traverse because their studies most closely align with the goals and methods that I look to undertake. The work of Metz and Simmitt (2015) first helps to lay the foundation of how to listen to the experience of mathematics teachers as they reflect on

their interaction with mathematics while making sense of what is effective in their craft of teaching the content. They develop the method that they call the empathic second-person research perspective as a means of effectively capturing the experience while amplifying the voice of the math teacher participants in their research project (Metz & Simmitt, 2015). These authors use previously laid research methods to frame their capturing of the awareness, description, and experience of these math teachers in describing their initial doubt and then eventual certainty when teaching mathematics within the framework of the CCSS (Metz & Simmitt, 2015). These methods closely mirror the intent of this study and their spirit is carried on in this work.

Preciado Babb, Metz, and Marcotte (2013) present a study that is even more closely aligned with the intent of this work. In their work, they study the perspectives of teachers who participated in a three-year professional development program known as the Galileo Education Network Association, GENA, and look to glean what these teachers thought were the most effective practices (Preciado Babb, et al., 2013). The researchers for this work took a narrative approach in interviewing teacher participants in pairs, transcribing the interviews, using Nvivo software to identify themes, and identifying the two themes that drove the results of the GENA professional development program (Preciado Babb, et al., 2013). While the results of this study are intriguing in their own right, the strength of this study for my purposes is in the methods undertaken to achieve the authors' conclusions. Their methods of studying the perspectives of teacher participants in a three-year long professional development program for teaching mathematics, then identifying themes with which to make informed conclusions, very specifically mirrors my intentions on a much larger scale for this work.

Summary

Providing a thorough review of the literature for my purposes in this work has involved laying out a historical background, an analysis of some of the theories relevant to the research questions, and an analysis of some of the current empirical research related to my research questions. The historical background provided a discussion of the purpose of studying math, the historical achievement gaps present in mathematics, the gatekeeping effect of mathematics on higher education attainment, math paradigms present in teachers of mathematics and current math practices that teachers of mathematics carry out in their lessons. Exploring theories relevant to my research questions involved unearthing and discussing various theories of critical pedagogy, self-determination, human learning, elements of these learning theories specific to the learning of adults, and a comparison of various qualitative methodologies to lay out and reinforce the case for using narrative inquiry. Finally, the exploration of current empirical literature relevant to this study involved the analysis of current theories of human motivation to make changes and follow leadership, along with the most up to date paradigms of effective professional development. This study of effective professional development paradigms highlighted the power of teacher voice when designing and implementing various professional development programs. This discussion also presented previous work very specific to professional development for the purposes of teaching in an era of Common Core State Standards for mathematics, while also touching on the methods necessary to capture the power of teacher voice through a narrative inquiry study. Next, I will conduct a thorough discussion and analysis of these methods that are utilized in this study in order to capture a deeper and more thorough description of teacher perspective on what are the most effective practices for professionally developing math teachers in an era of CCSS

Chapter 3: Methodology

Introduction

Thus far, I have put together a significant case expressing the need to improve mathematics professional development (CAASPP, 2019). I have conducted a thorough literature review to lay the foundational elements of Critical Pedagogy (Aronowitz, 2015; Freire, 1970; 2018; Giroux, 2010), synthesized with Self-Determination Theory (Deci, et al., 2017; Pink 2009; Ryan & Deci, 2017) to create Critical Determination. The next step is to develop the argument of which methods most efficiently lead to learning what is needed to improve these professional development practices. What follows in this work is the unpacking of the argument that to take a narrative inquiry approach in the spirit of Clandinin (2016), Conle (2000), (2001), (2006), (2010), Connelly and Clandinin (1990), and Cresswell and Poth (2017) is the most effective means of accomplishing the goals of this work. This work endeavors to dialogue with CEMSPLI participants in a critically partnering fashion as the critical pedagogists would describe (Aronowitz, 2015; Freire, 1970; 2018; Giroux, 2010). This empowering dialogue is not only conducted through the lens of Self-Determination as defined by the three elements of autonomy, competency, and relatedness (Deci, et al., 2017; Pink 2009; Ryan & Deci, 2017) but also combines with specific elements of this theory in the interview data that were present within the successful CEMSPLI program.

Research Design

Cresswell and Poth (2017) state that the questions in any realm of study are what should determine the methods of inquiry in answering those questions. The questions guiding this dissertation lend themselves to an exploration of the lived experiences of teachers and principals as related to the CEMSPLI professional development program, so that we may better understand

how and why this program proved so effective, according to those closest to the learning. Of specific interest are the paradigms and pedagogical practices that shifted as a result of participation in this program that led to their marginalized students (Given, 2008) experiencing a greater degree of success than similar students from schools and districts representing similar student populations. After exploring this question through the lens of Critical Determination as created from Critical Pedagogy (Aronowitz, 2015; Freire, 1970; 2018; Giroux, 2010) and Self-Determination Theory (Deci, et al., 2017; Pink 2009; Ryan & Deci, 2017), the anticipated power of the story (Bruner, 2008) that the participants tell and the resultant framework of suggestions for professional development design are what may improve upon current efforts in mathematics professional development programs.

Cresswell and Poth (2017) state that narrative inquiry “as a method, begins with the experiences as expressed in lived and told stories of individuals” (p.67). The design of this study is based on the desire to capture these lived experiences thoroughly, with accuracy and fidelity, so as to give voice to the practitioners who work closest to the program being studied. These stories are captured by dialogically interviewing the study participants in the manner that is more thoroughly explained below. Once these interviews were completed, the data was analyzed through the lens of Critical Determination to identify the resultant themes that led to the a success that this community enjoyed in mathematics. These themes were then coupled with the elements of effective professional development as described in the work of Darling-Hammond, et al. (2017) and Sztajn, et al. (2012) to construct a framework of tangible professional development elements that produced real results in this real community.

Narrative Inquiry

History and Philosophy of Narrative Inquiry

As Cresswell and Poth (2017) state, narrative research “continues to be a popular field in the making” (p. 68), and its origins can be traced to “literature, history, anthropology, sociology, sociolinguistics, and education” (p.68). Clandinin (2016) gives this definition to describe muddled defining elements of narrative inquiry:

...narrative inquiry is a way of understanding and inquiring into experience. It is nothing more and nothing less. Narrative inquiry is situated in relationships and in community, and it attends to notions of expertise and knowing in relational and participatory ways (p.13).

Clandinin (2016) also gives a bit of a genesis story of narrative inquiry as she traces her work with Connelly to seven years before their first article, where they use the expression narrative inquiry in 1990 (Clandinin & Connelly, 1990). She states that during her doctoral work, Connelly advised her to read the book *After Virtue* by Alasdair MacIntyre (1981), focusing on the chapter regarding narrative unity and “to say more about how you see knowledge as embodied, embedded in a culture, and based on narrative unity” (Clandinin, 2016, p. 10). What she says, in quoting MacIntyre (1981) that solidifies my reasoning for the choices of critical pedagogy, self-determination, and narrative inquiry to drive this study is “it is because we all live out narratives in our lives and because we understand our own lives in terms of the narratives that the form of narrative is appropriate for understanding the actions of others. Stories are lived before they are told” (p. 197). Though I am a mathematician by undergraduate training, and have spent half a life using math and the resultant numbers to tell stories, a quantitative approach to answering my research questions felt superficial at best when compared to the power that strong, personal stories from those that lived this CEMSPLI experience can convey. Change to an archaic system is the ultimate goal guiding every decision in this project. Since stories provide

the most powerfully promising path to change, stories were captured, analyzed, and communicated with the intent to most effectively change this system.

Types of Narrative Inquiry

Cresswell and Poth (2017) narrow down the strands of narrative inquiry to two generally agreed upon paths of travel. One path leads to the exploration of which methods are used to analyze the data gleaned from narrative inquiry, whereas the other path leads down the path of considering the types of narratives that are used to explain the experience in question. They state that the decision on which path to take relies on the researcher determining the “nature of the experiences, the story-generating process, and the audience for the narrative.” (Cresswell & Poth, 2017, p. 69). The example that the authors use to frame this point is using time as a limiter. They state that if what is being studied spans a substantial length of time, then a “life history” (Cresswell & Poth, 2017, p. 69) may be most effective, although a thematic approach may also be used, but may be better served when exploring similar experiences among different participants.

Due to the nature and design of this project, my choice is to take on the thematic approach to analyze and convey the themes extracted using a storytelling approach, due to the power of storytelling in human learning. Using Freire’s (1970) dialogical approach to meaning making and theming along with the Cresswell and Poth (2017) analytical approach that emphasizes creating a narrative that is “composed interactively between researchers and participants” (p. 70), this dissertation sheds light on the power of the CEMSPLI program by describing what participants thought were the most critically effective elements of it. As elaborated upon further later in this work, once themes were created, they were taken back to

participants to determine if my interpretation matched the participants' perspective as the person most closely linked to the professional development program.

Sampling and Data Collection

Purposive sampling, as defined by Cresswell and Poth (2017), was used in identifying and interviewing study participants. As Padilla-Diaz (2015) states: "Purposive sampling is characterized by the incorporation of specific criteria met by the participants at the moment of selection" (p. 104). The specific criteria met for my purposes is that all participants experienced first-hand participation in the CEMSPLI professional development program either as a site principal or participating teacher. As Conle (2010) states: "data sources are temporal sets of events and situations that are either directly experienced or emerge from memory" (p. 155). These descriptions of the temporal events and situations that Conle (2010) describes were obtained by conducting extensive interviews. These interviews were open and semi-structured; I asked probing questions that got participants to open up and expound upon their experience with the CEMSPLI program. The interview protocol instrument outlining the exact open-ended questions is attached below.

The initial, semi-structured, open interviews were scheduled with each of the three teacher and three principal participants in 45-minute blocks at the convenience of the participants. These interviews took place at the participants' schools in a room that was private and uninterrupted for the 45-minute block of time that was needed to conduct the necessary deep conversation. Using the attached interview protocol, participants were asked open-ended questions regarding their experience with the CEMSPLI program and their responses were recorded using a dedicated digital audio recorder. After completing this first round of interviews and transcription, the preliminary codes and themes were brought to the study participants in a

second round of 20-30-minute interviews to check for accuracy and any needed clarification to their responses. A final interview, originally was planned in case the second round of interviews yielded the need for continued clean-up, was deemed unnecessary as all participants were satisfied with the representation of their responses.

Setting

Interviews took place in the participants' classrooms, the school library, or the principal's office. This decision was made through the same lens of decision making as the rest of this work: by considering the best setting in which the participant felt the most comfortable and empowered to express their story with respect to the CEMSPLI program.

Participants

Purposive sampling as outlined by Conle (2010), Cresswell and Poth (2017), and Padilla-Diaz (2015) was used to select six total participants from the CEMSPLI professional development program. The fact that the CEMSPLI program was specific to an individual suburban Southern California school district narrowed down the focus of the study to this district and the educators that participated in the grant. Cresswell and Poth (2017) discuss that "Narrative research is best for capturing the detailed stories of life experiences of a single individual or the lives of a small number of individuals" (p. 71). I decided that six participants was an appropriate amount because I identified three teachers and three principals of the nearly thirty total participants in the program that were available and willing to participate in interviews for this study. These participants represent elementary educators from a wide cross section of ethnicities and ages, with two male and four female participants representing the sample. The average number of years in education was twenty, with the most seasoned veteran having served for 24 years while the newest to the profession had served eight.

Positionality

I, as the primary investigator, have no professional or personal ties to the district in which the participants are employed and participated in the CEMSPLI program. There is no hierarchical relationship or any sort of disproportionate power dynamic to be considered regarding this work, as there is no pre-existing relationship of any sort with any of the participants. I am a White, Christian, middle-aged, able-bodied straight male. I am the father of two adult daughters. I have been married for 21 years, and employed in the same public-school district in Southern California for 23 years. I have worked as a custodian, teacher, athletic coach, athletic director, math coach, and administrator throughout my career in education. My challenge was to remain objective and open to the necessary dialogue to extract the lived experience of the participants without biasing any of my questioning or data analysis with my positionality. The plan through this work is to gain a clearer understanding of what works best in mathematical teachers' professional development so that I may use this in the future, possibly as a site level principal and adjunct professor for teacher and administrator preparation to best serve the needs of my community.

