CULTURALLY RELEVANT MATHEMATICS FOR HIGH POVERTY 8TH GRADERS:

INFLUENCES ON MATHEMATICS SELF-EFFICACY

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of CYNTHIA ANNE TOWNSEND find it satisfactory and recommend that it be accepted.

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This study sought to bring awareness and potential suggestions to the problem of low mathematics achievement for students living in poverty and the potential that equity pedagogies may offer for these students. Tenets of Culturally Relevant Mathematics Pedagogy (CRMP) in both curriculum and instructional practices were investigated in an eighth grade mathematics classroom in a high poverty majority-minority school. This was done by examining the teaching of three CRMP tasks related to algebraic functions over four months’ time. This mixed methods action research utilized case studies of students, including a student with an identified learning disability and Latina/o English language learners. Both quantitative and qualitative methods were used, which included, mathematics self-efficacy surveys, student interviews, a CRMP lesson analysis tool, CRMP task artifact analyses, a teacher reflection journal, and both teacher and student observations with observation scales. Data was analyzed to determine influences on both students’ mathematics achievement and their mathematics self-efficacy beliefs. Findings indicated that real world CRMP tasks taught within cooperative learning structures did influence both students’ achievement and self-efficacy in mathematics. These teacher-created tasks had high cognitive and language demands, utilized multiple representations, and afforded students opportunities to experience productive struggle. Students grew in their understanding of algebraic functions and their beliefs in themselves as doers of mathematics through teacher
scaffolding, questioning, praise, and frequent feedback. It was also seen that status differences were minimized through the use of group norms and becoming an expert on their topic. Students’ mathematics self-efficacy was positively influenced by lessening their physiological state through strong teacher-student and peer relationships, as well as multiple opportunities to observe the modeling of others through vicarious experiences. All students with identified learning disabilities grew in both mathematics achievement and self-efficacy. Mixed results were seen in ELL and exited ELL students. Recommendations are made for supporting students with special academic and language needs. Implications for developing more equitable secondary mathematics experiences for students living in poverty are discussed for teachers, administrators, curriculum developers, professional development designers, and policy makers.
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CHAPTER ONE

INTRODUCTION

Statement of the Problem

The mathematics achievement of various sub-groups has risen to the surface of concerns within educational, societal, and political circles, in part due to federal accountability regulations, such as the No Child Left Behind Act (NCLB) (2008) and the Race to the Top grant program (United States Department of Education, 2010). One group that continues to achieve low passing rates on standardized tests are those identified as economically disadvantaged or those students living in poverty. Researchers have determined that students from impoverished families may have more difficulties learning mathematics because of a multitude of factors related to their environment, their physical health, the schools they attend, and their psychological wellbeing (Brooks-Gunn, Linver, & Fauth, 2005; Cortesão, 2011; Darling-Hammond, 2010; Knapp, 1995).

School-related factors have been found to be one of the most important factors within students’ mathematics learning (Darling-Hammond, 2000; Fantuzzo, LeBoeuf, & Rouse, 2014). Due to the stress of needing to meet Adequate Yearly Progress (AYP) as defined by NCLB (2008), schools have increased their implementation of scripted curricular programs that utilize direct instruction; devoid of culture, background, experiences, or instructional strategies, which are known to be preferred by students from marginalized populations (Lubienski, 2000; McSpadden McNeil, 2005). Additionally, students of poverty and their families must struggle against an uneven balance of power in society, as well as endure higher rates of classism, racism, and ableism, due to their diverse populations (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005; Kozol, 1991; Milner, 2013). To meet the needs of these students, research shows that mathematics teachers should be educating students through an equity lens, such as using a
teaching framework grounded in culturally relevant mathematics pedagogy (CRMP) (Gay, 2009; Gollnick & Chinn, 2006; Greer, Mukhopadhyay, Powell, & Nelson-Barber, 2009; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Ladson-Billings, 1995). This includes teachers building strong caring relationships with their students, setting high expectations for every student, and utilizing instructional methods and curriculum that connects mathematics standards to students’ culture, as well as to issues of social justice.

Research has also shown that many students from impoverished families can and do flourish within the conditions they are living in and the schools that they attend (Zimmerman & Arunkumar, 1994). Studies define these students as resilient and demonstrate that for students living in poverty to move towards resiliency they need certain protective factors in place that provide an optimal environment for learning and growth (Benard, 1991, 2004). Protective factors are “developmental supports and opportunities, which mitigate adversities” and contribute to the development of student strengths in social situations, problem solving, autonomy, and having a sense of purpose and future (Truebridge, 2014, p. 15). These factors apply to all subjects and educational settings as teachers work towards “providing authentic caring relationships, maintaining high expectations, and providing meaningful opportunities for student participation and contribution” (Truebridge, 2014, p. 4), but can also be directly applied to mathematics education as mathematical resilience. Mathematical resilience is the internal perseverance that a student develops which motivates them to continue working on challenging mathematics even through setbacks, such as mistakes, frustration, and confusion (Johnston-Wilder & Lee, 2010).

One strength that is needed for a student to work towards mathematical resilience is a high mathematics self-efficacy (Bandura, 1987). Specifically related to education and mathematics, self-efficacy is closely related to a person’s confidence in performing a specific
task at a specified level (Seifert, 2004). In other words, mathematics self-efficacy is the belief that a student develops regarding their own ability to complete mathematics tasks accurately. Without a strong mathematics self-efficacy, students may create self-fulfilling prophecies, acquire bouts of learned helplessness, and, ultimately, do poorer in mathematics (Margolis & McCabe, 2006). Self-efficacy is an important topic as mathematics standards are reaching new heights, high-stakes accountability measures are determining graduation, and the school drop-out rate continues to be high, especially among historically marginalized groups (Krieg, 2011), “groups excluded due to race, religion, political or cultural group, age, gender, or financial status” (Cook, 2008). It is imperative that schools and teachers understand and put into place environmental conditions, curriculum, and pedagogies in which students in poverty can learn and make sense of mathematics. In addition, it is important for schools to address inequitable practices and work to provide these students with the best possible academic, emotional, social, and mental foundation for them to enter into adulthood (Boaler, 2016; Gorski, 2013).

**Purpose of the Study**

The purpose of this study was to investigate how an 8th grade mathematics teacher utilized the tenets of CRMP to influence mathematics achievement and mathematics self-efficacy through mixed methods action research. Low mathematics self-efficacy has been shown to be associated with low mathematics achievement (Pajares & Graham, 1999). In this study, mathematics achievement is defined as learning based on the 8th grade Common Core State Standards and Practices of Mathematics (CCSSM) assessed using numerical scores on various types of teacher created assessments (National Governors Association (NGA), 2010). In addition, many students have an inaccurate belief or self-efficacy of their actual mathematics ability. Many low achieving students tend to overestimate their own mathematics understanding.
and preparedness for assessments and some high achieving students tend to underestimate their mathematics abilities, especially girls (Hackett & Betz, 1989; Pajares & Graham, 1999). This can lead to lower self-efficacy, achievement, personal expectations, and future career goals. Goals of this study included: (a) investigating how an 8th grade mathematics teacher in a high poverty school used curricular and instructional elements of CRMP to teach algebraic functions and (b) examining how students’ mathematics achievement and mathematics self-efficacy may be influenced by teaching algebra through a CRMP lens.

CRMP is a teaching and learning framework theorized by multiple researchers which seeks to create equitable mathematics learning environments for students from marginalized populations. Creating these types of learning environments was achieved in this study by attempting to implement the following five main tenets (see Figure 1):

1. Situating mathematics curriculum and instruction within students’ cultural traditions, experiences, beliefs, language, and community values (Gay, 2010; Gutstein et al., 1997; Ladson-Billings, 1995; Tate, 1995).

2. Using a social constructivist instructional approach with an emphasis on learning mathematics through cooperative group tasks, critical dialogue, and active engagement, such as Complex Instruction (Boaler & Staples, 2008; Cohen & Lotan, 1997; Gay, 2010; Horn, 2012; Ladson-Billings, 1995; Matthews, 2003; Slavin, 1996).

3. Developing caring relationships between teachers and students that promote the learning of challenging mathematics through high expectations and personal responsibility (Averill, 2012; Bartell, 2011; Gay, 2010; Ladson-Billings, 1995; Matthews, 2003; Valenzuela, 1999).
4. Developing cultural competence and critical mathematical thinking in students and teachers through the use of open dialogue, social justice lessons, and by fostering an orientation towards student empowerment and advocacy (Gay, 2010; Gutstein, 2003; Gutstein, et al., 1997; Ladson-Billings, 1995).

5. Promoting teacher and student reflection regarding personal assumptions and beliefs of students’ mathematics knowledge, ability, and motivation, due to stereotypes, racism, classism, and mathematics self-efficacy and understanding how they may influence classroom and school operations (Allensaat-Snider & Hart, 2001; Gay, 2010; Ladson-Billings, 1995; Marat, 2005).

Educational action research, as defined by Mills (2011, p. 5), is inquiry by educators about the teaching, learning, or other operations that occur within an educational setting for the purpose of “gaining insight, developing reflective practice, effecting positive changes in the school environment (and on educational practices in general), and improving student outcomes and the lives of those involved.” As a practicing teacher, I used action research methodology in this study to better understand the problems of low mathematics achievement among students of poverty and how it related to their mathematics self-efficacy. Using action research gave me the flexibility to use both qualitative and quantitative methods in a pragmatic fashion to best meet the learning needs of my students, meet the constraints of my classroom, and answer the research questions. In addition, this action research took a critical or transformative approach, where collaboratively, my students and I attempted to “disrupt the status quo to achieve greater equity in educational outcomes for students” in our classroom (Grogan, Donaldson, & Simmons, 2007, para. 21; Mills, 2011).
This convergent mixed methods study, with a multiphase design, proceeded while using a three phase dialectic action research spiral, as described by Mills (2011, p. 19). This began with identifying an area of focus, collecting data, analyzing and interpreting the data, and developing an action plan for each phase (Creswell & Plano Clark, 2011). The three phases included concurrent qualitative and quantitative data collection and analysis methods which informed the next phases (see Figure 2 & Appendix A). The first stage comprised of collecting quantitative data on students’ mathematics self-efficacy and achievement, which was analyzed in order to choose participants to investigate further with qualitative instruments in the next phase. In addition, I wrote entries in a reflection journal (see Appendix B) throughout the study to document curricular and instructional implementation decisions regarding CRMP, instances of relationship building through mathematics teaching and learning, examples of student self-efficacy beliefs, developments of student and teacher cultural competence, and student difficulties with instructional methods, concepts, and contexts.

The second stage included continued quantitative data collection of students’ mathematics self-efficacy and achievement, as well as additional qualitative data collection during three specific CRMP tasks. During these tasks, the selected students and the teacher were videotaped to provide observations that were viewed at a later time and analyzed using rating scales on student self-efficacy behaviors and teacher CRMP components, student and teacher field notes, and a CRMP lesson analysis tool (TEACH MATH, 2012). These mathematics tasks, from the students, were retained as artifacts of student achievement during the study. In the final phase of the study, quantitative post measures were administered to determine any student mathematics self-efficacy growth over the period of the study and the selected participants were interviewed using a semistructured interview protocol informed by data collection and analysis.
in Phase 2. Qualitative and quantitative data were analyzed separately and then merged into one final set of data, which was then triangulated to determine findings which addressed the research questions.

**Local Context**

This study took place at a middle school in a small Pacific Northwest city, with a population of approximately 7,000 residents, of which approximately 25% lived below the poverty line, as determined by the United States federal government (United States Census Bureau, 2014). The school had approximately 310 students in grades six through eight with the state identifying over 95% as economically disadvantaged, 12% as students with disabilities, and 55% as English language learners (ELLs) in 2015. ELLs were determined based on students’ performance on the English Language Proficiency Assessment (ELPA) (Townsend, 2013). Due to the high numbers of students of poverty, this school was eligible and participated in the school-wide Title I federal program. Additionally, this school was a majority-minority school, with approximately 66% of the students identified as being of Latina/o ethnicity, 32% as Caucasian, and 2% as multi-racial or of another ethnicity. Due to the high occurrences of families living in poverty, being migrant workers, needing governmental assistance, or being homeless, this school district offered all students three free meals a day. Breakfast and lunch were provided through the federal government’s Community Eligibility Provision and an afterschool supper was provided as part of their afterschool enrichment program (United States Department of Agriculture (USDA), 2014).

Having had difficulties meeting Adequate Yearly Progress (AYP) as defined by NCLB, this school implemented many interventions and programs over the past ten years to try and assist students in meeting standards and passing standardized tests. Specifically, in regard to
mathematics, all mathematics classes were detracked in previous years to create heterogeneously mixed ability classrooms. A NSF-funded curriculum, Connected Mathematics Project (CMP), was used as the main mathematics textbook in all three grades for the past eight years in an attempt to give students a problem-based mathematics learning experience, as well as to gain higher performance on state mandated standardized tests (Lappan, Phillips, Fey, & Friel, 2014). Professional development training on CMP, which included such topics as cooperative learning, questioning techniques, and manipulative use, was completed by all mathematics teachers. In my mathematics classes, I also enacted approaches from Complex Instruction, including randomized group assignments, student roles, using tasks with multiple entry points, and being cognizant of and trying to improve upon students’ status in the classroom (Cohen & Lotan, 1997).

With new administration, this school was in a transition mode during this study, but continued their school-wide focus on preparation for the new generation of mandated standardized testing, which in this state is the Smarter Balanced Assessment Consortium’s Summative Mathematics Assessment (SBAC) (SBAC, 2014). All teachers worked to improve reading and writing within and across their content areas by using increasingly challenging texts, having students cite text-based evidence, and expanding the use of collaborative group discussions. District-wide there was a drive to improve alignment in mathematics curriculum and instruction between the elementary, middle, and high school. During the time of his study, the middle school had a more progressive mathematics curriculum, with the elementary and high schools beginning transitions to move towards a more progressive problem-based curriculum and instructional focus. Having applied for and been awarded a 21st century community learning grant, this school had both afterschool tutorial classes to assist students in understanding and completing assignments, as well as a STEM (Science, Technology, Engineering, and
Mathematics) enrichment after school program to enhance interest in those fields. Through these grant funds, students were able to take courses such as robotics, horticulture, computer coding, chemistry, and environmental science.

The community was overall very supportive of the directions that this school and district had taken with their curriculum and instructional decisions, as well as their continued focus on creating additional opportunities outside of the school day for students. Businesses and individuals regularly supported school athletics and academics with monetary and physical donations, however, parents and community members were rarely seen in a regular sense because of increased work and family obligations.

**Research Questions**

The research questions that this mixed methods action research study addressed are provided below. For my 8th grade class in a high poverty school:

1.) How do I use curricular elements of CRMP (e.g., high cognitive demand, cultural relevance, and social justice components) to teach algebraic functions?

2.) How do I use instructional elements of CRMP (e.g., social constructivist methods, caring relationships, and multiple avenues for learning support) to teach algebraic functions?

3.) What is the relationship between my student’s mathematics achievement and my teaching through a CRMP lens?

4.) What is the relationship between my student’s mathematics self-efficacy and my teaching through a CRMP lens?

**Definition of Relevant Terms**
**Adequate Yearly Progress (AYP)** is yearly progress needed, as defined by the United States Department of Education, towards meeting state or national standards as part of NCLB (2008).

**Algebraic thinking** includes the processes involved in understanding how to represent mathematical functions using operations and structure by building rules and moving towards mathematical abstraction (Driscoll, 1999).

**Calibration accuracy** is the difference between a person’s self-efficacy rating of a particular task and the person’s actual performance on the task, including the direction (either overestimating, a positive value, or underestimating, a negative value) (Pajares & Graham, 1999).

**Culturally relevant mathematics pedagogy (CRMP)** refers to elements of mathematics teaching that may be used to increase student engagement, achievement, and relevance by situating the curriculum and/or instruction within students’ cultural experiences, beliefs, and/or values. This may include the use of high expectations, challenging real world mathematical contexts, social constructivist instructional methods, caring relationships, and/or by empowering students through the development of their own cultural competence (Averill, 2012; Bartell, 2011; Gay, 2010; Gutstein et al., 1997; Ladson-Billings, 1995; Matthews, 2003; Tate, 1995).

**Detracked** refers to the practice of putting students in mixed ability classes versus ability or leveled classes (Boaler & Staples, 2008).

**Direct instruction** is a teaching practice where the teacher gives content knowledge to students directly, many times through lecture, versus students constructing their own knowledge (McSpadden McNeil, 2005).
Economically disadvantaged is a state defined category, which, for most states, refers to students within a household that meet the income eligibility guidelines for free or reduced-price meals at school (less than or equal to 185% of Federal Poverty Guidelines) under the National School Lunch Program (United States Department of Education, 2012).

Equity in mathematics education includes conscious efforts to provide access to relevant and high level mathematics to all students (Bishop & Forgasz, 2007). This includes access to quality teachers with high expectations for all students, utilizing instructional and curricular philosophies that emphasize equitable practices, and analyzing current systemic issues within the classroom, school, district, or society that may cater to gaps in opportunities to learn relevant and high level mathematics (NCTM, 2008). Equity in mathematics education may be achieved when we are unable to predict students’ mathematics achievement, participation, and ability to analyze, reason about, and critique knowledge and events in the world as a result of mathematical practice, based solely upon characteristics such as race, class, ethnicity, gender, beliefs, and proficiency in the dominant language (Gutiérrez, 2007).

Marginalized refers to “groups excluded due to race, religion, political or cultural group, age, gender, or financial status” (Cook, 2008).

Mathematical resilience refers to the ability of a student to overcome adversity in mathematics, such as boredom, past difficulties, anxiety, poor instruction, and non-supportive teachers and peers, in order to persevere in their learning of the content. Developing mathematical resilience includes developing attitudes that can counteract past negative experiences and lead to future successes, such as seeing value in mathematics, appropriate and calculated challenges and struggles, and having a growth mindset (Dweck, 2006; Johnston-Wilder & Lee, 2010; Kook, Welsh, McCoach, Johnston-Wilder, & Lee, 2013).
No Child Left Behind Act (NCLB) (2008) is a federal school accountability law requiring states to report standardized test scores in math and reading from grades three through eleven for all subgroups in all public schools throughout the United States.

Outcome expectations is a psychological construct that includes the beliefs that one has about the outcomes that one expects to occur due to certain behaviors (Bandura, 1986).

Past mathematics performances is considered the most influential source of developing one’s self-efficacy. Otherwise known as mastery experiences and enactive attainment, past mathematics performances positively influence mathematics self-efficacy when students successfully perform a mathematics task, especially if success comes from extended effort that overcomes previous failed attempts (Bandura 1986, 1987).

Poverty is normally defined by the United States federal guidelines, which states that the poverty line is an annual gross income for a family of four earning less than $23,050 annually (United States Census Bureau, 2014). However, in this study, students living in poverty, are classified as any student and their family who is currently utilizing the Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance to Needy Families (TANF), Food Distribution Program on Indian Reservations (FDPIR), and/or Medicaid, or are identified as homeless, a runaway youth, migrant, a youth in foster care, or are enrolled in the Head Start or Even Start programs (USDA, 2014).

Pragmatism is a theoretical paradigm used in this study to demonstrate a methodological focus on the problem, using abductive reasoning, and instituting any methods that are necessary to address the research questions (Hall, 2013).

Protective factors or processes are elements seen in families and schools that lead students to become resilient in the face of adversities. These supports, such as caring
relationships, high expectations, and meaningful opportunities for participation, counteract the
effects of potential hardships and may lead to increased self-esteem, self-efficacy, and
achievement (Benard, 1991, 2004; Borman & Overman, 2004).

*Qualitizing* is an analysis process used in mixed methods research whereby quantitative
or numerical data is transformed or changed into qualitative or textual data (Creswell & Plano
Clark, 2011).

*Resilience* is “a developmental process occurring over time, eventually characterized by
good psychosocial and behavioral adaptation despite developmental risk, acute stressors, or
chronic adversities” (Borman & Overman, 2004, p. 180).

*Self-efficacy* is defined by Bandura (1986, p. 391) as “peoples’ judgments of their
capabilities to organize and execute courses of action required to attain designated types of
performances.”