Gate Keeper

The liaison between myself and the research participants for this project was a district level administrator with the title of Director of Accountability and Measurements. The participating principals also served as gatekeepers to accessing the teachers that were employed at their school site. All participants completed a consent to participate form obtained from the University of Redlands that outlines the salient facts regarding their participation. Participants were given general information regarding the study, how long their participation would take, what would happen if they participated in the study, the methods of recording their responses,

how their privacy would be protected, what would happen if they experienced any problems or discomfort before or after their participation, and where to direct any questions or concerns they may have regarding the study. A copy of this consent to participate form is attached in Figure 9 below. All participants were over the age of 18, so no special circumstances or child consent to participate forms were needed.

Protection of Participants

Using purposive sampling (Conle, 2010; Cresswell & Poth, 2017, Padilla-Diaz, 2015) means that the participants in this study were recruited because of a specific characteristic, which in this case was that they participated in the CEMSPLI mathematics professional development program. Because of this easily identifiable characteristic, extensive efforts were taken to protect the identity of these teachers and principals. Participants were recruited with a specific recruitment letter (attached below). This letter helped me to recruit only voluntary participants. All documentation of responses to interview questions was protected by storage on a password protected recording device and computer, and pseudonyms are used in written descriptions of study findings. In addition to the protection of individual identities, I chose to use generic labels to describe not only the district where participants work, but also the specific schools within this district.

Potential Risks of the Study

As is the case with any interaction between human beings, there is the potential for psychosocial harm based on the resiliency levels of those interacting. For the purposes of this project, this risk appears minimal because participants were frontloaded with the intricacies of the study when asked for their interest in participation, and the topic of inquiry seems benign as far as discussing any traumatic personal experiences. Economic harm may be present to

participants if their confidentiality is breached and any sensitive information that is divulged regarding their superiors makes it to those in control of their avenue of professional advancement. As previously stated, precautions were taken to protect the identity of participants in this study. The recording device used for interviews was a dedicated digital audio recorder that remains locked in a desk drawer in my home office, the electronic files used to upload to the transcription website were stored on the hard drive of a password protected computer, the transcribed text files were stored on the same password protected computer, any names used in the write-up are pseudonyms, and all raw data files will be destroyed by myself upon this project's acceptable completion.

Instrumentation

Using the lenses of Critical Pedagogy (Aronowitz, 2015; Freire, 1970; 2018; Giroux, 2010), Self-Determination Theory (Deci, et al., 2017; Pink 2009; Ryan & Deci, 2017), and a narrative inquiry method (Clandinin, 2016; Conle, 2000, 2001, 2006, 2010; Connelly & Clandinin, 1990; Cresswell & Poth, 2017) of answering my research questions led to a very open interview protocol. The purpose of conducting narrative inquiry is to understand the lived experiences of humans who have first-hand experience with a particular area of interest (Clandinin, 2016; Conle, 2000, 2001, 2006, 2010; Connelly & Clandinin, 1990; Cresswell & Poth, 2017). The area of interest that I chose to focus on was the shared experience that three teachers and three principals have in participating in the CEMSPLI professional development program. Cresswell and Poth (2017) emphasize the importance of keeping the questions open ended and general so that the experience can be described and thoroughly explained from the perspective of the participant. From this, the ultimate goal is to understand the common experiences of participants and best explain the program from their perspective so that the

resultant dialogue can help to co-construct a description of the critical elements of the CEMSPLI program that led to the success of their students as Clandinin (2016), Conle (2000, 2001, 2006, 2010), Connelly and Clandinin (1990), and Cresswell and Poth (2017) describe.

Data Analysis

Once all first-round interviews were completed, the resultant recordings were transcribed and then thematically analyzed to identify themes from the data. These themes, as analyzed using the theoretical construct of Critical Determination, helped to build a framework describing the nature of the participant experience with the CEMSPLI program. Once these themes were taken back to participants and further clarity was solicited, it was unnecessary to conduct a second analysis, as all participants were satisfied with the portrayal of their voice in the first interview. Once the initial framework of identified themes was constructed, I conducted a preliminary synthesis and attachment to previously established elements of adult learning and professional development theories through the constructed lens of Critical Determination. This synthesis yielded a specific list of identified elements present within the CEMSPLI program, which were linked to previously constructed adult learning and professional development literature that helped create a framework of recommendations for designing early mathematics education professional learning programs.

Summary

Working within the constructed lens of Critical Determination (Aronowitz, 2015; Deci, et al., 2017; Freire, 1970; 2018; Giroux, 2010; Pink 2009; Ryan & Deci, 2017), a narrative inquiry approach (Clandinin, 2016; Conle, 2000, 2001, 2006, 2010; Connelly & Clandinin, 1990; Cresswell & Poth, 2017) was taken to thoroughly explore answers to the below research questions. Through this exploration, I found promising answers to the question of what worked

to create the conditions of academic success in mathematics as displayed on CAASSP (2019) test results for this marginalized community. The voices of teacher and principal participants in the CEMSPLI professional development program were recognized, amplified, and employed in the construction of a coherent framework of what may work in similar settings for marginalized communities to create more equitable outcomes for all students.

Research Questions

To address these previously outlined problems in foundational mathematics instruction, three research questions guided this project. Those three questions are:

1. What professional learning practices do participating teachers and principals in the California Elementary Mathematics and Science Professional Learning Initiative Grant perceive led to disproportionately high math achievement in a community of impoverished and disenfranchised students?
2. What themes emerge when listening to teacher and principal voices related to shifts in teacher paradigms and/or teacher practices?
3. What recommendations can be made for mathematical professional learning programs to improve future mathematics professional learning offerings?

Chapter 4: Data Analysis and Findings

Purpose

The purpose of this study was to shed light on how and why the CEMSPLI math professional learning program was able to achieve positive results in math achievement in the community under consideration, as learned from the professionals who were closest to the learning. As stated previously, the ten participating schools achieved a boost in CAASPP (2019) math assessment scores in the years directly following teacher and principal participation in this program. Setting aside the debate on the over-reliance of the current American educational system on standardized testing and accountability, the fact is that students learned more math as a result of their teachers' and principals' participation in the CEMSPLI program. The grant leaders studied what was done in the form of class walkthroughs that tracked examples of pedagogical practices tied to the eight standards for mathematical practice, as explained more thoroughly in the work of Kruse, Schlosser, and Bostic (2017). However, the voice of the participants had never been captured to understand how and why this program was so successful for this community as told by those that participated. This work set out to address this gap in knowledge using the three research questions that concluded Chapter 3 to guide the pursuit of answers that would lead to a better understanding of how and why the CEMSPLI program was able to work so well by capturing the experience of participants. The intention was to glean suggestions that could be scaled to other, similar communities in an attempt to work toward a more just and equitable educational system in mathematics instruction and possibly other content areas after further, future study.

Narratives

Teacher Participant 1

Teacher Participant 1 was the first to respond to my recruitment efforts. This person was very helpful and exuberant to participate in this project right from the beginning of the process, as evidenced by their quick response to all emails establishing the interview appointment. When I arrived for our first meeting, there was a very warm and helpful aura present in their classroom. Once the interview started, from the very beginning, statements like “I hope I am helpful to you” and “Hopefully, that is what you’re looking for,” demonstrated that there was a dose of humility and perhaps self-doubt on the part of this teacher. This person demonstrated that while they have been teaching for a while, their confidence in teaching math was newfound because of “the UCLA professors,” as they put it. This teacher also stated that their early experience with math was a struggle. They said that they remembered being taken out of the regular classroom setting for additional help in math. They also discussed their parents being both very good at math, but not too patient when helping with homework. As the interview progressed, this person began to warm up and spoke fondly of their experience with the CEMSPLI program.

The value of this person’s response in our conversation was in their insight as to what was transformative to their beliefs and subsequent practices as a result of participation with this program. They plainly stated that they had little to no confidence in teaching math before their participation with this program, but as a result of these two years, they now felt empowered. Below, I will lay out the specifics of what all participants provided in the way of themes through various figures. This first participant was a heavy contributor to every theme that was developed in creating these. Their most profound impact on this work overall was in their statements that helped build the theme of self-efficacy. A powerful example of this came in the statement: “It made me like know that I actually have more of a mathematical type of thinking than I originally thought I did.” Throughout the conversation with this person, this concept of efficacy being built

through the development of mathematical understanding kept ringing through. How this mathematical prowess was developed came in the form of some of the other themes that emerged.

This teacher stated how valuable the accountability of having to report out after taking “homework” assignments back to their class was. All CEMSPLI participants would learn various pedagogical methods and would then be assigned to take them and try them in class. At the next CEMSPLI class, all participants would be asked to report out on how the methods worked in class. These methods that were taught in class helped to build the themes of modeling and inquiry techniques. The professors would model the types of open-ended questions that they believed would help to unlock the learning of math at deeper levels. This teacher stated that many of the participants that grew up learning math twenty to thirty years ago struggled with this approach and would impatiently ask the professors to just give them the steps needed to reach an answer. This was indeed the point of the modeling and different pedagogical techniques of these open-ended questions. The creation of the conditions for students to inquire and productively struggle, according to the participant, were indeed powerful in shifting this participants’ paradigms and consequent pedagogical practices in teaching math.

To round out the conversation, this participant reinforced that their transformation would not have been possible without being able to lean on other participants in the program. They reinforced the powerful sense of belonging that was created through the shared struggle of learning these heady math concepts and new questioning strategies. This sense of belonging and teamwork was created by the participants both during professional learning classes and outside of the normal sessions. Participants would reach out to each other and work on homework assignments outside of the classes; they truly formed a bond in pulling each other through the

challenging program. This participant forged a bond with the other participant from their school site to the point that both still collaborate, although the other participant now teaches a grade level outside the focus of the CEMSPLI program. In fact, this first teacher participant used this established relationship to get me in contact with this other teacher to become my second teacher participant.

Teacher Participant 2

This second teacher participant was interviewed directly after the first participant on the same day, at the same school site. Similar to the first participant, this participant was very excited and eager to help with this project. This person was much newer to the profession of teaching and possessed a deeper level of confidence in math before and after the CEMSPLI program. Early in the conversation, the teacher stated that the CEMSPLI program "... was just more of just verifying that what my thoughts were are correct." They stated this in the context of discussing that they were more recently removed from credentialing classes and had learned some of these strategies as a part of their teacher preparation courses. While this teacher was very confident with math in general and did state that they were a good math student when coming up through the educational system, they did make contradictory statements to the effect that they were challenged to learn math in a different way. Similar to the first teacher participant, this teacher also commented that they would struggle with the open-ended nature of the higher-level math problems. They would sometimes just want the professors to give the steps to the solution as well.

This teacher also added to the creation of all of themes that are thoroughly unpacked below in the themes section. Their most important insight into this work came in reinforcing the accountability mentioned above while also shedding light on the fact that they were challenged

to constantly use a more conceptual approach with higher cognitive rigor in their math lessons. This teacher did come to the program with confidence from their math upbringing, but perhaps the paradigmatic and consequent pedagogical shift in this person came from this more conceptual approach. Though this statement is rather long, it sheds light on a shift in this teacher's approach to math: "So those are like what we've really been doing and I think that just being able to have the students explain their reasoning and their thinking and actually with my first graders right before we came, I was really trying to have them put it into words today so they were: "It's just that I know that, $5 + 3$ is 8," ok but how? So, like really getting them to figure out 'oh you mean like I put the 5 in my head and then I counted on?' So, they're really having that deeper understanding of math and so I feel like that really encourages me to make sure I'm always doing that and not just doing it once in a while." From this comment, it became clear that this teacher was reflective and found the importance of the need to develop a deeper understanding through inquiry techniques that became new tools in their repertoire.

This participant emphasized encouragement and productive struggle in the statement: "I always encourage my students even when they're not like getting something." Digging deeper as to whether this was a result of CEMSPLI or whether just something this teacher did, they eluded again to the fact that they learned this in their teacher preparation program, but that CEMSPLI reinforced and reminded. This resulted in a more consistent paradigm of encouragement through productive struggle for this participant through their efforts in CEMPSLI. This participant also stated that CEMSPLI participants would encourage each other to productively struggle through the difficult concepts that were presented in their professional learning environment.