*Self-evaluation* is a process of self-judgment whereby people compare their performance
on a specific task with a standard, benchmark, or grade (Cleary, Callan, & Zimmerman, 2012).

*Self-fulfilling prophecy* is a psychological construct that explains how a person may come
to believe about themselves what others believe about them (Guyll, Madon, Prieto, & Scherr,
2010).

*Self-monitoring* is a process whereby people use specific strategies to monitor their own
learning and progress towards goals (Cleary et al., 2012).

*Social justice mathematics education* is a philosophy by which teachers use social issues
to teach mathematics concepts while simultaneously helping students develop “sociopolitical
consciousness” (Freire, 1993), a sense of personal and social agency, and positive social and
cultural identities (Gutstein, 2003).
Theoretical Framework

The theoretical framework for this study bridges Vygotsky’s sociocultural theory and Bandura’s social cognitive theory (Bandura, 1986; Vygotsky, 1978). Through this section, I will explain how these two overarching theoretical views can connect a cultural view of teaching and learning with a cognitive view by relating the multitude of similarities within other more specific theories linked within these broader paradigms (see Figure 1).

Sociocultural Theory

Sociocultural theory stems from Vygotsky’s theories on learning through the use of social interaction and cultural tools, such as symbols, language, and communication (1978). Within this view in mathematics, students create their own knowledge and develop their own mathematical meanings through a process of sense-making and connecting to their own and others’ experiences, thoughts, and understandings. Sociocultural theory is humanistic, community centered, value-laden, and takes into account students’ cultural experiences and backgrounds (Cobb, 1994). Mathematics teachers utilizing this theoretical framework for teaching and learning help students build their knowledge through scaffolding current content with student’s prior knowledge, continuously trying to stay within each student’s zone of proximal development (Cobb, 1994; Van de Pol, Volman & Beishuizen, 2010; Vygotsky, 1978). They do this by creating an active social learning environment grounded in explaining and justifying their thinking to others, as well as incorporating lessons that connect to students’ lives in and out of school (Cobb, 1994; Steele, 2001).

Culturally relevant pedagogy is one theoretical view derived from sociocultural theory. It is a teaching and learning lens that considers traditional schooling to be inequitable to students from marginalized populations, including students of poverty. With respect to mathematics
education, I will refer to CRP as CRMP, culturally relevant mathematics pedagogy. This view on teaching and learning maintains a focus on improving students’ mathematical learning while sustaining or enhancing their cultural identity and promoting student empowerment by teaching them how to use mathematics to look critically at the world around them (Gay, 2010; Gutstein et al., 1997; Ladson-Billings, 1995). Teachers looking to create more equitable classrooms and improve students’ mathematics learning, specifically of marginalized populations, may find this framework to be helpful in choosing culturally relevant contexts for their mathematics curriculum and planning appropriate instructional strategies. In addition, CRMP is closely related to social justice mathematics (SJM), where it is believed that when teachers help students develop positive identities, agency, and sociopolitical consciousness, they will be more engaged in learning and more empowered to take steps towards changing society, all while learning challenging mathematics (Gutstein, 2003).

Figure 1 shows how CRMP and SJM can be combined within one framework with five main tenets for teachers to take into consideration when planning their curriculum and pedagogy. The first element in this framework is that learning is situated within the context of the students’ cultural backgrounds, experiences, beliefs, and community values, (Gay, 2010; Ladson-Billings, 1995; Lave & Wenger, 1991). This may involve teachers becoming aware of the local places, current community issues, and communicating with families about their values, interests, and their own cultural knowledge (Moll, Amanti, Neff, & Gonzalez, 1992). Second, Gutstein (2003) theorizes that teachers need to assist students in developing positive social identities. This can be accomplished through the use of social constructivist instructional strategies, as suggested through CRMP literature (Gay, 2010; Ladson-Billings, 1995; Moses, West, & Davis, 2009). Third, teachers utilizing this framework work to develop caring relationships with their students,
as well as promote caring relationships between students and their peers (Gay, 2009; Gay, 2010; Ladson-Billings, 1995). One way that teachers promote these types of relationships is by having high expectations academically of each student, by supporting them in their mathematics development, and by helping them to develop social agency and autonomy (Gutstein, 2003). Social agency, as defined by Gutstein (2003), is the ability of a person to believe they have control over their place in society and that they have the power to change unjust circumstances in their lives and in others. The fourth tenet suggests that teachers should work towards developing students’ cultural identity through exploring their own competence about cultural understanding and by building their own sociopolitical consciousness (Gay, 2010; Gutstein, 2003; Ladson-Billings, 1995; Martin & McGee, 2009). Sociopolitical consciousness is an awareness of the connections between issues of society, such as racism, classism, and xenophobia, and the political arena, as well as how power influences decisions that affect us (Gutstein, 2003). Lastly, teachers choosing to utilize such a framework, as seen in Figure 1, will need to be reflective by challenging their own biases, assumptions, and stereotypes about their students and their families (Gay, 2010; Gutstein, 2003; Ladson-Billings, 1995; Moschkovich & Nelson-Barber, 2009). These teachers will also need to question current rules, decisions, and placements made by schools, districts, and legislators that may promote inequity for students’ mathematics learning and become advocates for equitable change (Gay, 2010; Gutstein, 2003; Ladson-Billings, 1995).

Social Cognitive Theory

Bandura’s social cognitive theory is a complex theory of interactions and influences leading to human behaviors and learning (1986). The main foundation of social cognitive theory is that learning primarily occurs through observation or modeling within a process of attention, retention, production, and motivation. These observations of others influence both the students’
self-efficacy (their belief about what they can achieve and how well they can achieve it) and their self-regulation (their ability to advocate for and use strategies that lead to success) (Bandura, 1977; Zimmerman, 1990). Self-efficacy is influenced by observation and modeling of others, fosters outcome expectations, and influences self-regulation, goal setting, self-monitoring, self-evaluation, and the use of strategies when doing tasks. It is a critical factor within mathematics achievement because self-efficacy influences the choices that students make, the amount of effort they expend, the perseverance that they exude when dealing with challenges, and the thoughts and emotions that they experience while working on tasks (Bandura, 1987). Self-regulation is described by Zimmerman (2002), as a three phase process of specific strategies that teaches students to be active participants in their own learning: forethought, performance, and self-reflection. These phases include such strategies as goal setting, assessing self-efficacy, focusing attention, self-monitoring, and self-evaluation.

When combined, self-efficacy theory and theoretical views on self-regulation can provide a framework for teachers looking to assist students in improving their mathematics learning and subsequent achievement (see Figure 1). Bandura’s (1987) self-efficacy theory states that self-efficacy develops through four sources: past mathematics performances, vicarious experiences, social persuasions, and students’ physical and emotional states. Past mathematics performances are instances in which students interpret how well they believe they know or understand the concepts or skills they are learning in mathematics and is considered to be the most influential source of developing a positive self-efficacy (Bandura, 1986). Students that feel successful at that moment will experience a rise in mathematics self-efficacy, whereas students who feel unsuccessful will experience a lowering of their mathematics self-efficacy. Raising student competency and confidence in mathematics, and therefore increasing positive mathematics
performances, can be assisted through the use of self-regulation strategies, such as setting high expectations, working towards short term goals, self-monitoring their understanding and use of time, and self-evaluating their work.

By vicarious experiences, Bandura (1987) suggests that students develop self-efficacy through observing models, which can be teachers, peers, themselves, and even technology. Self-efficacy is improved by observing others be successful at solving problems, especially if we feel the others are similar to ourselves. Teachers can provide support in this area by using cooperative learning and teaching self-regulation strategies, such as help seeking strategies and metacognition (Slavin, 1996). The third source of self-efficacy hypothesized by Bandura is the benefit of social persuasions to improving self-efficacy. Teachers use social persuasions when they build caring relationships with their students, encourage and support caring relationships between students and their peers, honor students’ voices by giving students choices, and by frequently celebrating big and small successes in their mathematics learning. Finally, self-efficacy can be positively or negatively influenced by a students’ physical and emotional state. Teachers can reduce stress and anxiety by creating a positive and unthreatening classroom environment focused on the process of learning, working to minimize bias and stereotypes in the classroom, and by using engaging and culturally relevant curriculum and instructional strategies.

**Resilience Theory**

One promising avenue of research on the academic achievement of students living in poverty is resilience theory. This can be seen at the center of Figure 1, suggesting that resilience theory can be bridged between both culturally relevant mathematics pedagogy and self-efficacy theory due to similarities in the theoretical paradigms, as well as the pedagogical and curricular choices made by mathematics teachers when implementing both frameworks. Researchers who
study resilience theory investigate students that encounter risk exposures, such as many children who grow up in poverty circumstances, focusing on “strengths rather than deficits” (Fergus & Zimmerman, 2005, p. 399). The theory examines students’ assets (internal factors), their resources (external factors), and their relationships between decision making, achievement, and “understanding healthy development in spite of risk exposure” (Fergus & Zimmerman, 2005, p. 399). Students that grow up in poverty, especially ethnically and racially diverse students, have generally lower self-efficacy when it comes to academics, and attend schools that are “less conducive to academic resilience” (Borman & Overman, 2004, p. 191). Resilient students of marginalized populations show greater engagement, greater self-efficacy, greater self-esteem, and more positive outlooks on school, specifically in regards to learning mathematics (Borman & Overman, 2004).

As seen in Figure 1, three protective factors needed for students to move towards resilience have been hypothesized by Benard (2004): caring relationships, high expectations, and opportunities to participate and contribute in their lives. Mathematics education researchers have applied these protective factors to mathematical resilience, suggesting that resilience is needed specifically in mathematics because of the way in which it is traditionally taught and common beliefs about mathematics being a fixed ability (Dweck, 2006; Kooken et al., 2013). Mathematical resilience is defined as developing a perseverance to learning mathematics despite struggles, such as frustration and confusion (Johnston-Wilder & Lee, 2010; Kooken et al., 2013; Wilburne, Wildmann, Morret & Stipanovic, 2014). This may be seen through a student’s increased participation, understanding, interest, and enjoyment in the mathematics classroom, as well as an overall improvement in their mathematics performance.
To assist students in moving towards mathematical resilience, teachers need to advance students' abilities in social competence, problem solving, developing autonomy, and building a sense of purpose through mathematics contexts (Bernard, 2004; Johnston-Wilder & Lee, 2010). Social competence in mathematics can be developed through the use of social constructivist instructional strategies, such as cooperative learning and Complex Instruction, and by utilizing and teaching help seeking strategies and peer modeling (Horn, 2012; Johnston-Wilder & Lee, 2010; Lotan & Cohen, 1997). Mathematical problem solving can be enhanced by advancing high expectations of all students, increasing student engagement through the use of interesting contexts, cultivating students’ sociopolitical consciousness, building a positive, unthreatening classroom environment, and by utilizing self-regulation strategies (Gay, 2009; Gutstein, 2006; Johnston-Wilder & Lee, 2010; Parajes, 1996b; Parajes & Miller, 1994). Providing students with engaging tasks that require productive struggle to make sense of the mathematics can also lead towards mathematical resilience (Hiebert & Grouws, 2007; NCTM, 2014; Warshauer, 2015).

Teachers can help students build autonomy through positive relationships built on respect of their cultural identity, developing a sense of agency through goal setting, metacognition, and self-evaluations, and celebrating student successes (Cleary et al., 2012; Gay, 2010; Shumate, Campbell-Whatley, & Lo, 2012). To move students toward mathematical resilience, teachers also need to foster a sense of purpose for mathematics in their students’ present and future lives (Johnston-Wilder & Lee, 2010).

**Significance of Study**

This study will continue to expand the knowledge on using CRMP in mathematics classrooms. Mathematics research with a focus on equity, using CRMP, is common, however, similar research on students of poverty is limited. This study will add to existing research on the
use of CRMP, specifically referring to the challenges and choices that a teacher makes while utilizing the CRMP framework for curricular and pedagogical decision making. In addition, there is a need to investigate the use of CRMP with students of poverty for improving mathematics achievement. This study will attempt to bridge that gap in the current research. The work that is necessary to reform schools and educate teachers on these issues is greatly needed at this current time due to the complex multitude of pedagogical considerations for teachers looking to teach more equitably (Kitchen, 2003).

This study may be significant in informing and expanding emerging research in mathematics self-efficacy of students living in poverty. Much of the current research in mathematics self-efficacy is focused on quantitative analysis of self-efficacy rating scales with very few studies examining students’ own voices. Pajares (1996a) reported that more qualitative studies using direct observations are needed in mathematics self-efficacy in order to better understand students’ views about school, mathematics learning and their academic habits (Usher & Pajares, 2008). Mathematics self-efficacy has consistently been shown to be a significant factor in predicting students’ mathematics achievement, performance, problem solving, vocational interests, and career goals (Fouad & Smith, 1996; Multon, Brown, & Lent, 1991; O’Brien, Martinez-Pons, & Kopala, 1999; Pajares & Graham, 1999; Pajares & Miller, 1994). Additional knowledge on the mathematical resilience and self-efficacy beliefs of students living in poverty may be gained through this study, which may help other teachers assist their students who are dealing with similar circumstances.

Using a lens of CRMP and self-efficacy theory together will advance this understanding making it particularly relevant to the practicing teacher with an eye towards equity and advancing the mathematics achievement of students of poverty. This will include how a teacher
may provide supports for improving self-efficacy within the CRMP framework, whether the CRMP framework has sufficient guidance for teachers wanting to improve student self-efficacy in mathematics, and how student mathematics achievement may influence their self-efficacy and vice versa. This study will help other researchers understand how CRMP is developed in a high poverty mathematics classroom and how its components may influence students’ mathematics self-efficacy. By gaining this understanding, teachers may be able to bring research into practice and create more equitable learning environments, which in turn may improve students’ mathematics self-efficacy and achievement.

This research may also be significant in highlighting the use of mixed methods action research based in a mathematics classroom. This may include how a teacher researcher structures time consuming and complicated research tasks while being a practicing teacher, such as data collection and analysis, teacher reflection, and writing within the phases of the study. There is a need for mathematics self-efficacy research that utilizes qualitative and mixed methods (Usher, 2009). Pajares (1996a, p. 566) states:

Quantitative efforts will have to be complemented by qualitative studies aimed at exploring how efficacy beliefs are developed, how students perceive that these beliefs influence their academic attainments and the academic paths that they follow, and how the beliefs influence choices, effort, persistence, perseverance, and resiliency.

In addition, this research will define and describe the use of specific data collection tools that other teacher researchers may find helpful in their own studies on CRMP or self-efficacy. These include various student interview protocols, student and teacher observation scales and self-efficacy rating tools.
CHAPTER TWO
LITERATURE REVIEW

According to the United States Census, in 2012, approximately 15% of American residents were living below the poverty threshold, which for a family of four is earning less than $23,050 annually (United States Census Bureau, 2014). For children under the age of 18, the percentage increases to 21.8%. In addition, people of racial or ethnic diversity make up a larger proportion of those living in poverty. For example, of people living in poverty, only approximately 10% are classified as non-Hispanic White, while the other 90% are of a non-White race or ethnicity, most commonly Black, Hispanic, Native American, or multiracial (United States Census Bureau, 2014). Although most poverty measurements are based on a mathematical formula devised by the Census, it can also be based on the amount of free and reduced lunches offered through schools, or based on certain characteristics and situations people may be in because of a lack of resources, for example homelessness and joblessness (Milner, 2013).

This literature review will begin with an overview of assumptions and myths about poverty, including what some researchers call the culture of poverty. This will be followed by a discussion on the physical, mental, emotional, and academic realities for many people living in poverty. It will then transition into a discussion concerning gap-gazing, specifically referring to the differences between the terms opportunity gap, achievement gap, and the idea of not fixating on a gap among or within the mathematics learning of students. Next, I will begin to discuss what a pedagogy of poverty looks like and how and why mathematics education needs to change in order to provide equity for students living in poverty. Equity pedagogies, such as culturally relevant mathematics pedagogy (CRMP), equity literacy, and social justice mathematics (SJM)
will be compared and examined, followed by a discussion on mathematics self-efficacy and self-regulation. Finally, I will bring these topics together as I discuss resilience theory in mathematics. I will consider how this theory encompasses much of the prior pedagogies and psychological constructs discussed. This review will conclude by suggesting that, through a combination of these theoretical views, teachers can work to build students of poverty up by empowering them to become autonomous learners through developing their own cultural identity, improving their mathematics self-efficacy, and increasing their overall mathematics achievement.

**Myths about Poverty**

There are many prevalent myths pertaining to people of poverty that are currently widespread throughout society and within education. These myths breed falsehoods and perpetuate stereotypes that can lead to inequitable circumstances for students. One myth that is particularly harmful is the belief that the parents of children living in poverty do not value education because their children tend to have higher numbers of absences and because their parents may not show up for parent teacher conferences (Gorski, 2008a). Research, however, has shown that parents living in poverty do care about their children’s education, but many times their older children are forced to miss school, or cannot devote as much time to school work, because of numerous family responsibilities (e.g., babysitting, translating, and working) (Cortesão, 2011). There also exists the idea that non-English speaking parents are less involved with their child’s education because they may not speak the dialect of the dominant culture, when in fact they may be very involved in providing educational opportunities outside of the school walls, within family traditions, workplaces, or household duties (Gee, 2004). From another angle, Ladson-Billings (2014) suggests that poor people do not value *traditional*
schooling because they recognize the irrelevancy to real life and the lack of preparation for the workplace.

The *culture of poverty* is another myth that suggests that “poor people share more or less monolithic and predictable beliefs, values, and behaviors” (Gorski, 2008a, p. 32; Lewis, 1961). Teachers’ beliefs and perceptions of students’ abilities, based on socioeconomic status, can have an impact on the content difficulty they choose to teach, the instructional strategies they use to teach that content, the language and discourse patterns they choose to use, and the relationships that they build with their students (Atweh, Bleicher, & Cooper, 1998). Oscar Lewis (1961) coined the term *culture of poverty* in his seminal case studies on poverty in Mexico. He identified dozens of characteristics that he attributed to people living in poverty, such as crime and drugs. Ruby Payne (2003) is a current player spreading this idea of a culture of poverty. In her books, she promotes the view that racially diverse students do not understand how to operate within the White mainstream culture (Gorski, 2008b; Milner, 2013). Many researchers deny that there is such a thing as a culture of poverty (Gorski, 2008b; Milner, 2013). Instead, they challenge this notion by demonstrating that people living in poverty do not have any less of a work ethic, are not less motivated, do not use drugs and alcohol more, and do not value education less than wealthier people (Galea, Ahern, & Vlahov, 2004; National Center for Children in Poverty, 2004).

The deficit perspective of a culture of poverty creates attention on the suffering and obstacles of living in poverty, yet distracts attention away from what Gorski (2008a) calls the *culture of classism*. This culture of classism derives from deficit theory, which suggests that people living in poverty are poor because they lack the intellect and morality to move ahead in life. This belief perpetuates the idea that poor people are underserving and ignores the resources...
that people living in poverty lack, such as health care, clean water, safe and affordable housing, and a living wage job (Gorski, 2008a). It deters the focus away from social justice and equity and continues to feed into some school and teacher beliefs that low-income students need only low expectations for their learning. In addition, the culture of poverty maintains a *myth of meritocracy*, the widespread idea that if you work hard enough you can move up the social ladder, get a good job, and be a successful American (Milner, 2012). Many teachers believe this myth and teach students to try their best and work hard in order to meet the learning expectations, without fully understanding the many inequities and obstacles their students must overcome to meet the same expectations as other wealthier students. As Milner (2012) put it, meritocracy is a false expectation because people in poverty do not start off at the same position on the social ladder.

**Realities about Poverty**

As the culture of poverty and other myths spread, they can be particularly damaging in schools, as teachers from middle class upbringings attempt to build relationships based on these myths, biases, or past beliefs about the poor (Gorski, 2008a). Yet, even though there are many assumptions made about people who live in poverty, there are important realities that must be taken into account when teachers are working to build relationships with students and families in order to plan for students’ mathematics instruction. Realities that must be considered include the neighborhoods they live in and physical, mental, behavioral, and academic issues that may affect these students’ mathematics learning.