This teacher also reinforced the sense of belonging that was established with all participants by discussing how close participants became during the process. They stated that

they would push each other and help other teachers on campus who weren't CEMSPLI participants. When they were notified of the positive results that CEMSPLI schools experienced after the conclusion of the program, they were quick to point out that these results were a team effort among all teachers on campus. Upon pushing a little more on this subject, this participant pointed out that many casual conversations through many spontaneous interactions among teachers on that campus led to the dissemination of the CEMSPLI program's learning material. According to this participant, this dissemination undoubtedly led to shifts in the mindsets and practices of other teachers that did not participate in the CEMSPLI program. This theme of participants autonomously bonding together with other teachers through this program resonated through the responses of all participants, whether teacher or principal.

Teacher Participant 3

The third teacher participant in this study was perhaps the strongest teacher in terms of math confidence, professional presence, and quality of thoughtful responses to the inquiry that I presented. Though this person entered the program very confident in their mathematical teaching abilities, there were still opportunities for paradigm and pedagogical shifts through CEMSPLI, as made evident in our conversation. This participant helped to build all themes discussed later in this work through their very thorough responses. However, this participant's most substantial contribution to the cause was bringing to light the themes of accountability, humble reflection, and cognitive rigor.

This participant has been teaching for more than twenty years and stated that math was their favorite subject growing up. This helped this teacher feel very confident coming into the CEMSPLI program. However, this teacher did discuss the power of the accountability in the program in pushing them to an even higher level of expertise. The first theme that emerged when

talking with this person was that the accountability was a huge push for them to stretch their thinking. They said that it had been so long since they had taken quizzes and tests and really been held accountable for learning something new. They said that some of the content that was quizzed and tested on was pedagogical techniques that led to the creation of the humble reflection and inquiry techniques theme.

This participant stated that though they were very confident in math, they had to humbly reflect on the way they learned math as a child and rethink their approach based on what they were learning in CEMSPLI. They said that they really had to think and push themselves to be clear in explaining their solutions to the various math topics that were covered. This person's challenge was not in the cognitive rigor of the difficult math problems, because the concepts were mastered easily. The challenge came in this person being able to thoroughly yet simply explain the steps that they took to solve the difficult math problems. They stated that they were constantly pushed by the professors to explain every step that they took. This person would become frustrated in this phase, because they thought many of the steps to be intuitive, but the facilitators wanted them more thoroughly explained. A comment that illustrates this is in their response: "...they really were very specific of letting us know that it's not just churning out that answer, it's the whole thinking about it. How are you problem solving? What are you looking at? And then in turn, what are you making your students look at because of how you say things?" This person exuded the confidence that many high achieving math students do in their attitude of: "I just know how to do it and can't explain why." They were pushed by the professor's modeling of the inquiry techniques on the difficult math concepts that were learned in the evening classes and were challenged to use these same inquiry techniques with their elementary-aged students.

As with all participants thus far, this teacher helped to create the theme of autonomous sense of belonging. This person helped to reinforce the concept that the ten schools where participants teach did not experience their positive math achievement solely because of the efforts of the CEMSPLI participants. This person talked about their interactions in the staff room with other teachers on that campus; this person stated that they began developing a reputation as the “math guru” in the staff room. They would talk about different instructional strategies and their colleagues would kind of roll their eyes and say “Oh, (Participant’s Name) and their math.” This person also expressed that many of the participants remained in contact with each other through various district trainings, social interactions such as group text messages, and occasional lunch outings. They did this despite the fact that the CEMSPLI program had formally concluded in December of 2017. This reinforced the special bond that all participants forged through their shared experience with CEMSPLI.

Principal Participant 1

All principals were rather difficult to recruit for this study. There wasn’t any formal resistance to recruitment efforts; rather principals just wouldn’t respond to any form of communication. It took repeated attempts, through email, phone messages, and teacher word of mouth over multiple weeks to get the three participants to respond. This first participant was secured through my communication with their secretary at the school I visited for the first two teacher participants. This coupled with these teacher participants reminding their principal to participate led to a return call from their secretary to secure the appointment. When interviewing this principal, I worked hard to keep the conversation flowing and information coming because there was a sense that this person wanted to get the interview over with so they could continue to carry out their day. This person has worked in education for over twenty years, of which fifteen

of those have been in education. This experience and background as a successful reading specialist underlaid an aura of professionalism and confidence verging on arrogance in their expertise as an educator in mathematics. They expressed that they enjoyed math up until secondary school and felt that the era of Common Core State Standards ushered in new techniques and mindsets that they easily adjusted to because of this reading background. It was difficult to ascertain if there was a shift in paradigms and pedagogical mastery in this participant because of their exuding that they already knew everything that CEMSPLI had to offer.

Similar to all teacher participants, this person aided in the creation of all themes, but they emphasized specific themes more than others. This principal zeroed in on and reinforced the themes of accountability and purpose, cognitive rigor, and inquiry techniques more than the rest. Accountability and purpose were definitely the strongest themes that this participant contributed to this study. They seemed to revel in the fact that teacher walkthroughs were a substantial element of the program over the two years that it ran. They commented: "...once the workshops stopped and once ... like I remember people were coming in to observe and everything. Once that stopped, at least with one of the teachers here, because there's two, at least with one of the teachers here, she stopped all the other stuff. So once there was not somebody that was coming in to monitor, somebody to come to observe, it reverted back to, this is what we're doing." This comment illustrates how important this participant felt the accountability piece was.

Beyond accountability and purpose, this participant helped in telling the story of how their belief in the need for cognitively rigorous math learning experiences was reinforced by the program. I say reinforced as opposed to transformed because, again, this participant made it clear that their paradigms and pedagogical practices were not really transformed as a result of this program. They stated clearly that they already possessed the knowledge and skills that CEMSPLI

was intended to pass on and that what was presented merely reinforced what they already knew and did in their professional duties. They did, however, discuss that they were implementing some of the elements of CEMSPLI with regard to cognitive rigor, but without giving specific credit to CEMSPLI. They stated that areas of instructional emphasis on their campus through the Professional Learning Community (PLC) process in math were an exploration of the bigger picture, such as answering questions multiple ways and the use of manipulatives. These aspects of our conversation not only helped build the theme of cognitive rigor as a transformational element of CEMSPLI but also helped build the theme of inquiry techniques.

This principal minimally contributed to the theme of autonomous sense of belonging but did shed light on the closeness of the two teacher participants from their school site. They stated that the two of them became closer through their experience with this program and were influential with the rest of the teachers on campus. Again, some of the administrative mindset of holding subordinates accountable rang through in comments like: “The only other thing I remember my teachers saying is they were so strict about the classes they had to take. And so if there was say an event at their school and they were going to be late or whatever, it was like they were chastised like they were in elementary school and, you're late for school and you need to be here at this time. You can't go to your school and thing, because you need to be here. The teachers would cover for each other and send the message through their colleagues not in the program that the people were expecting this commitment.” This last sentence of the quote does illustrate some of the camaraderie that was being cultivated among teacher participants and other non-participating teachers on their campus.

Principal Participant 2

The second principal participant has been in education for twenty-three years with various responsibilities during that time. They enjoyed math as a student up until high school and then enjoyed and excelled at it again in college. Like all participants, this person helped in the creation of all themes, but this principal was the most helpful and insightful of all of the principal participants. The conversation with this person was easy to maintain and the responses were insightful, helping to give a deep understanding of the CEMSPLI experience from the principal perspective. The most important thematic contributions that this participant provided to this work were in the themes of autonomous sense of belonging, cognitive rigor, and self-efficacy, while contributing to all other themes.

The most powerful theme that our conversation resulted in was the theme of self-efficacy. This theme permeated the conversations with all participants, but with this participant the responses given really demonstrated the ability of the CEMSPLI program to transform the confidence and resultant efficacy of teachers, in the opinion of this principal. This person seemed very genuine and open to what the program offered and was complimentary to the resultant transformation in their statement: “It definitely sounded like they bonded over the time that they all spent with each other over the course of the program.” Though this was not the most resounding praise for the program, it did demonstrate that this principal believed a transformation took place within their teachers. The conversation also took on a tone of gratitude for the work put in by all stakeholders that took part in this program, demonstrating the spirit of teamwork and shared purpose. Also, related to this theme of self-efficacy, this participant alluded to the themes of accountability and purpose, encouragement and productive struggle, and inquiry techniques in discussing how the participants would push themselves and each other not only to understand the difficult math concepts but to also embrace the different pedagogical techniques.

Cognitive rigor was the second most powerful theme that came through during the middle of our conversation. Many times, the discussion went down the path of this principal appreciating the deeper, conceptual approach to math instruction that the CEMSPLI program championed. This participant noticed the deeper dive into the building of the math concepts through applications and questioning as opposed to just the memorization of formulas and algorithms. The following statement helps to reinforce this point: “I’m not sure if the CEMSPLI program can take all of the credit for this shift, but ever since common core has come on the scene, there has been a shift toward a more comprehensive method of math instruction. There is a deeper emphasis on understanding the underlying concepts instead of just answering the “what” of the questions.” There was also a sense of relief in this principal that teachers were obtaining a deeper understanding of math so that they could have more pedagogical and assessment techniques than just developing the skills of rote memorization and assessing the demonstration of facts on worksheets.

Like all other participants, this principal saw the power of the sense of belonging that was developed within participants when left to their own autonomous means. They discussed their observation that participants would bond and push each other to trudge through the difficult times in a shared manner. This principal even discussed a bit of this theme through the lens of leadership. Though, the other principal participants for this work did not mention a bond to each of the other two principal participants, this principal did discuss connecting with some of the other principal participants in the program. The conversation shed light that these principals would discuss what they were learning and pick each other’s brains on what was working and what wasn’t.

Principal Participant 3

The final principal participant was the final participant interview. This principal has worked in education for twenty years, of which the last five have been in administration. This person's experience with math as a student can best be described as vanilla, run of the mill, nothing extraordinary either positive or negative. In their words: "As a student, I remember just basically following the curriculum. I could actually predict what was going to be taught the next day because I would just turn the chapter or turn the page, and I'd see the next lesson." The most powerful themes that this participant helped craft were autonomous sense of belonging and cognitive rigor, among their contributions to all other themes.

The unique information that this participant provided was in their description that the principal participants were responsible for presenting to the district leadership team what specifically was being learned in the CEMSPLI program. These presentations were also aligned with the planning of professional learning efforts taken on by the instructional coaching staff in this district. This information demonstrated that the CEMSPLI program had the fundamental elements of teamwork built into the design by compelling administrative participants to work with non-participants in spreading these valuable learnings to the rest of the district. This participant seemed enthusiastic and thankful for the opportunity to connect with other district leaders and alluded to the fact that this was a paradigmatic shift from the disjointed professional learning efforts of the district's past.

The most profound pedagogical shift that this participant underwent from where they entered the program was in the theme of cognitive rigor. As stated above, this participant had an ordinary math experience coming through their educational experience as a child. As a result of the CEMSPLI program, this principal stated that they encourage their teachers to: "...always bring real world experiences at the end of a unit or a chapter so they have that application piece."

They reinforced that when they were in school, they remember teachers skipping these more challenging math concepts and specifically skipping many of the measurement problems in the curriculum. This participant also demonstrated a greater sense of math confidence and self-efficacy as a math educator upon completion of the CEMSPLI program specifically because of the debriefing conversations that would take place after completing walkthroughs. They stated that the discussions with this dissertation's chair and the professional development specialist who helped write the CEMSPLI grant helped develop their thoughts on what high-level math instruction should look like.

All participants in this study brought their own unique perspective to the conversations that were conducted in order to better understand why the CEMSPLI program was so effective in improving the math achievement scores in their schools. I have made my best attempt at capturing their stories in the above narratives. In following up with all participants to analyze the original interview transcripts, all participants were satisfied with the capturing of the conversations. My contribution to the work is in my best description of the unspoken communication and overall atmosphere of the environment that we shared in discussing what they experienced. What follows is a deeper dive into the specifics of what crafted the emergent themes, followed by implications for practice. In other words, I will attempt to answer why anyone would want to read this work and what the can world gain from its efforts.