The neighborhood in which a child grows up in has shown to affect student achievement, especially at the adolescent stages (Catsambis & Bevreidge, 2001). People that live in poverty, due to their lack of monetary funds, tend to live in neighborhoods that have an increased amount
of violence, gangs, and drugs (Fang, Rosenfeld, Dahlberg, & Florence, 2013; Kozol, 1991). In addition, the socioeconomic status of a neighborhood has been shown to indirectly affect students’ mathematics achievement because many low socioeconomic parents are not able to help their children with their schoolwork for various reasons, such as their own difficulties in mathematics or their need to work multiple jobs and be away from the home for long periods of time (Catsambis & Beveridge, 2001; Reeves, 2012). Many children in impoverished homes do not have access to the tools that most middle class children have: such as reading books, writing materials, and computers (Engle & Black, 2008; Kozol, 1991). To improve the mathematics learning of these students, teachers must to be aware of the additional needs and supports that these students and families may require to be successful in school mathematics.

Poverty can also impact the physical ability of children to function and succeed in school. Children who are born into poverty have a higher probability of having lower birth weights, more health problems, poorer nutrition, and increased exposure to lead, which can cause complications with motor control and attention (Linver, Brooks-Gunn, & Kohen, 2002). In addition, children who grow up in poverty are more likely to have experienced abuse, family addictions, nutritional deficiencies, missed meals, excessive school absences, homelessness, and higher levels of chaos in their lives (Evans et al., 2005; Milner, 2013). These children tend to have a higher probability than non-poor students of internalizing behaviors, such as anxiety, withdrawal, and depression (Brooks-Gunn & Duncan, 1997; Cortesão, 2011). Students who experience poverty during their school-age years have a higher tendency to display externalizing behaviors, such as aggression, violence, and acting out. Although, children who experience poverty have a significantly higher chance to incur these learning challenges, it is imperative to point out that most children living in poverty grow up to be happy, healthy, and intelligent adults.
with only minor or no potential difficulties in their cognitive abilities, a phenomenon known as resilience (Zimmerman & Arunkumar, 1994).

Poverty has been shown to affect children’s learning and development in mathematics (Leventhal & Brooks-Gunn, 2000). Brooks-Gunn, Linver, and Fauth (2005) showed that poor children’s IQ scores, assessed between two and five years of age, ranged from two to four points lower than non-poor children and children in deep poverty showed a difference of six to thirteen points on tests of achievement, IQ and verbal ability (Brooks-Gunn & Duncan, 1997). In addition, Axinn, Duncan, and Thornton (1997) demonstrated that, as years pass, these differences may lead to even greater differences in achievement and retention and may eventually lead to school dropout. Leventhal and Brooks-Gunn’s (2000) results indicated that lower mathematics achievement have been shown to be related to the individual and combined effects of family income, poverty status, parental education, family structure, parental occupation, and parental employment.

Finally, children living in poverty are more likely to experience compounded negative educational factors in their schools that may limit their educational growth. For example, many schools in high poverty communities have rundown facilities, an increased number of teachers with less experience, more teacher absences and substitute teachers, and more teachers who teach outside of their subject area expertise (Barton, 2004; Kitchen, 2003). Many teachers within these schools cite higher workloads, many extracurricular commitments, and multiple administrative duties, which they are expected to tackle on top of their primary job of planning for and teaching mathematics (Kitchen, 2003). High poverty schools can be highly culturally diverse or highly monoracial, but they do have a tendency to vary greatly in the mathematic abilities of their students, as measured by standardized tests (Knapp, 1995). High poverty school
districts are often underfunded compared to wealthier districts because of state formulas which are based, at least partly, on property taxes (Payne & Biddle, 1999). Carey (2004, p. 1) demonstrated this “funding gap” by showing that, in 2004, there was “a nationwide disparity between high-poverty and low-poverty districts of $1,348 per student.” A lack of appropriate funding can lead to an absence of appropriate and current technology, a limited number of elective and advanced courses, and a shortage in adequate teacher and student supplies and materials (Darling-Hammond, 2010). It is important to bring these realities to the surface in order to begin conversations within schools, districts, and public policy. To improve the mathematics learning of these students, all parties need to be aware of the additional supports that these students and their families may need in order to be successful in learning school mathematics.

**Gaps**

Standardized tests, NCLB, and the notion of Adequate Yearly Progress have proliferated attention to racial, ethnic, and socioeconomic subgroups by requiring disaggregated assessment data for each student, school, and district from each state (NCLB, 2008). Through this process of labeling schools and students as “passing” or “failing,” based on state standardized testing results, educational leaders, researchers, the media, and bureaucrats regularly use the term achievement gap to describe the difference between groups of students that meet or do not meet state benchmarks. This deficit-based perspective, has been the conversation of many political and educational discussions nationwide, yet it focuses on what skills and knowledge these groups of students do not yet have versus what strengths they do have (Milner, 2012). The blaming for these gaps is placed upon the students, teachers, parents, and the students’ culture, taking away the focus from the inequalities between groups that continue to maintain these gaps. Milner’s (2012) response to the deficit view of the term achievement gap, is that the term forces all groups
to be compared to the dominant White cultural frame of reference. Gutiérrez (2008, p. 359) believes that when researchers focus on the achievement gap they leave out individual factors of student learning and send “an unintended message that marginalized students are not worth studying in their own right.” This inadvertent supporting of deficit thinking and negative stereotypes, in essence, emphasizes and perpetuates the achievement gap. Instead of focusing on the achievement gap, Milner (2012) suggests that we should focus on *opportunity gaps*. By considering how and why children in poverty have less opportunities, we can concentrate our efforts more on reforming the educational system that is sustaining the status quo, without succumbing to a deficit perspective (Tate, 2008).

Some researchers in mathematics education believe that we should focus on gains and the process of improvement seen in the achievement of students in poverty versus fixating on gaps (Gutiérrez, 2008; Rodríguez, 2001). Rodríguez (2001) believes that gap gazing leads to dichotomous, black or white, thinking, which leaves out important contextual data in the analysis of students’ mathematics achievement, such as teacher quality, current resources, and appropriate facilities. He suggests that researchers should work towards better understanding the reform process systemically. Similarly, R. Gutiérrez (2009) suggests that gap gazing supports deficit thinking and the idea that there is a quick fix for improving the mathematics achievement for students in poverty. Lubienski and Gutiérrez (2008) debated the use of gaps and gap analysis in mathematics education for equity. In this article, Gutiérrez argues that analyzing achievement gaps has had little impact in reducing such gaps over time and reports of such analysis in the media make the issue seem overwhelming. Lubienski argues that gap analyses are necessary to make policy makers aware of the gaps, which may lead to increases in resources (Lubienski & Gutiérrez, 2008). Lubienski (2008) also adds that mathematics education researchers need to be
able to counter claims by researchers and bureaucrats outside of mathematics education and that more strategic analyses could shed light on how gaps are influenced by equity issues, such as wealth disparity, job availability, economics, and policy decisions. In terms of mathematics instruction, R. Gutiérrez (2009) states that gap analyses may influence schools and teachers to make unfounded pedagogical choices, away from higher order thinking, in order to improve standardized testing scores to decrease the gap. Whereas, Lubienski (2008) states that analyses using gaps can help us see which groups need intervention, why they need the intervention, and what intervention strategies may work best to address their lower achievement.

Focusing too much attention on gaps can cause teachers and schools to essentialize their instruction and interventions, or provide a one size fits all education (Gutiérrez, 2013; Leonard, Brooks, Barnes-Johnson & Berry, 2010). Essentializing is defined by Gutiérrez (2013, p. 51) as “reducing a group to a single characteristic that seeks to convey the essence of that group.” This issue can be especially difficult when trying to implement culturally relevant instruction or take on mathematics tied to social justice (Leonard et al., 2010). Gutiérrez (2002) suggests that teachers should attempt to learn about their students’ needs on an individual level through observation, listening, and interacting with them to avoid essentializing their instruction. Gutiérrez (2007, p. 42) believes that there is a time for what she calls strategic essentialism, a “process of deliberately categorizing people based upon definable traits for the purpose of reaching higher (equity) goals.” Mathematics teachers striving for equity in their classrooms and their students’ achievement would do well to incorporate curriculum and instruction with their students’ voices included (Gay, 2010; Ladson-Billings, 1995). Gutiérrez (2013, p. 52) states that “without the voices of marginalized people commenting on their interpretations of the mathematical practices in which they are engaged, we are unlikely to fully understand the
possibilities of other arrangements in mathematics education.” This is in agreement with Freire’s (1993) “problem-posing” education, where students and teachers co-create their learning through dialogue, reflection, and action.

**Pedagogy of Poverty**

Schools must be able to provide a supportive and engaging environment for learning in order to fulfill their promise of equity to all students. Unfortunately, many schools and teachers succumb to deficit perspectives when it comes to students and their families who live in poverty, such as focusing on the terms achievement gap, at-risk, and minority (Valencia, 2010). For example, the word *minority* is used to describe a group of people different from the dominant group in race, ethnicity, or religious affiliation. This suggests that these groups of diverse students are less in population, when, in fact, the number of majority-minority schools in American continues to grow (Cortesão, 2011). As a deficit perspective, the word minority also insinuates that people classified as being the minority are lacking in something or below in ability to the majority. These perspectives lead to poor relationship building, inequitable educational practices, and increased standardization in schools (Cortesão, 2011). With standardization comes standardized testing to determine how well schools, teachers, and students are meeting those standards. This then leads to labeling students, schools, and teachers as ineffective and at-risk. With standardization, teachers are being told what standards to teach and, especially within high poverty schools, how to teach it (Kitchen, 2003), however, Milner (2012, p. 694) states that “standardization is antithetical to diversity,” suggesting sameness and homogeneity, which neither correctly categorizes most American classrooms in high poverty communities. Unfortunately, much of what is encouraged is scripted and a highly mechanized
direct instruction of vocabulary, skills, and content knowledge (Hill, 2010; McSpadden McNeil, 2005).