Data Analysis

Process

1. All interviews were conducted on the school site where the participants were currently employed. They were conducted in participant classrooms, the library, or

- the principals' office. These interviews were guided by the interview protocol contained herein and recorded with a dedicated recording device.
2. The digital audio files were then transferred to a secure password protected computer then uploaded to the transcription service rev.com to be transcribed and converted to text files.
 3. Once these text files were returned, I copied and pasted the text files into the digital interview protocol file and aligned responses to corresponding questions within these files. Each of these files were titled T1, T2, T3, P1, P2, P3 according to which participant the data originated from. Again, these files were stored on the same password protected computer.
 4. These text files were then read through sentence by sentence and paraphrased using the comments feature of Microsoft Word during the first round of analysis in what Cresswell and Poth (2017) define as "restorying" (p. 72).
 5. A second round of analysis was then conducted where all paraphrased codes from the first round were analyzed and distilled to as few words as possible to explain the essence of the thought expressed by each participant.
 6. Finally, a third round of analysis was done in which each of these minimal word descriptions was analyzed to identify what one to two words could describe the essence of the response. These one-word descriptions were finally whittled down and categorized into the eight identified themes that are outlined and discussed below.
 7. All of this was done through the mindset and analytical lens of Critical Determination as defined throughout this work along with the help of the best practices of Darling-

- Hammond, et al. (2017) and Sztajn, et al. (2012) to provide the theoretical anchoring point to tether these themes to.
8. Once themes were discovered and solidified, the tables below were crafted to succinctly place these themes with examples of raw data and examples of first pass analysis paraphrases. The themes were then connected to the elements of Critical Determination and the professional development best practices of Darling-Hammond, et al. (2017) and Sztajn, et al. (2012).
 9. Once all of this data was examined and conclusions were reached involving the eight emergent themes, a thematic narrative was crafted to tell the story of the CEMSPLI participants in the below findings section of this work.

Findings

The first two themes began emerging immediately upon paraphrasing the responses sentence by sentence. The themes that began to jump out immediately were the themes of challenge and accountability—specifically the challenge that the program brought to all of the participants and the accountability that the program held each participant to. Responses such as: “...it was very challenging for me,” and “sometimes I had to ask a lot of questions,” suggested that the CEMSPLI program had some rigorous content. During this phase, it was also becoming evident that not only was the math content rigorous and challenging, but the professors were also pushing the metacognitive envelope with participants by constantly asking the participants how and why they achieved the various math calculations. This helped to solidify my decision to name this theme “cognitive rigor.” Another trend that emerged from the analysis was the importance of the questioning techniques that participants were saying they were not only enduring from the professors, but also expected to use with the students in their elementary

classrooms. Hence I fleshed out the theme which I first called “questioning methods” and then “pedagogical mastery” before I settled on “inquiry techniques.”

As the analysis continued, the next theme that began to emerge was that of accountability. Participants began to tell this story in responses such as: “we did not want to come back to class without anything to share and be called out,” and “so we’re all having to participate somehow, some way in every class.” My life experience as an educator of nearly 24 years gnawed at me to ask the questions of: how? and why? In my experience, educators—or people in general for that matter—tend to not be so open to challenges and accountability so easily, so I wanted to understand why these participants were willing to endure the challenges and accountability that they were describing.

This questioning and underlying knowledge that the literature base of Critical Determination provided helped the most important foundational themes to emerge from the data. Fundamental tenets of Self-Determination Theory (Deci, et al., 2017; Pink, 2011; Ryan & Deci, 2017) from which half of Critical Determination is derived, posit that people are willing to challenge themselves and make themselves vulnerable if they feel they have control over their destiny and are a part of something bigger than themselves. This was demonstrated in the data in responses such as: “It was a good experience where we all supported each other and did not want to let each other down,” and “we would help each other a lot and work really hard to do the math ourselves before reaching out to the professors.” This constant theme of togetherness by choice is what helped to solidify the thoughts that helped the theme of autonomy / team false dichotomy emerge. The reason for choosing this distinction was that according to the data, the team element was crucial to the success of this program, and the team element was not contrived. Participants were able to autonomously choose to coalesce into these collaborative support teams which

derived their power from their autonomous creation. Within these teams, all participants were afforded the opportunity to reflect upon the changes to their paradigms and pedagogy that would be necessary to reach the learning goals of the CEMSPLI program. The responses such as: “It’s not just cut and dry one way or another. So just being open-minded to stuff. Being very open-minded...to change,” began to paint the picture of the change process in participants. This change came from their humble reflection on their current reality and the gap between where they were and where they wanted to be as math instructors.

Woven throughout the responses were myriad examples of the next two themes: “modeling and encouragement” and “productive struggle.” The facilitators of the CEMSPLI learning sessions were constantly modeling the inquiry techniques, cognitively rigorous activities, and overall learning environment that were expected outcomes of the program. With this constant modeling came the pervasive examples of encouragement of all involved through the inevitable feelings of productive struggle that accompany deep levels of learning. Encouragement was such an abundant code in the responses that in the below framework in Chapter 5, the reader can see how the suggestion for future professional learning programs is that encouragement and productive struggle are woven throughout all facets of the learning environment.

Central and perhaps the most important is the theme of self-efficacy, which seemed the most powerfully transformational for the participants as per their responses. Such simple yet elegantly effective responses as: “I feel better about how I do in math now because of it (CEMSPLI),” and “my confidence in math was kind of spiked,” paint the picture of the power of developing the confidence in these teachers that they could and would be successful in teaching math. As demonstrated through the literature review of this work, the research is abundant in

demonstrating the power of belief and self-efficacy in achieving learning outcomes. Belief and self-efficacy on the part of the instructor and the student of which CEMSPLI participants occupied both roles.

Themes and Categories

What follows below are graphical representations of excerpts of analyzed data, displaying how the raw data of responses funneled into the paraphrase phase of the first round of coding and how these connected to the literature of Aronowitz (2015), Freire (1970), Giroux (2010), Deci, et al. (2017), Pink (2011), Ryan and Deci (2017), Darling-Hammond, et al. (2017) and Sztajn, et al. (2012). These scholars represent the theoretical underpinnings and consequent mindset framing of Critical Determination in the analysis phase of this work. A stated goal of this work was to identify elements of the CEMSPLI program that would attach to these previously established theories found in literature while maintaining an open and critical mind to emergent themes. The results of this work appear to iterate toward a delicate balance of attaching to existing literature while at the same time deviating enough so that new knowledge is developed. The constructed themes stand separate but also similar to the scholars upon whose theories they build.

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Accountability and Purpose	<ul style="list-style-type: none"> • Dialogue • Problem Posing • Purpose • Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>6 – 8:</u> Feedback and Reflection Continually Assess and Reflect (Darling Hammond et al., 2017) (Sztajn et al., 2012)	• Homework Assignments	“Oh yeah, we actually had to bring stuff back to our class and like get data for that and bring it back to our class that we were in.”
			• Class Walkthroughs	“Oh yeah they would walk around in our classrooms.”
			• Active Participation	“So we’re all having to participate somehow, some way in every class.”
			• Report Out or be Called Out	“Oh, and also I feel like having to go to class and try things then bring back how it went was very useful. We did not want to come back to class without anything to share and be called out.”
			• Discomfort to be Called Out	“Like it made me sometimes feel uncomfortable because you’d just get called out, you had to do your part.”
			• Active Involvement and Student Experimentation	“I felt like we all had to be very involved and participate as much as we could to the full extent in the course as well as having our students try the different strategies or problems we had.”
			• Had to be Assessed	“I mean, it was the hardest part, because it’s like it’s been so long since I’ve had to take quizzes and do tests and things.”

Figure 9. Theme 1: Accountability and Purpose – Teacher Perspective

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Autonomous Sense of Belonging	<ul style="list-style-type: none"> • Dialogue • Humanization • Liberation • Problem Posing • Autonomy • Purpose • Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>2, 3 – 3:</u> Active Learning Strategies Collaboration Accounts for Existing Knowledge (Darling Hammond et al., 2017) (Sztajn et al., 2012)	• Working with each other and being open to divergent point of view.	“Working with groups more. Working with each other and also solving it in different ways. Like learning from another person’s strategy, like what did they do.”
			• Shared strategies and philosophies with non-participants.	“We shared information with colleagues on our site. We did share what works and what their philosophies were.”
			• Collaboration as adult learner and collaboration within their classroom.	“Collaboration, and not just complete silence all the time while they’re working... We did that so that’s what we got used to and we came back to our classroom we kind of mimicked that.”
			• Leaned on each other to get through the content before asking professors.	“We would help each other a lot and work really hard to do the math ourselves before reaching out to the professors.”
			• Listen to each other and hear each other out.	“And listen to each other. Like if somebody disagreed on something, like just like we teach our kids strategies for disagreeing like we still listened to what they had to say and even if you didn’t do it that way and something else worked for you it’s still important to hear other people out.”
			• Supported each other and held each other accountable.	“It was a very good experience where we all supported each other and we did not want to let each other down.”
			• Spent additional time together and interact regarding math instruction.	“Right, little by little, it does. I mean, especially the fourth and fifth grade team here, for the most part is, I mean, we have lunch together. We’re eating, we’re talking, and so we’ll bring up things there and talk about things there. Even with my colleagues at this grade level, I’ll say: Oh, this is really cool. Remember how we used to teach this?”

Figure 10. Theme 2: Autonomous Sense of Belonging – Teacher Perspective

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Cognitive Rigor	<ul style="list-style-type: none"> Conscientização Dialogue Praxis Problem Posing Autonomy Competence Mastery <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>1 and 5:</u>	<ul style="list-style-type: none"> UCLA helped participant learn math at a deeper level. 	"I only gained my deeper understanding of math, which is not even that deep because I'm an adult learning it, so I did that once I took these courses through UCLA."
		Content Focused	<ul style="list-style-type: none"> The 3 courses were very rigorous. 	"I personally took all 3 of the courses that they offered to us for the program and it was very challenging for me."
		Engagement with CCSS SMP's and Content Standards	<ul style="list-style-type: none"> The UCLA courses helped improve instructional efforts. The content was rigorous enough where support was needed. 	"Those UCLA courses helped me so much and enlightened me like, wow I can't believe that people didn't teach this way when I was a kid."
		Coaching and Expert Facilitation / Support	<ul style="list-style-type: none"> The material was much more rigorous than 3rd grade math. The why is more important than the what. This was high level math that was difficult but worth it. 	"So, the activities that they would sometimes give us were a little too over a third graders head, but I took the one's that I felt would apply to a third grader and I use them in my class now."
		(Darling Hammond et al., 2017) (Sztajn et al., 2012)		"Sometimes I had to ask a lot of questions because it was very challenging for me."

Figure 11. Theme 3: Cognitive Rigor – Teacher Perspective

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Cognitive Rigor	<ul style="list-style-type: none"> Conscientização Dialogue Praxis Problem Posing Autonomy Competence Mastery <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>1 – 1 and 5 – 5:</u>	<ul style="list-style-type: none"> The classes were challenging. 	"The classes were pretty challenging even though I was more recent out of college."
		Content Focused	<ul style="list-style-type: none"> Math was viewed at a deeper level and this was applied in class. 	"But I love the program because of the way it helped me look at math differently, just for me, myself. And I'm thinking: Wow, okay. So if I can emphasize some of those things when I'm teaching."
		Engagement with CCSS SMP's and Content Standards	<ul style="list-style-type: none"> The deeper number sense is more important than memorization. Communicating reasoning and thinking was difficult. 	"And it's like they need that deeper understanding. I can understand why like when they're older you would want them to have it like this (snap snap) but we also want them to understand and have that number sense that comes with it because that's what's been missing when they come to us."
		Coaching and Expert Facilitation / Support	<ul style="list-style-type: none"> Explaining was a challenge. Thinking and metacognition were very important. All the rigorous content was studied. 	"Which is the part I still struggled with. In the parts where I had to really explain my thinking, it's like I can't explain my thinking because it just happens."
		(Darling Hammond et al., 2017) (Sztajn et al., 2012)		"Trying to explain how I got there because of some conceptual thing, that was the most difficult part."

Figure 12. Theme 3: Cognitive Rigor 2 – Teacher Perspective

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Encouragement and Productive Struggle	<ul style="list-style-type: none"> Dialogue Humanization Liberation Problem Posing Autonomy Competence Mastery Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>5 – 5:</u></p> <p>Coaching and Expert Facilitation</p> <p>Expert Support</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> Encouragement that learning comes from mistakes. 	“Yeah, I just reiterate to my students all the time that you know, you learn by making mistakes and mistakes are a part of the process and I try to do a lot of hands on activities because when I was in elementary school, I remember it was none of that.”
			<ul style="list-style-type: none"> This program made participants uncomfortable but in a good way. 	“So it was just constantly putting us in that thing of being just uncomfortable enough with what we knew or thought we knew to kind of go: Oh, okay. Oh, all right, that makes sense.”
			<ul style="list-style-type: none"> Students are encouraged to explore and inquire. 	“I make sure as a teacher that I give them opportunities to kind of like make sense of numbers not just that this is the number and I need to memorize it and blah, blah, blah.”
			<ul style="list-style-type: none"> Encouraging that learning takes time. 	“So we’re on the same page here, we’re getting some of the concepts.” It hasn’t been a really quick process. It’s not like all of a sudden, boom, everything turned over overnight. I think it’s going to take some time.”
			<ul style="list-style-type: none"> Students are encouraged to persevere. 	“I’m always a big, like I always encourage my students even when they’re not like getting something.”
			<ul style="list-style-type: none"> Students are encouraged that math is not mysterious. 	“And so I try to kind of see where those are lacking, or try to at least open it up and say, “Okay, it’s not as mysterious as you think.”
			<ul style="list-style-type: none"> Emphasize improvement. 	“Like it’s ok, you just want to be able to you know get better.”

Figure 13. Theme 4: Encouragement and Productive Struggle – Teacher Perspective

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Humble Reflection	<ul style="list-style-type: none"> Dialogue Humanization Liberation Problem Posing Autonomy <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>6 – 8:</u></p> <p>Feedback and Reflection</p> <p>Continually Assess and Reflect</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> Being open-minded to change. 	“It’s not just cut and dry one way or another. So just being open minded to stuff. Being very open minded to stuff to change.”
			<ul style="list-style-type: none"> Abandoning existing paradigms. 	“You know? Because I didn’t learn math the way that we were being taught and it made so much more sense.”
			<ul style="list-style-type: none"> Older teachers being willing to change styles. 	“Especially for teachers like myself who had been teaching for a while come to that point even and I had a certain way I did things always. I mean I still do things a certain way but then I tweak them a little bit to meet the needs of my students more in this generation of kids.”
			<ul style="list-style-type: none"> Epiphany that they didn’t know everything. 	“I mean, so we went over topic, we went over concepts. I mean, yeah, we knew this. And so going into it, we were like, Well, when are you going to teach us? We know math. We know math. But what we knew is, we knew the algorithms and the formulas and things.”
			<ul style="list-style-type: none"> All from the same district to change thinking and teaching methods. 	“I feel like it was the whole group talking with each other and I think because we’re all in the same district coming from the same spot and knowing that we’re here to kind of change, possibly change our way of thinking or teaching.”
			<ul style="list-style-type: none"> Paradigms were examined. 	“We couldn’t answer it because that’s not what we were taught.”
			<ul style="list-style-type: none"> Reflecting on the math and sorting out thoughts. 	“And so we’re always constantly reflecting on what we saw, taking notes.”

Figure 14. Theme 5: Humble Reflection – Teacher Perspective

Teacher Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Inquiry Techniques	<ul style="list-style-type: none"> Dialogue Praxis Problem Posing Autonomy Competence Mastery <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>6 – 8 and 5 – 5:</u>	<ul style="list-style-type: none"> Pedagogy shift to using manipulatives. 	"Like on their desks you can even see, we're doing fractions and they have little pizzas that they're cutting out."
		Feedback and Reflection	<ul style="list-style-type: none"> Questioning why instead of what. 	"I think that we focused a lot on asking why we got what we got instead of just being asked what answers were."
		Continually Assess and Reflect	<ul style="list-style-type: none"> Creating the conditions to reflect. 	"I make sure as a teacher that I give them opportunities to kind of like make sense of numbers not just that this is the number and I need to memorize it and blah, blah, blah."
		Coaching and Expert Facilitation	<ul style="list-style-type: none"> How you deliver phrases and ask questions matters. 	"That your language matters, how you talk about things. You can't take things lightly."
		Expert Support	<ul style="list-style-type: none"> Mastering Questioning Techniques. 	"Like why is it like that, explain it, tell me more, you know and that kind of thing, where I didn't do that always."
		(Darling Hammond et al., 2017)	<ul style="list-style-type: none"> Precision of language. 	"It's just down to like even how you say things and the language that you're using, how precise it is."
		(Sztajn et al., 2012)	<ul style="list-style-type: none"> Probing questioning techniques. 	"Right like how did you get that? You didn't just know it. You did something in there. What did you do? Like verbalize it. Then it helps with their vocabulary too."

Figure 15. Theme 6: Inquiry Techniques – Teacher Perspective

Teacher Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Modeling	<ul style="list-style-type: none"> Dialogue Praxis Problem Posing Competence Mastery Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>4 – 2:</u>	<ul style="list-style-type: none"> Modeling 	"So, they modeled for us how to teach the class and we did the same thing."
		Models and Modeling	<ul style="list-style-type: none"> Professors modeled how to question. 	"The professors modeled how to constantly question our assumptions and rarely ever just gave us answers to whatever we would struggle with."
		PD Shows Examples of What CCSS Look Like	<ul style="list-style-type: none"> Reminder from professor to explain because that's what students will need. 	"I skip over steps in my head, but they were like: We need you to bring it out because this is what you're going to have to do with your students."
		(Darling Hammond et al., 2017)	<ul style="list-style-type: none"> Professor modeling how to question. 	"Some of the concepts, even when they asked us, Well, what does that mean? What do you mean, what does it mean? That's the answer. You know?"
		(Sztajn et al., 2012)	<ul style="list-style-type: none"> The professors were sadistic manipulators? 	"Over there they would ask a question and she would just sit like this, and not prompt us anymore. And then, so we're going, "Okay, well that seemed like a simple question. Well, maybe now not a simple question, because why am I thinking of an answer but she seems to be waiting for something else?"
			<ul style="list-style-type: none"> Professor modeling how to question again. 	"How are you problem solving? What are you looking at? And then in turn, what are you making your students look at because of how you say things."
			<ul style="list-style-type: none"> Professor modeling questioning techniques. 	"And each time they're always asking us: So, how do you think that would impact your students?"

Figure 16. Theme 7: Modeling – Teacher Perspective

Teacher Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Self-Efficacy	<ul style="list-style-type: none"> Conscientização Dialogue Humanization Liberation Praxis Problem Posing Autonomy Competence Mastery Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>2, 3 – 3:</u></p> <p>Active Learning Strategies</p> <p>Collaboration</p> <p>Accounts for Existing Knowledge</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> Created a self confidence. 	<p>"It made me like know that I actually have more of a mathematical type of thinking than I originally thought I did."</p>
			<ul style="list-style-type: none"> Reinforcing and affirming current beliefs. 	<p>"And then for me, I personally it was just more of just verifying that what my thoughts were are correct."</p>
			<ul style="list-style-type: none"> Built confidence. 	<p>"So like my confidence in math was kind of spiked."</p>
			<ul style="list-style-type: none"> Learning new methods opened up understanding and made math fun. 	<p>"We're looking to the answer of a puzzle and it became more fun and challenging that way."</p>
			<ul style="list-style-type: none"> Confidence built. 	<p>"I feel better about how I do in math now because of it."</p>
			<ul style="list-style-type: none"> Excitement for math because of competence. 	<p>"And for them it's like it's almost the same thing. I mean, you have adults who still to this day, I'm not good at math. And so, they go by the program that we have and things and that's what they do, but they're not as comfortable with math or as excited about it that I am. I mean, I love it."</p>
			<ul style="list-style-type: none"> Confidence boost. 	<p>"So I guess my confidence increased in math."</p>

Figure 17. Theme 8: Self – Efficacy – Teacher Perspective

Principal Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Accountability and Purpose	<ul style="list-style-type: none"> Dialogue Problem Posing Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>6 – 8:</u></p> <p>Feedback and Reflection</p> <p>Continually Assess and Reflect</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> Once teachers weren't being watched they went back to normal. 	<p>"I think they were. But again, once the workshops stopped and once ... like I remember people were coming in to observe and everything."</p>
			<ul style="list-style-type: none"> People walking through keeps us honest. 	<p>"I noticed that there were a lot of walkthrough observations during the program that I liked because they brought a lot of attention to what was going on in the classrooms."</p>
			<ul style="list-style-type: none"> Once there was no accountability, we didn't use these strategies anymore. 	<p>"So once there was not somebody that was coming in to monitor, somebody to come to observe, it reverted back to: This is what we're doing."</p>
			<ul style="list-style-type: none"> Teachers were given assignments to keep them accountable. 	<p>"Again, there was also the accountability element because teachers were given homework tasks to try out in class and they would have to return to the next session and report out on the results of what they had tried with their students."</p>
			<ul style="list-style-type: none"> We need to force teachers to do these trainings. 	<p>"I think that there has to be a combination of volunteer and this whole entire grade levels doing it right."</p>
			<ul style="list-style-type: none"> Keeping each other accountable helped. 	<p>"They did say that leaning on each other was extremely valuable though."</p>
			<ul style="list-style-type: none"> Strict was helpful. 	<p>"The only other thing I remember my teachers saying is they were so strict about the classes they had to take."</p>

Figure 18. Theme 1: Accountability and Purpose – Principal Perspective

Principal Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Autonomous Sense of Belonging	<ul style="list-style-type: none"> Dialogue Humanization Liberation Problem Posing Autonomy Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>2, 3 – 3:</u>	<ul style="list-style-type: none"> Working with each other and staying accountable to the team was beneficial. 	"They did say that leaning on each other was extremely valuable though."
		Active Learning Strategies	<ul style="list-style-type: none"> A team was created that helped participants learn how to teach math better in many ways. 	"We did this through the development of thriving, collaboratively-led professional learning communities where site-level teams co-developed their knowledge in math-focused content, pedagogy, and technology-infused instructions."
		Collaboration	<ul style="list-style-type: none"> They created a team and got close in their efforts. 	"It definitely sounded like they bonded over the time that they all spent with each other over the course of the program."
		Accounts for Existing Knowledge	<ul style="list-style-type: none"> Mentorship and team dynamics helped create positive outcomes. 	"Principals received mentorship, provided mentorship for teachers, and participated along with teachers in professional learning communities."

Figure 19. Theme 2: Autonomous Sense of Belonging – Principal Perspective

Principal Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Cognitive Rigor	<ul style="list-style-type: none"> Conscientização Dialogue Praxis Problem Posing Autonomy Competence Mastery <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>1 and 5:</u>	<ul style="list-style-type: none"> CFA's were developed with higher cognitive demand questions. 	"And so the kind of questions there are, there might be a couple of questions that are just basic you add and subtract. But other than that, you have to use a model to solve ... which model? You have to use a model to solve this math problem. You don't use the model."
		Content Focused	<ul style="list-style-type: none"> Headly classes that took commitment. 	"I do remember that there were some very extensive classes that the teachers participated in that took a big commitment on their part."
		Engagement with CCSS SMP's and Content Standards	<ul style="list-style-type: none"> CCSS and CEMSPLI have forced a deeper dive. 	"I'm not sure if the CEMSPLI program can take all of the credit for this shift but, ever since common core has come on the scene there has been a shift toward a more comprehensive method of math instruction."
		Coaching and Expert Facilitation / Support	<ul style="list-style-type: none"> Emphasis on depth over breadth. A deeper understanding is being pushed at this school. 	"There is a deeper emphasis on understanding the underlying concepts instead of just answering the what of the questions."