Haberman (1991) identified this type of instruction during his examination of urban, high poverty schools as a *pedagogy of poverty*. Besides a focus on direct instruction and skills, Haberman (1991) viewed, what he considered dehumanizing practices that act to promote teacher authority and power, for example, a majority of time was spent on lecturing, assigning, monitoring, and grading homework and tests, and behavior management. As Haberman explains (1991, p. 292), “It is a pedagogy in which learners can ‘succeed’ without becoming either involved or thoughtful.” This more traditionally minded perspective still dominates in most mathematics classroom and has been documented in mathematics education research. Buckley (2010, p. 62) suggests this type of mathematics education, with a heavy focus on procedures and non-relevant problems, as a *deprived* curriculum because teachers give little attention to understanding and sense making. In elementary classrooms, researchers have found that the majority of time is spent on using prescribed curriculum that was teacher centered and focused on lecture, drill, and memorization versus hands-on learning, problem solving, and using manipulatives (McKinney, Chappell, Berry, & Hickman, 2009). These traditional approaches have been shown to leave students of poverty behind their peers in their mathematical understanding (Watson, 2006). Lubienski (2000) determined that middle school students from impoverished homes can be fearful of saying the wrong thing during problem solving, want more direction, and feel more comfortable with worksheets and immediate results. Waxman, Padrón, Shin, and Rivera (2008) showed that students identified as non-resilient scored lower on mathematics achievement than resilient students when taught through direct instruction and lecture.
Lubinski and Crockett (2007) analyzed data from the National Assessment of Educational Progress (NAEP) and determined that there was significantly less rigor within algebra courses in schools that serve a high proportion of minority students. Some teachers do not believe that students of poverty can learn mathematics through higher order thinking and open ended tasks (Boaler, 2002). They feel these students need more structure, explicit procedures to follow, and practice in mastering basic skills (Ladson-Billings, 2014). This deficit perspective of a pedagogy of poverty promotes stereotypes, essentializing, and focuses schools and teachers on students’ perceived deficits from being poor, rather than on their strengths and resiliencies due to their cultural backgrounds and experiences (Gutiérrez, 2002). Schools should be “widening the world for poor children, not constraining and narrowing” it and equity pedagogies provide a different perspective for teachers to explore when looking to increase mathematics achievement of students living in poverty (Ladson-Billings, 2014, p. 12).

**Equity Pedagogies**

Gorski (2013) poses the question, how do we improve educational opportunities for children living in poverty, not just test scores? The common response to NCLB from schools in high poverty areas labeled as failing is to focus completely on raising standardized test scores (Darling-Hammond, 2010; No Child Left Behind, 2008). The belief was, and still is, in many high poverty schools, that if we teach students only the standards in question, in a direct and skill-based way, with test-taking strategies, the students will improve their test scores and schools will no longer be failing. Welsh, Eastwood, and D’Agostino (2014) demonstrated that teaching to the test reduces the amount of time for instruction tied to conceptual understanding, problem solving, and critical thinking, and, ultimately, does not result in an increase in student achievement. One option for schools is to prioritize equity, over test scores, by reforming
classroom and school processes to specifically target increases in student learning using practices, such as those found in the process standards from the National Council of Teachers of Mathematics (NCTM) and the more recent mathematical practices in the CCSSM (National Council of Teachers of Mathematics (NCTM), 2000; NGA, 2010). Using these practices within problem solving with rich tasks, mathematical discussions, and increased conceptual development and understanding have been shown to result in improved standardized test scores of marginalized populations (Boaler, 2002; Gimbert, Bol, & Wallace, 2007). The use of cooperative learning strategies, such as Complex Instruction, have been shown to be of more importance to students’ mathematics learning and standardized test performance than the choice of curriculum or textbooks and the teaching of test taking strategies (Cohen & Lotan, 1997; Horn, 2012; Slavin, Lake, & Groff, 2009).

Complex Instruction is an instructional framework for designing tasks, facilitating student group work, and creating equity within the classroom for learning mathematics. This is done through the development and use of multiple ability open-ended problems, assigning responsibility or roles to students (for example, facilitator, resource manager, recorder/reporter and team captain), and addressing status by reaffirming lower-status student’s ideas and mathematical understandings (Cohen & Lotan, 1997; Cohen, Lotan, Scarloss, & Arellano, 1999; Horn, 2012). Implementation of Complex Instruction entails teachers having high expectations of all students, stressing effort over innate ability, and having clear expectations and routines (Boaler & Staples, 2008; Horn, 2012; Staples, 2014). Esmonde (2009) observed that during group work in secondary mathematics classrooms students quickly adopt a status position within the group. These positions hinder collaboration, especially when there is a perceived expert in the group, and leads to working individually. Groups using true collaboration allow for multiple
solution paths and explanations of all group members to be heard. Tasks used with Complex Instruction are organized around a main theme or question, are multidimensional to allow all students access to enter the problem, and are developed to have a need for interaction and collaboration between group members in order to accomplish the task (Cohen et al., 1999). Boaler and Staples (2008) demonstrated that students taught mathematics using Complex Instruction were more positive about learning mathematics than students not using this approach. Their research also showed that students progressed to showing increased respect to one another in the mathematics classroom and inequities between ethnic groups reduced or disappeared after using Complex Instruction.

Complex Instruction elements can be utilized within the implementation of curriculum built upon similar philosophies. One such curriculum is the middle school mathematics textbook series Connected Mathematic Project (CMP). CMP is a problem-centered textbook which uses an inquiry approach to solving real world mathematics problems (Lappan et al., 2014). Daily mathematics problems are launched through questioning and students work together in groups to come up with solutions, many times through various methods (Boaler & Brodie, 2004; Boaler & Humphreys, 2005). CMP is considered to be a standards-based or reform-based curricula because of its focus on conceptual understanding, procedures, and problem solving tied to the NCTM standards (NCTM, 2000). Stein, Remillard, and Smith (2007) state that standards-based mathematics curriculum gives students more opportunities to develop sense making of mathematics content than more traditional curricula. On performance tasks involving algebraic functions, students who had had three years of teaching using CMP were able to demonstrate conceptual understanding, strategic competence, procedural fluency, adaptive reasoning, and perseverance towards finding a solution (Krebs, 2003). Students in the middle school who are
taught with CMP have been shown to do significantly better on problem solving and conceptual sections of standardized tests, as well as on algebra and data analysis related items (Post et al., 2008; Reys, Reys, Lappan, Holliday, & Wasman, 2003). When teachers and students were asked about their thoughts on CMP, they overwhelmingly believed that the students were becoming better problem solvers and were able to critically think about mathematics, as well as the teachers were better able to understand the mathematics algorithms and formulas (Cain, 2002). Students in this study also stated that the problems in the program were fun and they liked the relevance of the materials.

*Good teaching*, according to Haberman (1991), includes students being actively engaged in cooperatively designing, creating, and learning content that is relevant to their lives, and to the lives of those they care about. Bowers (2000) may call a classroom as described by Haberman (1991) as instilling a *pedagogy of success*. It is important in mathematics to encourage sense making for students to acquire deep understanding (Schoenfeld, 2008). In addition, sense making encourages numeracy and fluency skills for students to work towards problem solving efficiency. Good teaching helps students build their social and cultural identities as mathematicians and supports their mathematics self-efficacy beliefs as they move towards higher level, more abstract, mathematics. CRMP includes approaches that would be considered *good* teaching; such as using innovative teaching strategies with a focus on student strengths and an overarching eye on curriculum and pedagogy towards equity (Gay, 2010; Greer et al., 2009; Ladson-Billings, 1995). These approaches can engage marginalized students in mathematics learning through the use of culturally relevant real world contexts in inquiry based problem solving tasks and cooperative learning, however, this framework has not regularly been applied to research involving students of poverty (Gay, 2010; Greer et al., 2009; Ladson-Billings, 1995).
Milner (2013) and Gorski (2013) agree that teachers should incorporate real-life examples in their teaching that are connected to students’ realities, however, they also suggest that these problems should include references to poverty and the injustices that people in poverty experience. By including matters of poverty, teachers can bring social justice issues into the classroom that directly impact students’ lives and the lives of their families. SJM has been shown to engage students in rigorous mathematics, while simultaneously helping students to see the world through mathematics and develop mathematical power, the ability to utilize mathematics to analyze inequitable social circumstances (Gutstein, 2003). In order for teachers to incorporate student experiences within their mathematics lessons, they need to learn about their students’ home lives and culture through building meaningful relationships with them and their families and then applying those situations to mathematics problems (Moll et al., 1992). Mathematics education researchers state that students living in poverty should be active participants in their own sense making and understanding of mathematics (Hill, 2010) through the use of rich mathematical tasks that expand on their interests (Lubienski, 2007). Such tasks should include situations where students are using multiple representations and multiple strategies, as well as requiring students to explain their thinking (Stein & Lane, 1996). Teaching mathematics for equity also includes systemic school-wide reforms, such as creating a school culture of care, cultural respect and discontinuing the use of student tracking in mathematics (Boaler & Staples, 2008; Gay, 2010; Gorski, 2013; Ladson-Billings, 1995). Equitable mathematical practices can be envisioned through strength-based perspectives such as CRMP, SJM, and equity literacy, as will be discussed in the following sections.

**Culturally Relevant Mathematics Pedagogy (CRMP).** CRMP conflicts with many of the traditional approaches previously discussed. Many traditional approaches to mathematics
education are viewed as inequitable to marginalized populations, including students of poverty. CRMP approaches are used to improve student’s mathematics learning, sustain or enhance student cultural identity, and promote student empowerment by teaching students how to look critically at the world around them using mathematics (Gay, 2010; Ladson-Billings, 1995; Gutstein et al., 1997). These three goals are accomplished by educators using a holistic vision that encompasses all facets of mathematics teaching from building relationships to curriculum to instruction to assessment (Gay, 2010). Encompassing theories from Ladson-Billings (1995), Gay (2010), and Greer, Mukhopadhyay, Powell, and Nelson-Barber (2009), I propose five main factors of CRMP that can be utilized within a mathematics classroom striving for equity among students of poverty: using students’ culture within the pedagogy, using instructional decisions based in socioconstructivism, developing caring relationships with students and between students, developing personal responsibility for both teacher and student, and taking a critical or social justice perspective.