Figure 20. Theme 3: Cognitive Rigor – Principal Perspective

Principal Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Encouragement and Productive Struggle	<ul style="list-style-type: none"> Dialogue Humanization Liberation Problem Posing Autonomy Competence Mastery Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>5 – 5:</u></p> <p>Coaching and Expert Facilitation</p> <p>Expert Support</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> Positivity was the key. 	<p>"I wouldn't let them say: Oh, we have to do math. It was: We're going to learn about fractions. We're going to learn a faster way to add. We're going to learn this."</p>
			<ul style="list-style-type: none"> The teacher acts as a facilitator who encourages and guides the learning. 	<p>"These days the teachers role is more of the role model who is able to guide the thoughts of the students in class to be able to ask and answer the right questions that will lead to them developing the tools to not only build their own knowledge but to continue building this knowledge long after they exit the public education system."</p>
			<ul style="list-style-type: none"> Struggling productively. 	<p>"She told me that it was very uncomfortable at times having to constantly stretch and think about the tricky concepts."</p>
			<ul style="list-style-type: none"> Again, struggling but productively. 	<p>"Rarely, if ever, did they just provide us with cut and dry answers to things that were asked."</p>
			<ul style="list-style-type: none"> Encouraging learning and guiding the struggle. 	<p>"We are really working hard to get away from the sage on the stage and into a more guide on the side mentality of instruction in all realms, not just in math."</p>

Figure 21. Theme 4: Encouragement and Productive Struggle – Principal Perspective

Principal Perspective

Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Humble Reflection	<ul style="list-style-type: none"> Dialogue Humanization Liberation Problem Posing Autonomy <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>6 – 8:</u></p> <p>Feedback and Reflection</p> <p>Continually Assess and Reflect</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> Teachers must humbly accept that their roles are changing. 	<p>"We live in an era where kids can look up anything they want in a matter of seconds so gone are the days when the teacher was the valuable provider of knowledge and facts."</p>
			<ul style="list-style-type: none"> Reflecting on practices. 	<p>"The constant modeling and opportunities to reflect upon our practices I feel are what led us to shift how we instructed math."</p>
			<ul style="list-style-type: none"> Admitting own challenges. Demonstrating vulnerability. 	<p>"I myself if I were to go back in the classroom would be challenged to be less of the provider of answers and tricks and more of the coach pushing students to find the answers on their own through their own inquiry."</p>
			<ul style="list-style-type: none"> Mentorship implies a need to reflect and improve. 	<p>"Principals received mentorship, provided mentorship for teachers, and participated along with teachers in professional learning communities."</p>
			<ul style="list-style-type: none"> Learning of the past is different and must be humbly changed. 	<p>"At some point how we all learned coming up was that the teacher told us what to do and we did it."</p>

Figure 22. Theme 5: Humble Reflection – Principal Perspective

Principal Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Inquiry Techniques	<ul style="list-style-type: none"> Dialogue Praxis Problem Posing Autonomy Competence Mastery <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>6 – 8 and 5 – 5:</u>	<ul style="list-style-type: none"> The delivery positively impacted the learning. 	"It was sometimes the way the information was presented."
		Feedback and Reflection	<ul style="list-style-type: none"> Instructional practices matter. 	"I did notice that there was a lot of this deeper push to have teachers learn to question their students more rather than going through the steps of solving problems and just giving out another worksheet."
		Continually Assess and Reflect	<ul style="list-style-type: none"> More tools in the toolbox were what helped kids learn math. 	"We had to think of other ways to do it because if I just told certain kids this is the shortcut or this is how you do it, they weren't going to get it."
		Coaching and Expert Facilitation	<ul style="list-style-type: none"> Working on methods of guiding rather than telling are being implemented. 	"We are really working hard to get away from the sage on the stage and into a more guide on the side mentality of instruction in all realms, not just in math."
		Expert Support	<ul style="list-style-type: none"> Being a Reading Specialist, this principal believes in pedagogical expertise. 	"And so when you teach them kids how to read, you use a variety of things. It's not just this is ... you can always sound out or you can always do this. So I took basically the same approach when I taught math because math is easy for me in elementary, but I don't think that it was necessarily easy for all kids."
		(Darling Hammond et al., 2017) (Sztajn et al., 2012)	<ul style="list-style-type: none"> Inquiry techniques and the art of questioning. 	"These days the teachers role is more of the role model who is able to guide the thoughts of the students in class to be able to ask and answer the right questions that will lead to them developing the tools to not only build their own knowledge but to continue building this knowledge long after they exit the public education system."

Figure 23. Theme 6: Inquiry Techniques – Principal Perspective

Principal Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Modeling	<ul style="list-style-type: none"> Dialogue Praxis Problem Posing Competence Mastery Purpose Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<u>4 – 2:</u>	<ul style="list-style-type: none"> Professors and their questioning. 	"They would just keep asking things like: What do you think? Or tell me more."
		Models and Modeling	<ul style="list-style-type: none"> The professors showed how to give the time and space needed. 	"Again, the professors always provided us with the space and time to really reflect on the material and never just gave us any of the answers."
		PD Shows Examples of What CCSS Look Like	<ul style="list-style-type: none"> Facilitators modeled the instructional practices they were promoting. 	"I think this practice was modeled in the way the sessions were facilitated."
		(Darling Hammond et al., 2017)	<ul style="list-style-type: none"> The professors modeling what the practices looked like helped. 	"The constant modeling and opportunities to reflect upon our practices I feel are what led us to shift how we instructed math."
		(Sztajn et al., 2012)	<ul style="list-style-type: none"> The way the information was presented made a difference. 	"It was sometimes the way the information was presented."
			<ul style="list-style-type: none"> This modeled how we were to facilitate lessons. 	"Rarely, if ever, did they just provide us with cut and dry answers to things that were asked."
			<ul style="list-style-type: none"> The professors modeled what they were saying. 	"The limited amount of time that I was able to participate, I noticed that the professors were practicing what they preached to us."

Figure 24. Theme 7: Modeling – Principal Perspective

Principal Perspective				
Theme	Critical Determination Indicator	PD Best Practice Indicator	Descriptor	Textual Evidence
Self-Efficacy	<ul style="list-style-type: none"> • Conscientização • Dialogue • Humanization • Liberation • Praxis • Problem Posing <ul style="list-style-type: none"> • Autonomy • Competence • Mastery • Purpose • Relatedness <p>(Aronowitz, 2015; Freire, 1970; Giroux, 2010)</p> <p>(Deci et al., 2017; Pink, 2011; Ryan & Deci, 2017)</p>	<p><u>2, 3 – 3:</u></p> <p>Active Learning Strategies</p> <p>Collaboration</p> <p>Accounts for Existing Knowledge</p> <p>(Darling Hammond et al., 2017)</p> <p>(Sztajn et al., 2012)</p>	<ul style="list-style-type: none"> • Confidence means that teaching math isn't a burden. 	<p>"I think because I liked it as an elementary, I want my kids to like it, so I think that's how it impacted it. It wasn't a burden."</p>
			<ul style="list-style-type: none"> • From the deeper learning came the excitement and openness to be observed in action. 	<p>"Teachers were motivated by what they were learning in the program and seemed excited to demonstrate their new strategies once the observers came into their classrooms."</p>
			<ul style="list-style-type: none"> • Learning the math and having fun resulted in better confidence in teaching it. 	<p>"In conversations with our teacher who has participated I can tell that she enjoyed the program and as a result of what she has learned is much more confident teaching math in her class."</p>
			<ul style="list-style-type: none"> • Working through the difficult concepts brought a sense of accomplishment. 	<p>"I had some fun working with my colleagues on some of the difficult calculus type problems that the professors assigned. I'll tell you what, when you've completed one of those monsters, you definitely accomplished something."</p>
			<ul style="list-style-type: none"> • Being trained has built confidence. 	<p>"Going through the limited trainings that I did helped me to see what deeper level math instruction should look like. I feel more confident now on how to better coach our teachers."</p>

Figure 25. Theme 8: Self-Efficacy – Principal Perspective

Participants

The participants were all educators in the same district with three teachers and three principals making up the representative sample of CEMSPLI participants. The teachers and principals were recruited in the spirit of Cresswell and Poth's (2017) notion of purposive sampling specifically because they were participants in the CEMSPLI program which happened to take place in the same district in a low socioeconomic community of color. All participants worked in the elementary school setting with the three principals representing three different elementary schools, only one of which was at the same elementary school where they participated in the CEMSPLI program. Two of the teachers came from the same school and the third from a different school. One principal was from the same school as any of the participating teachers. In total, four different elementary schools were represented by the participants, which created the cross section of perspectives and environments for the collected data.

Participant	School	Experience	Assignment
Teacher 1	School 1	24 years all in same district. 2 years in middle school.	3 rd grade
Teacher 2	School 1	9 years all in elementary teaching in same district.	3 rd grade at the time of participation
Teacher 3	School 2	20 years teaching in the same district	5 th grade
Principal 1	School 3	24 years, 9 years as a teacher and 15 years as an administrator.	K - 5
Principal 2	School 4	23 years, 8 years in administration.	K - 5
Principal 3	School 5	20 years, 5 years in administration.	K - 5

Figure 26. Participant Snapshot

Teacher 1: Teacher 1 has been a teacher for twenty-four years and has taught in this district for their entire career. Teacher 1 began their career on an intern credential and taught middle school in the district for the first two years of their career. This person currently teaches third grade and participated in the CEMSPLI program with this third grade responsibility as their assignment. Teacher 1 grew up with bad experiences in math and these experiences shifted profoundly as a result of their participation in the entire three-course sequence of the CEMSPLI program.

Teacher 2: Teacher 2 has been teaching for nine years and it was not made clear if all of those years have been spent in the same district. This person was also a third grade teacher at the time of their participation in the CEMSPLI program, but now teaches first grade and is incorporating what they learned in that setting. Teacher 2 grew up liking and excelling in math, and their participation in the CEMSPLI program helped to solidify some of their previously held beliefs and practices regarding teaching mathematics.

Teacher 3: Teacher 3 has been teaching for twenty years, and similar to Teacher 2, it was not made clear if all of those years have been spent in the same district. This person has always

taught either fourth or fifth grade for their entire career and it was not clear which of these grades was their teaching responsibility during their participation in the CEMSPLI program. Again, similar to Teacher 2, Teacher 3 grew up liking and excelling in math, though this person did make it apparent that there was a profound shift in how they learned math and how they now teach math as a result of the program. Of all participants, this person seemed the most confident and impassioned to teach and learn math at the deepest of levels. This participant provided the deepest discussion and richest data for the purposes of this study.

Principal 1: Principal 1 has worked in education for over twenty-four years. This participant taught for nine years and has worked in leadership for the past fifteen years. This person had a positive experience learning math growing up until they reached middle school. This principal comes from a reading specialist background, and it was clear that many of the ideas and experiences provided by CEMSPLI were ideas that this person has harbored throughout their career in their efforts to teach students math at the deepest of levels. This participant provided the strongest views on the power of accountability with teachers and believed that without the accountability of the CEMSPLI walkthroughs, many of the lessons taught by CEMSPLI were fading in the current classrooms. Again, this person stated that they could see the shift in beliefs and practices in their teachers, but they did not feel that many of their beliefs or practices shifted, because they had what CEMSPLI was teaching before they were exposed to this program.

Principal 2: Principal 2 has been an educator at various levels for over twenty-three years. It was not clear how many years have been spent at the various levels, and they have been in administration for over eight years. This person stated that they enjoyed and excelled in math until high school, where they encountered a series of weak teachers looking to retire, but they

then experienced success and enjoyment again in their higher education experiences. Of all of the principals, this participant provided the richest data from the leadership perspective regarding paradigm and pedagogy shifts that they experienced as well as what they saw within their teachers. Principal 2 was able to touch on and provide insight similar to the teachers that helped build the ideas leading to the formation of the eight themes that permeate this work.

Principal 3: Principal 3 has worked in education for twenty years and has been in administration over the last five years. This person stated that there was nothing of note to their personal math experience other than following along in all of the books, learning all of the formulas, and knowing what was coming next because it was always what came next in the textbook. This principal was perhaps the most excited about the shifts in the paradigms and pedagogy of their teachers as a result of their CEMSPLI experience, as made evident in their responses of excitement toward the success of their teacher that participated. They made it abundantly clear that they saw a shift in application-based activities accompanied by a more inquiry and open questioning-based pedagogy for their teacher, who also happened to teach a dual immersion English / Spanish language acquisition class. A personal note is that this participant also encouraged me to persevere and finish this project post-haste because they knew what I was going through, as they had just gone through the same experience last year at this same time.

Chapter 5: Conclusion

Summary of the Study

Chapter 1 of this work set the stage for why this study matters. In the chapter, I discussed how in the era of CCSSM there still exists a wide gap between what students are expected to know and what they actually know (CAASPP, 2019). This gap is disproportionately wider for impoverished students of color, as I outlined in the discussion in Chapter 1 and buttressed by the graphs I created using data obtained from the CAASPP website. Also discussed in this section of Chapter 1 was the fragmented nature of math professional development programs in this new era of CCSS (Sztajn, et al., 2012). The significance of this study is in its ambition to bring coherence to this fragmented system by amplifying the voice of the professional learners who went through the CEMSPLI program and emerged as better educators, as made evident by the math achievement of the students in their elementary schools (CAASPP, 2019). To amplify the participant's voices, I used the constructed framework of Critical Determination, created from the existing theory of Critical Pedagogy of Aronowitz (2015), Freire (1970), Giroux (2010), Self-Determination Theory of Deci, et al. (2017), Pink (2011), Ryan and Deci (2017), seasoned with the effective professional development practices of Darling-Hammond, et al. (2017) and Sztajn, et al. (2012). This framework guided my thoughts as I worked through the data analysis phase, aiming to add to the knowledge base that can be used to bring relief to the problem of low math achievement. Though the population in question in this study is students of color who are living in poverty, my intention is that this knowledge can benefit all students.

Chapter 2 worked through the relevant literature pertaining to the problems and the methods used to address them, as presented in Chapter 1. I outlined a historical background of mathematics as a scholarly area of study, the purpose for studying math, the historical

achievement gaps present in math achievement, how math acts as a gatekeeper to higher education attainment, and finally the historical paradigms and instructional practices of math instructors. From this historical background, the discussion pivoted to surface level investigation of the various learning theories of human—and specifically adult—learning, that exist in the literature before transitioning into a discussion of what methodology would best address the research questions guiding this work. I then include a brief discussion of my reasoning for choosing qualitative methods, followed by a justification for choosing narrative inquiry to capture the deep, lived experiences of the participants of the CEMSPLI professional learning program. After this discussion, I address the current empirical literature that underlies the constructed conceptual lens of Critical Determination. The theory of Critical Pedagogy, as labored over and teased out in the work of Aronowitz (2015), Freire (1970), and Giroux (2010), was discussed to bring the reader's attention to the identifying characteristics of Critical Pedagogy. Next the concepts of Self-Determination, as defined in the work of Deci, et al. (2017), Pink (2011), Ryan and Deci (2017), was discussed to complete the other half of the Critical Determination framework. I completed the discussion of the current empirical literature section with the work in the field of professional development for teachers, as described by Darling-Hammond, et al. (2017) and Sztajn, et al. (2012).

Getting into the methods section in Chapter 3, I discussed the research design of this study, followed by a more in-depth discussion of the history and philosophical origins of the narrative inquiry method. I discussed the different strands of narrative inquiry and made the case for why a thematic narrative inquiry approach was taken for the purposes of this study. Beyond this, I discussed the purposive sampling technique used to choose the six participants who participated in the CEMSPLI program, followed by the setting in which the data collection took

place, and a brief discussion of characteristics of the participants. Next followed a positionality statement in which I gave my brief background description and insight into the lens with which I view the world. Finally, I described some of the finer points that were used to obtain institutional review board approval, such as gatekeeper permission from the participating district, the consent form that was used, potential risks to participants, instruments used to collect data, and the data analysis process.

Chapter 4 took us into the new knowledge that this work helped develop, and it brought to light some of the answers to how and why the CESMPLI professional learning program worked so well. The purpose of the study was reviewed, followed by a thorough description of the data analysis process that helped describe the methods in enough detail that the study could be replicated if desired. The findings were then discussed in detail in which the eight identified themes of Accountability and Purpose, Autonomy / Team False Dichotomy, Cognitive Rigor, Encouragement and Productive Struggle, Humble Reflection, Inquiry Techniques, Modeling, and Self-Efficacy were first introduced and explained. Finally, to conclude Chapter 4, I provided a more thorough description of the participants, accompanied by a brief description of their contributions to the data set.

Finally, here in Chapter 5, I bring together the study and summarize in as succinct a manner as possible the efforts that were undertaken over the course of nearly two years to complete this endeavor. As the reader can see upon the conclusion of reading this paragraph, a research discussion precedes a discussion of implications of this study in which recommendations for future professional learning program design are made. To complete this work, I take the reader through a brief conclusion, followed by the limitations that this project experienced, and ending with suggestions for future research.

Research Questions Discussion

1. What professional learning practices do participating teachers and principals in the California Elementary Mathematics and Science Professional Learning Initiative Grant perceive led to disproportionately high math achievement in a community of impoverished and disenfranchised students?

Both of the first two research questions were addressed at the same time during the data analysis phase of this project. As can be concluded from the tables and discussion provided in Chapter 4, this research study has narrowed down the thoughts of the six participants on how and why the CEMSPLI program proved so effective in increasing math achievement in this marginalized community to the eight identified themes of:

- Accountability and Purpose
- Autonomy and team False Dichotomy
- Cognitive Rigor
- Encouragement and Productive Struggle
- Humble Reflection
- Inquiry Techniques
- Modeling
- Self-Efficacy.

After multiple passes of extensive coding of participant responses, these themes best describe what all participants felt were the catalysts for the positive shifts in their paradigms and pedagogy as produced by the CEMSPLI professional development program. As made evident in the figures from Chapter 4, there were many responses in the data that solidified these themes as the most salient elements present within the design and implementation of the CEMSPLI

program. The deep questioning and examination of the teacher and principal participants' voices through amplifying their responses helped lead to the conclusion of these eight as the themes best representative of their experience.

2. What themes emerge when listening to teacher and principal voices related to shifts in teacher paradigms and/or teacher practices?

Narrowing down and categorizing the eight identified themes into the categories of paradigms and pedagogy shifts yield the following categorizations of each:

Paradigms

- Accountability and Purpose
- Autonomy / Team False Dichotomy
- Humble Reflection
- Self-Efficacy

Pedagogy

- Cognitive Rigor
- Encouragement and Productive Struggle
- Inquiry Techniques
- Modeling

The four themes of accountability and purpose, autonomy / team false dichotomy, and self-efficacy can best be described as shifts in mindsets that helped create the conditions for success in this program. Each of these is representative of internal transformation on the part of the learner in the program that led to the outward actions in the form of pedagogical practices. The four themes of cognitive rigor, encouragement and productive struggle, inquiry techniques, and modeling are all representative of actions that were carried out by CEMSPLI participants as the shifts in mindset were happening.

3. What recommendations can be made for mathematical professional learning programs to improve future mathematics professional learning offerings?

As is expanded upon further below, the results of this study provide exciting

recommendations about what can be done to improve professional learning offerings in mathematics and possibly in professional learning offerings across subject areas. In the following implications section, I present a conceptual framework to guide the development of future math professional learning programs in graphic form; I then expand upon it in detail, outlining recommendations for optimal developmental considerations.

Figure 27. Implications Concept Map Through the Lens of Critical Determination

The implications of this work provide promising insights into how to design and implement a professional learning program that may promote optimal learning outcomes. Deconstructing the above graphic, I start from the bottom and work my way up in much the same way that most physical structures are created. My first suggestion when designing a professional learning program in mathematics, or quite possibly for any content, is to establish a foundation of trust and teamwork in line with the needs and desires of the learners. As was unpacked earlier in this work in describing the theme of autonomy and team false dichotomy, one might presume

that autonomy and team would be opposing concepts, but as has been demonstrated in the data of this work, the two provided an interconnected positive influence in the participants of this study. Many times, through studying the voices of the participants the concept of team and supporting each other by their own choice came through in the data. Of course, the facilitator created some conditions for this to happen during the professional learning sessions, but the participants also created these conditions autonomously when working outside the constraints of the learning sessions. The implication of this finding is that there is power to be found in establishing the foundational elements of team, camaraderie, and collaboration as a first step in the design process of any math professional learning program. Once this foundation of trusting team and shared purpose is created, then the rest of the framework of the professional learning program can be designed.

The next step up from autonomy and team false dichotomy would be the theme of humble reflection. Throughout the data, participants would demonstrate elements of this humble reflection as the direct precursor to any change that was being attempted, whether in their paradigms or instructional practices. Once participants were comfortable and not guarded as a result of the trusting team environment that was established, they were able to reflect upon what they believed and were consequently doing in the learning environment that impacted their students' learning of mathematics. The second piece in developing a mathematics professional learning program would be to develop activities or conditions that would ignite this humble reflection in participants. Participants would be put in situations in which their current state—and the stated goal of where they are to end up as a result of the learning program—would be brought into question. They would be asked to examine the stated outcomes of the math learning program and humbly reflect upon their current reality so that they may identify any deficiencies or gaps in

their current paradigms and/or instructional practices. This humble reflection would honor their autonomy and value their current base of knowledge as stated in the critical determination framework of this work and work to build upon their existing knowledge in a partnering, humanizing fashion.

Once these two layers of team and humble reflection are solidified, the next phase of the program would involve building in mechanisms of accountability, both personally to oneself and interpersonally to the team. Time and again, the data demonstrated that all participants found value and power in the accountability that the CEMSPLI program provided. Accountability without trust and humble reflection can backfire quickly, though, and build resentment and defensiveness on the part of the participants. This is why this theme provides the third layer once the previous two have been established. Once the spirit of team is established, the power of staying accountable to pull one's own weight is a very motivating influence. Within any strong team, the drive to not let the person down that you are sharing the struggle with is more powerful than any of the ancillary political dynamics or personal motives that one may harbor. Holding oneself accountable to the team, and in turn the team holding each other accountable to accomplishing the shared mission, are powerful drivers of human behavior when struggling through something as difficult as learning math instructional practices at the deepest of levels.

The reader may notice that in the above graphic there exists the slightest difference in distance between the bottom three themes and the four above it. This is meant to create a distinction. The best interpretation is to imagine the previously mentioned three themes creating a three-layer, half pyramid foundation, with the next three themes—modeling cognitive rigor, and inquiry techniques—creating another half pyramid of similar size, and by implication importance, to undergird what I now argue is the most important theme of self-efficacy. Once the

previously described themes of team, humble reflection, and accountability are established, the true hard work of learning in math—and possibly any—professional learning programs can begin.

From the data present as a result of this study, I argue the importance of modeling as a foundational element that any facilitator of a math learning environment must master and use extensively. Time and again the voice of the participants demonstrated the ubiquity of modeling in the adult learning environment as well as a fundamental characteristic of the learning environment that they were being trained to create with their elementary school students. Modeling what the expected learning outcomes look like and demonstrating tangible examples of what is expected of the learner prove crucial and indispensable to creating the paradigmatic and pedagogical shifts similar to what was produced in the CEMSPLI program. Not only does modeling provide a vision of what is expected, but it also creates a sense of credibility in the facilitator as a valuable, trustworthy catalyst for growth. Through modeling, the facilitator is able to practice what she or he preaches and is a valuable participant within the team dynamic in a truly dialogical and partnering fashion, much in the Freirean spirit.

Placed on the next level of the conceptual framework, just above modeling, are the themes of cognitive rigor and inquiry techniques, which dually inhabit this level with equal importance. What the facilitator of optimally designed math professional learning programs would be modeling, as gleaned from the data, would be inquiry techniques providing cognitively rigorous opportunities for learning. Participants repeatedly voiced that the challenge and rigor of the CEMSPLI program were valuable elements that they felt led to their transformation, and in turn the transformation of the learning environment for their students. This challenge and rigor were present in the math content, in the challenging of their previously held paradigms, and in

the constant push to change their methods of inquiry as pedagogical tools in their classrooms.

The challenge of all tasks and interactions in the program came from the constant push for depth of knowledge and always asking the question: why? The results of this work suggest that once all previously established themes have been duly constructed as support mechanisms for all participants, then the next step is to engage with deeply challenging activities and methods of inquiry within the learning environment. There is no challenge too great to provide to learners who are able to lean into a team, humbly reflect on their course of action, hold each other accountable, and see through a model facilitator what it is that is expected of them throughout the process and on the other side of the challenge.