With CRMP, learning is situated within the context of the students’ cultural backgrounds, experiences, beliefs, and communities (Gay, 2010; Ladson-Billings, 1995; Lave & Wenger, 1991; Wlodkowski & Ginsberg, 1995). Building off of students’ own culture has been shown to help students develop positive attitudes and gain competence in their abilities, leading towards increased student motivation and self-efficacy (Wlodkowski & Ginsberg, 1995). Ladson-Billings (1995) saw this through her examination of excellent African-American teachers who took the time to learn about each of their students, develop curriculum that connected with their students’ cultural backgrounds, and used scaffolding and multiple forms of assessment to reach all of their learners (Black, Harrison & Lee, 2003). One goal in connecting curriculum to student culture is to assist them in developing cultural competency (Ladson-Billings, 1995). Developing or
maintaining cultural competency involves respecting the home cultures of students and their families by allowing students to use these resources in the classroom, such as their home language and cultural and community strengths (Gutiérrez 2002; Ladson-Billings, 1995; Moll et al., 1992). By using students’ cultural backgrounds and experiences, educators affirm and validate students’ identities (Gay, 2010). Gay (2010) suggests this can be empowering to students of marginalized populations because they may feel they have a voice and that schools value who they are as a cultural being, however, little research has been done to show how to use CRMP in this way with students of poverty.

Utilizing students’ and family’s cultural backgrounds, experiences, and knowledge in the classroom is referred to as using their funds of knowledge (Moll et al., 1992). Moll, Amanti, Neff, and Gonzalez (1992) used home visits as a way to gain cultural knowledge that could then be included in classroom content, lessons, or larger units and projects. Lin and Bates’ (2010) study on home visits demonstrates that teachers who go on home visits begin to see their students and their families from a more positive perspective and are then able to create more culturally relevant lessons. Mathematics education research on funds of knowledge and culturally relevant curriculum has been demonstrated using knowledge from native populations, such as native Alaskans and the Māori peoples of New Zealand. Kisker et al. (2012) demonstrated that elementary students’ mathematics understanding of measurement and place value increased after using curriculum centered on berry picking and traveling to an island. Mathematics lessons were created for Māori students that tied into their local knowledge of traditional games, stories, songs, and crafts (Averill et al., 2009). Some researchers have taken the mathematics out of the classroom. The community and the spaces around the community constitute place and offer another fund of knowledge for teachers to examine (Greenwood, 2009). This includes pedagogy
related to the land, indigenous peoples, landmarks in an area and the social, historical, or political issues that may be connected to the place. Using a theoretical perspective of realistic mathematics education (Gravemeijer, 1998), Masingila and de Silva (2001) researched students who did mathematics at a miniature golf course. They found using this lens was particularly helpful in thinking about and understanding students’ mathematical ideas about geometry. Realistic mathematics problems were also developed to teach statistics to students in Portugal by having them explore local salaries (Carvalho & Solomon, 2012). To further the connections to students of poverty, lessons and assessments can integrate mathematics with economics and social issues related to wealth (Van Den Heuval-Panhuizen, 2005).

CRMP suggests using a social constructivist approach to assure that students’ knowledge is constructed through cooperative dialogue and active engagement (Cobb, 1994; Gay, 2010; Ladson-Billings, 1995; Wlodkowski & Ginsberg, 1995). “Social constructivism views mathematical knowledge as being influenced by human activity and grows out of a community composed of individual mathematicians” (Telese, 1999). Wlodkowski and Ginsberg (1995) include this in their framework as part of establishing inclusion, a necessary component for motivating students. Teachers in Ladson-Billing’s (1995) study believed that knowledge was best gained through sharing, constructing, and building on prior experiences in a community of learners. They believed in “pulling knowledge out” versus putting knowledge in (Ladson-Billings, 1995, p. 479). In Boaler and Staple’s (2008) study, a reform oriented school used Complex Instruction to utilize group roles and cooperation as a way for students to work together towards an understanding of mathematics problem solving (Cohen & Lotan, 1997; Horn, 2012). Complex Instruction has been shown to increase status of lower-status students in the mathematics classroom, therefore improving their identity as doers of mathematics (Cohen &
Alexander, Chizhik, Chizhik and Goodman (2009) found that open tasks, such as CRMP tasks, can also improve students’ status by allowing for more participation in the mathematics and validation of students’ ideas. Roseth, Johnson, and Johnson (2008) determined that cooperative classroom structures predicted positive achievement and peer relationships in early adolescents versus competitive or individualistic structures. One example of using social constructivism and cooperative learning with CRMP is M. V. Gutiérrez’ (2009) study on a group of Latinas using mathematics to prevent a school from closing. The problem was multidimensional and, therefore, required students to do specific parts, such as designing surveys and collecting, organizing, analyzing, and representing the data. In addition, this study taught the students collaboration, responsibility, and a sense of agency to become active citizens.

Having an *ethic of caring* is the third component for teaching within a framework of CRMP (Ladson-Billings, 1995, p. 473). This involves teachers believing that all of their students are capable of high levels of academic success and continually working towards caring teacher-student relationships by developing supportive connections with each student. Gay (2010, p. 48) sees caring relationships, not just as “caring about” students, but “caring for” them. She states that “caring for” students “encompasses a combination of concern, compassion, commitment, responsibility, and action.” Teachers must truly believe that all students can succeed in the course and teach students to take personal responsibility for themselves and their learning (Ladson-Billings, 1995). Teachers must also take personal responsibility for their students’ success by making a commitment to each student. Morrison, Robbins, and Rose (2008) state that this can be done by making themselves available to help students when needed, pursuing outside professional development, and by celebrating successes with their students. Rodríguez (2008) demonstrated through his research that teacher-student relationships that are based in respect and
high expectations can transform student agency and motivation for academic success. Positive teacher-student relationships can also promote resilience (Borman & Overman, 2004). Bondy, Ross, Hambacher, and Acosta (2013, p. 423) propose that teachers known as warm demanders are caregivers, authoritative, and have a commitment to social justice to “improve the lives of children in and out of school.” Strambler and Weinstein (2010) showed that an increase in an individual student’s perception of negative feedback from their teacher led to an increase in their devaluing of academics. In Garza’s (2009) study, students of Latina/o heritage perceived teacher care as being supportive academically, providing help within the class time and outside of the class time, showing interest in them as a person, and continually supporting them towards success. It has also been shown that teacher care relationships led to increases in mathematics achievement and mathematics self-efficacy for Latina/o English learners (Lewis et al., 2012).

Caring is also seen as a reciprocal relationship between the student and the teacher (Valenzuela, 1999). Valenzuela (1999, p. 61) found that students from marginalized populations, specifically of Mexican heritage, “are committed to an authentic form of caring that emphasizes relations of reciprocity between teachers and students.” This is important for an educator to consider because forms of communication that disrespect or devalue students from marginalized populations potentially could cause friction and halt relationship building efforts, which could lead to a decline in mathematics learning (Shevalier & McKenzie, 2012). Specifically, in mathematics education, Averill (2012) states that caring teachers respect the learning process of each student, yet are explicit about progress expectations. They consistently find time to meet with students one on one and give students opportunities to share their mathematics experience, knowledge, and beliefs. They utilize students’ responses and work during class explanations and incorporate movement during the mathematics class. Hackenberg (2005) discusses mathematical
caring relations as an interaction between teacher and student that bridges the cognitive and the affective. She states that teachers act in these mathematical caring relations by monitoring and responding to changes in students’ energies and responses. Students participate in these relations by being open to the mathematical interventions and tasks and by being willing to ask and respond to questions. Bartell (2011) suggests that mathematics teachers who are caring know their students in various ways: mathematically, racially, culturally, and politically. In order to show caring in these multiple ways, teachers must reflect on their own assumptions about their students and work towards rejecting potential deficit perspectives.

Ladson-Billings (1995) and Gay (2010) both proposed that students and teachers should work towards personal responsibility. Using CRMP has been shown to “affect student dispositions, attitudes, and approaches to learning” (Gay, 2010, p. 31). Allexsaht-Snider and Hart (2001) promote CRMP as a way to improve engagement and belongingness of marginalized students in the classroom through modeling and solving of community centered problems. Shumate, Campbell-Whatley, and Lo (2012) studied middle school Latina/o students with learning disabilities while being taught with CRMP. They found that the students’ mathematics achievement was higher in the CRMP group versus the group receiving traditional instruction. In addition, the students gained autonomy and responsibility through the use of guided notes, graphic organizers, scaffolding, explicit instruction, and explicit communication of expectations, background knowledge, and successes towards short term goals in their mathematics learning. Mastery of a topic over a series of small successes has been shown to increase a student’s mathematics self-efficacy, their belief in their ability to do mathematics (Pajares, 1996b). Pajares (1996b) explains that an increase in self-efficacy can also improve student motivation and engagement in the mathematics classroom. CRMP may have potential to improve psychological,
emotional, and social factors in order to improve marginalized student learning and achievement. When students are encouraged to work together collaboratively, they develop a shared sense of purpose towards being accountable for each other’s learning (Ladson-Billings, 1995; Wlodkowski & Ginsberg, 1995). Cooperative learning strategies also help form personal responsibility within students. Within lecture style classrooms, teachers have the power to control all facets of the instruction. When students are put into cooperative groups to work together on mathematical problems or tasks, the power is shifted to them having more responsibility and control over their own learning (Gay, 2010).

Ladson-Billings (1995, p. 476) states that “not only must teachers encourage academic success and cultural competence, they must help students to recognize, understand, and critique current social inequities.” Gay (2010, p. 37) believes that students must learn to “become change agents committed to promoting greater equality, justice, and power balances among ethnic groups,” even in the classroom. Some CRMP educators reshape the curriculum (Morrison, Robbins, & Rose, 2008) into what Freire (1993) calls a problem-posing curriculum, a pedagogy of dialogue between teacher and students. Freire (1993) states that this type of curriculum transforms students into conscious, critical thinkers through reflection, creativity, and action. Hmelo-Silver (2004, p. 261) suggests that problem-based learning has the potential to increase student motivation and help students to become more “reflective and flexible thinkers,” however, scaffolding may be needed to support all students in accessing the context and mathematics (Hmelo-Silver, Duncan & Chinn, 2007; Kirschner, Sweller, & Clark, 2006). Gay (2010) proposes an integrated, interdisciplinary, and contextualized curriculum. Henderson and Landesman (1995) taught students of Mexican heritage mathematics through a thematically integrated unit and found that their attitudes towards mathematics were more positive after the
intervention. Contextualized mathematics curriculum taught through real world contexts and in a CRMP environment has led some researchers to explore mathematic dispositions and identities through students’ math talk (Carvalho & Solomon, 2012). This type of critical mathematics pedagogy is considered transformative because it “develops social consciousness, intellectual critique, and political and personal efficacy in students so that they can combat prejudices, racism, and other forms of oppression and exploitation” (Gay, 2010, p. 37).