As can be seen in the above graphic, the next theme of encouragement and productive struggle is meant to wrap around and support the themes above autonomy / team false dichotomy and below self-efficacy, covering everything in between as well. Throughout all interviews, the concept of encouraging learners through periods of productive struggle rang through in participant responses. Examples of this theme are woven through all of the others. During interactions among team members, or while humbly reflecting on changing one's mindsets and beliefs, while holding each other and oneself accountable, and modeling the depth of questioning math concepts, all participants discussed times of encouragement. Participants received this encouragement from above and among each other, as well as observing its effectiveness for elementary students. This encouragement, and productive struggle through the challenges presented in each scenario, was one of the most critical elements to the success of the CEMSPLI program, according to the responses of the participants. In designing a program hoping for similar optimal math learning outcomes, this encouragement and reminder of productive struggle being not only normal, but necessary for high levels of learning, is the next critical characteristic

of any program and must be interwoven into all efforts where the learners are being challenged to transform.

All of the described elements build toward and create the culminating conditions that make the most important identified theme possible. The top of the graphic identifies the theme of self-efficacy, as this was the most powerful theme identified among all participants. As simply yet effectively stated by one participant: “I feel better about how I do in math now because of it (CEMSPLI).” As discussed in previous chapters of this work, the tremendous power of belief in oneself is beyond crucial and critical in being able to accomplish a challenging goal that one sets. Overcoming a deep-rooted phobia or anxiety that one harbors toward the study and instruction of math is perhaps a most important goal of any math professional learning program that is designed. The conditions for this to happen aligned in this program to make this a reality in the participants of this study. The most substantial theme that emerged from the data, which all other themes support and build toward, is the power of the CEMSPLI program to develop confidence and self-efficacy in this study’s participants. The participants believed that they could and would be successful in instructing their math students at the deepest of levels. This suggests that the core ambition of any program design should be to create the conditions in which this belief in the learners own ability to change their reality—much in the spirit of Critical Determination—is created, nurtured, and developed into an unstoppable force.

Conclusion

Throughout this long and arduous process, the elegant goal has remained the same: to create something of tangible value that helps improve people’s lives. The hope was to address the lingering underachievement in mathematics that I have witnessed for my entire 23-year career in education. The systemic privilege afforded to math knowledge that we as agents of the

educational system perpetuate remains debatable at the root level of making math a compulsory subject of study. Unfortunately, the reality is that math is a required course of study that locks many deserving students out of their higher education dreams. Rather than address this fact and work to deconstruct this inequity, I chose to embrace this reality and study methods for improving math education and achievement from within the system. Six participants in a professional learning program that improved the learning of students in an impoverished community of color told their story of why this program was effective. The power of these stories helped the eight themes to emerge as the identified catalysts for change in these professional learners that led to the deeper learning of their students. We as human beings tend to learn the deepest from our connection to each other and the shared stories that we experience. The implications of this are that we can scale these learnings into the efforts of designing future mathematics professional learning programs that will optimize learning in the professionals that participate, and consequently in the learners they teach.

Limitations

A major limitation for student researchers is the stringent requirements of the institutional review board (IRB), regarding working with minor participants. Studies that may be interested in learning from the experiences of student participants are adjusted so as to avoid facing these strict requirements. This study may have endeavored to study the voice of the students in identifying their perspective regarding what may have shifted in math instruction, but this goal was quickly curbed in order to be able to meet IRB requirements in a timely manner.

Another limitation was in the dearth of principal participant information. School administrators are tasked with so many responsibilities in their professional setting that to be able to talk with them in a comfortable manner for an extended period of time proved very

challenging, once they were able to even commit to talking. One participant had to arrange the discussion for a Sunday morning away from school while their children were still sleeping, as that was the only portion of time they had available to discuss the CEMSPLI program. Finally, if the study were designed again, another twist to the design may have been to arrange a time where all participants could have participated in a roundtable discussion together in the same space. The hope for this would be twofold: first, I'd anticipate that a group discussion would massage the memory of all participants, allowing them to remember elements that they would struggle to remember on their own. The second reason for the group discussion would be to study some of the team dynamics in action when presenting their thoughts in a public setting. It would have been interesting to see if as much candor would be in place as in the individual interviews.

Future Research

As tends to be the case with many paths of inquiry, the work set forth in this project opens up curious paths of future inquiry. To begin with, any of the eight identified themes could be expanded upon and merit substantial study on their own. Narrowing these eight down to the most foundational theme of autonomous sense of belonging, I would like to study this theme more extensively in the future. It would be worthwhile to study what conditions foster the development of the most cohesive and high functioning teams, as examined through the lens of Critical Determination. The ideas of what defines most cohesive and high functioning would require some examination in order to identify how those conditions were created, but this strand of inquiry is highly intriguing as a potential direction.

Also, as identified in the responses of multiple participants, there is an opportunity to identify programs similar to CEMSPLI that address teachers of the lower grades: kindergarten

through second grade. Half of the participants in this study suggested that this program either be scaled to include these younger grades or a similar program be identified and implemented in their school district for these students at what they deemed the most crucial years. The reader is presented with the opportunity to scour the literature to see if such a program exists and apply it, or even to design one using the elements identified herein and study the effectiveness upon conclusion.

Finally, a very promising path of inquiry is to study these findings across content areas. To identify if similar findings could result in multiple content areas outside of mathematics would suggest that the implications of this and future studies in the same spirit could be scaled to include all professional learning content areas when designing optimal professional learning conditions. I do have the burning question of whether the anxiety that seems more prevalent to math than other subjects would affect the voice of learners in other content areas. I hypothesize that the profound feeling of efficacy and accomplishment upon conquering a challenge in a subject that one harbors anxiety in may not cross boundaries into a content area that the learner does not have anxiety about. Would the learner feel as accomplished in learning the highest of levels in history or psychology, for example, that they feel from conquering some of the highest levels of calculus? This remains to be studied and answered in future work.

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Appendix A

Participant Consent Letter

Consent to Participate in a Research Study

(For use with adult subjects only)

What follows is a consent form that explains what will be happening if you choose to participate in this research study. The first section (Investigator Information) should have been completed by the investigator. If this section is incomplete, do not continue with the study. Do not participate if this study has not been assigned an IRB approval number. The information you need to provide begins on Page 2. Please read each section carefully.

Investigator Information (to be completed by Principle Investigator)IRB approval number: Title of project: Name of principle investigator (PI): Email of PI: Telephone number of PI: Department or major of PI:

Position held by PI:

☐ faculty☐ administrator/staff☒ student

If PI is a student or staff, complete the remainder of Investigator Information, otherwise go to next page.

Name of faculty or administrator sponsor: Department or office of sponsor:

Position held by sponsor:

☒ faculty☐ administrator

General information about this study

You are being asked to participate in a research study. Whether you do is entirely up to you. You may refuse to participate, or you may stop participating at any time for any reason without any penalty.

Math achievement, especially within impoverished communities of color, is consistently dismal in the current era of Common Core State Standards in Mathematics. Tracing the root of this problem to the foundational source leads to the phenomenon of elementary level teacher mathematics anxiety that results in lower rigor and consequent lower foundational mathematical skills for these students (Bringard, 2017; Bryant, 2009; Bursal & Paznokas, 2009; CAASPP, 2018; Maloney & Beilock, 2012; Nation's Report Card, 2018; Nelson, Parker, & Zaslofsky, 2016; OECD, 2018; Ramirez, Hooper, Kersting, Ferguson, & Yeager, 2018; Schmidt, 2012). This project looks to amplify the voice of teachers and principals who participated in a professional development grant that resulted in marked growth in mathematics as measured by state standardized testing. Their perspectives on what was effective in this program will be systematically coded, themed, and attached to previously established theories of human learning in order to create an up to date professional development best practice framework in the current policy environment of what defines math learning success.

You are being asked to participate in this study because you are a teacher / principal who participated in the CEMSPLI professional development program. A total of 5 teachers and 5 principals who participated in this professional development program will be interviewed for this project.

How long this will take (i.e., duration of participation)

If you choose to participate in this study, your involvement will take about 90 – 120 minutes spaced over 2 separate interviews.

What will happen if you participate in this study

If you choose to participate in this study you will be interviewed twice in semi-structured, open interviews lasting roughly 45 minutes. The first interview will ask general questions related to your participation and experience in the California Education Mathematics and Science Professional Learning Initiative (CEMSPLI), Transforming Lives: The Mathematics Leadership Institute professional development program. This interview will be transcribed and analyzed then brought back to you in the second interview where you will get a chance to clarify any responses and corroborate the themes that are identified.

Audiotaping

You will be audiotaped to be sure I capture all of the details of your perspective on participating in the CESPLI program.

Protecting your privacy

People who participate in this study will not be identified in any report or publication about this study. Although every effort will be made to keep the research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is unlikely to happen, but if disclosure is required, the investigator will take whatever steps are allowable by law to protect the privacy of your personal information. In some cases, your information in this research study could be reviewed by representatives of the University of Redlands, research sponsors, or government agencies for purposes such as quality control or safety.

What will happen if you experience any problems or discomforts during or after your participation

It is possible that there are unknown risks or discomforts. Please report any problems immediately to the researcher.

Anything you do, including participating in research, carries with it some chance that something problematic or unwanted may happen. Although the researcher may direct you to medical, psychological, or other services, any costs related to such problems are your or your insurance company's responsibility.

Questions about this study

You may ask and have answered any question about the research. If you have questions or concerns, you should contact student Chris Jackson at phone: [REDACTED] email: Christopher_jackson@redlands.edu advisor Dr. Jose Lalas at Jose_lalas@redlands.edu.

Questions or concerns about the investigators, staff members, and your participation in the study

This study was approved by the University of Redlands Institutional Review Board (IRB). This board tries to ensure that your rights and welfare are protected if you choose to participate in the study. If you have any questions about your role or how you were treated by the research personnel, you may contact the Chair of the IRB at Catherine_salmon@redlands.edu or by telephone at 909-748-8672.

Participant's Agreement

I, _____ ,
Print Name Above

have read the information presented above. I have asked all questions I had at this time. I voluntarily agree to participate in this research study.

Signature of Research Participant	Date

To be completed by researcher:

Print Name of Person Obtaining Consent

Signature of Person Obtaining Consent	Date

Appendix B

Interview Protocol

Introduction	<ul style="list-style-type: none"> • Thank you for taking the time to meet with me and for agreeing to participate in my study on professional development that optimizes early math instruction. My name is Chris Jackson and I am speaking with _____. I am a doctoral student at the University of Redlands and this interview is part of the data collection process for my dissertation research project. This interview will last approximately 20 to 30 minutes. I will be audio recording the interview to make sure I have all the information you give me. I will also be asking you to review the transcript of the interview for accuracy once it has been transcribed. • All information in the interview will be kept confidential. Your name will be changed in any report written regarding this study. If there are any questions you do not wish to answer, that is your choice and you may choose to end this interview at any time. • If you are willing to participate, please state so. • With your permission I would like to audio record this interview. The purpose of recording this conversation is because I will not be able to write as quickly as you speak. It is important that I get your responses in their entirety. If you consent to audio recording, please let me know. • Please speak loud and clear so your entire responses will be recorded. • Do you have any questions with what I have explained?
General Background Information	<ol style="list-style-type: none"> 1. How long have you worked in education? 2. How long have you / did you taught / teach math? 3. What kind of experience did you have with math education while you were in school? 4. How did this experience impact you as a math educator? 5. What are your thoughts on professional development programs you have participated in throughout your career?
CEMSPLI Experience	<ol style="list-style-type: none"> 6. Tell me about your participation and experience in the California Elementary Mathematics and Science Professional Learning Initiative Professional Development program?

	<p>7. What was the context and situation like where you participated in the professional development activities for this CEMSPLI grant?</p> <p>8. What do you think specifically changed in your beliefs regarding math instruction as a result of the CEMSPLI grant?</p> <p>9. What professional learning practices in the CEMSPLI grant do you feel led to these changes in your beliefs?</p> <p>10. What do you think specifically changed in your math instructional practices as a result of the CEMSPLI grant?</p> <p>11. What professional learning practices in the CEMSPLI grant do you feel led to these changes in your instructional practices?</p>
Closing	<p>12. Is there anything you would like to add regarding your experiences before I turn off the recorder?</p> <p>Thank you for participating in this interview.</p>