**Social Justice Mathematics (SJM).** One goal in CRMP is assisting students in developing critical consciousness (Ladson-Billings, 1995). Developing a critical consciousness refers to enabling “people to understand their lives in new ways and consider ways to change systems that routinely oppress particular groups” (Aslan Tutak, Bondy, & Adams, 2011, p. 66). Gutstein, Lipman, Hernandez, & de los Reyes (1997) viewed students becoming critical mathematics thinkers through the use of CRMP, which they defined as being able to “make conjectures, develop arguments, investigate ideas, justify answers, and validate one’s own thinking.” Developing critical consciousness is also a goal of SJM. SJM rejects the illusion that mathematics is a neutral topic (Skovsmose & Valero, 2001) and attempts to assist students in the development of sociopolitical consciousness, a sense of social agency, and positive social and cultural identities (Gutstein, 2003). Gutstein (2003) believes that every school has unique characteristics and perspectives due to their specific population and that the mathematics curriculum should be adapted critically toward their views. Using mathematics related to race, poverty, and discrimination, Gutstein (2003, p. 37) found that his students learned to “read the world using mathematics, developed mathematical power, and changed their orientations towards mathematics” when supplementing his mathematics curriculum with real world projects grounded in these social justice issues.
SJM is considered a form of critical mathematics pedagogy, which is theorized through Freire’s work on problem-posing and humanizing curriculum and strives to connect issues of power, culture, and ideology (Freire, 1993; Stinson, Bidwell, & Powell 2012). Using a SJM project where high school Algebra II students investigated racial profiling by calculating, organizing, and analyzing statistics, Stinson, Bidwell, and Powell (2012) demonstrated that students continued to be critical mathematical thinkers even after the social justice lesson had ended. Atweh and Brady (2009) suggest that students not just be able to read the world with mathematics, but that they should work to transform it. They propose that teachers and students should be co-learners as they support each other in becoming responsible members of society without sacrificing the quality of the mathematics content or pedagogy. At times, the mathematics content of SJM can get lost, but Gutstein (2006) proposes that a final goal of SJM is to prepare students to succeed academically in mathematics as seen in the traditional sense. Academic success in this sense includes being able to access high level mathematics, pass standardized tests, graduate from high school, be successful in collegiate level mathematics, and pursue mathematics careers.

Equity literacy. CRMP and SJM have been utilized and researched heavily among marginalized populations classified racially and ethnically, however, there is a lack of classroom-based research tying these equity pedagogies directly to students of poverty. A new concept, equity literacy, developed by Swalwell (2011) and Gorski (2013), incorporates a specific poverty lens into CRMP and SJM, with the premise that equity is not only a cultural issue, but an issue related to a lack of resources, opportunities, and power for people of poverty. As defined by Gorski (2013, p. 19), equity literacy is:
The skills and dispositions that enable us to recognize, respond to, and redress conditions that deny some students access to the educational opportunities enjoyed by their peers and, in doing so, sustain equitable learning environments for all students and families.

The main premise of equity literacy is that educators should progress towards being equity literate, or having knowledge about equity, by learning to recognize, respond, and redress biases and stereotypes that perpetuate inequitable circumstances in schools and in society and use that knowledge to create and sustain further equitable practices in their own work (Gorski, 2013).

Fundamental to this recent teaching perspective is a strength-based approach to teaching that also embeds an understanding of poor people: their diversity, their struggles, and the biases that educators most often hold about them that makes inequities in the classroom apparent. In addition, equity literacy proclaims that test scores are ineffective at measuring equity (Gorski, 2013; Swalwell, 2011) and based on research of effective instruction for students of poverty, it is suggested that teachers use higher-order pedagogies, engaging curriculum, and set high expectations for every student to increase motivation, mathematical reasoning, problem solving skills, and achievement (McKinney & Frazier, 2008).

High poverty schools tend to have the most needs for teachers to become equity literate, due to their highly diverse populations, but all schools should work towards equity for all students. One example of equity literacy within a high poverty school can be seen in Valenzuela (1999) as she suggests that schools should be additive versus subtractive when it comes to caring for and teaching ethnically and racially diverse students. Instead of subtracting students’ cultural backgrounds and languages through acculturation practices, schools should bridge the gap, allowing students to use their languages and experiences within their education (Chamot & O’Malley, 1987). Equity literate teachers also utilize students’ languages, experiences,
backgrounds, and sociopolitical contexts to engage students in the learning of content (Moll et al., 1992).

In mathematics, the traditional way of schooling is so entrenched in many teachers’ and administrators’ memories that it can be difficult to change (Kitchen, 2003). For example, studies have shown that a disproportionate number of marginalized students are placed in lower tracks with no way to move in to a higher track, creating an inequitable path through all of their secondary mathematics experiences (Rubin, 2006). Boaler and Staples’ (2008) study also demonstrated how a working-class high school used equitable practices, such as detracking mathematics courses, creating heterogeneously mixed classrooms, and using reform based curriculums with cooperative learning strategies to increase mathematics achievement. Students at the reform based high school reported enjoying mathematics classes more and performed better on mathematics curriculum aligned tests than high school students taught in a more traditional format.

Many of the recommendations to promote equity literacy are the same or similar to CRMP and SJM: abolish tracking, reduce ability groupings, incorporate the arts and movement into curriculum, have high expectations for all students, use higher-order thinking practices, make connections in lessons to students’ lives, teach about poverty and classism, and develop a holistic view to teaching children that views the whole child (Gay, 2010; Gorski, 2008; 2013; Greer et al., 2009; Gutstein, 2003; Ladson-Billings, 1995). Teachers and schools must also work to cultivate trusting relationships with students, communicate regularly with students’ families, and work to ensure that school-wide information and events are accessible to all families.

**Criticisms and concerns of equity pedagogies.** Although research strongly suggests that equity based perspectives on curriculum and instruction are critical for the mathematics
development of poor students, there are many criticisms and concerns in regards to implementation. Schmeichel (2012) criticizes some researchers for unintentionally promoting a majority viewpoint by stressing disaggregated data and dichotomies, such as successful versus unsuccessful student populations. In addition, Schmeichel (2012) and Sleeter (2012) also criticize some educators for using cultural relevance in shallow ways, such as lessons about cultural celebrations, heroes, holidays, and food. CRMP educators may also essentialize the stereotypical cultural attributes of one ethnicity or race, looking for a one size fits all practice (Gutierrez, 2002; Leonard, Napp, & Adeleke, 2009).

One common concern that researchers have identified within teachers, is the fear of policy accountabilities. At a national level, this stems from top down approaches such as NCLB, CCSSM, and standardized testing. These initiatives force standardization and may cause institutional racism as students with cultural, linguistic, and unique learning needs are measured using the same scale and the same tests as all other students (Young, 2010). Standardization, and the decontextualization of curriculum that comes with it, promotes individualistic goals versus societal goals of democracy (Young, 2010). Fear of accountability measures, such as job loss and school closure or takeover, influence schools to mandate curriculum and influence teachers to teach only what is tested (Crocco & Costigan, 2007). Non-tested topics, contextualized curriculum, and cultural initiatives may be thrown aside if schools and teachers are not educated in current research (Crocco & Costigan, 2007).

In addition to accountability pressures, equity perspectives can be complex and overwhelming for educators to implement (Leonard et al., 2009). CRMP challenges much of the traditional mathematics teaching that occurs in American classrooms, (Morrison et al., 2008), therefore, there is a great need to educate multiple parties, such as parents, teachers, and policy
makers, on the tenets and benefits of this perspective (Sleeter, 2012). Teachers will need to develop significant background knowledge of student and community experiences in order to find and develop curriculum that balances rigor, culture, and social justice (Enyedy & Mukhopadhyay, 2007; Leonard et al., 2010; Leonard et al., 2009). Developing this background knowledge will not only take time, but could also require expense for materials or substitutes for teachers to collaborate, integrate, and develop partnerships (Ensign, 2003; Enyedy & Mukhopadhyay, 2007). Time is also needed to develop caring and supportive relationships with students, families, and community members (Morrison et al., 2008). Many teachers will need significant professional development to be able to implement equity pedagogies effectively in their classrooms, especially if their cultural background differs greatly from that of their students.

**Self-efficacy and Mathematics Learning**

Fasko & Fasko (1999, p. 298) state “that any program for improving academic performance and reducing problem behaviors must address self-efficacy needs.” Having high self-efficacy is one attribute of resilient students that allows students to persevere in the face of challenges (Borman & Overman, 2004). Self-efficacy, as defined by Bandura (1987, p. 3), is the “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments.” It is a subset of Bandura’s (1986) social cognitive theory, which draws on the idea of competence by enhancing student motivation through repeated personal successes, learning by watching peers, positive peer influences, and by reducing stress and anxiety (Bandura, 1987). Students that have high self-efficacy for a specific subject or task “participate more readily, work harder, and persist longer when they encounter difficulties” (Schunk, 1995).
Self-efficacy has been shown to have a direct effect on students’ mathematics achievement and persistence (Multon et al., 1991). Pintrich and DeGroot (1990) determined through regression analysis that self-regulation, self-efficacy, and test anxiety were the best predictors of performance in a middle school science and language arts class. In Pajares and Graham (1999), mathematics self-efficacy was the only motivational variable tested that predicted mathematics performance based on end of unit tests in a middle school. Mathematics self-efficacy has also been shown to be the strongest predictor for mathematics problem solving tasks (Pajares & Miller, 1994). This suggests further investigation into building students’ self-efficacy for mathematics problem solving through scaffolding prior knowledge, lowering problem solving anxiety, and explicitly teaching students self-regulation strategies to use when solving more complex tasks.

Self-efficacy has also been shown to have a direct influence on students’ vocational interests and career goals in ethnically diverse middle school students (Fouad & Smith, 1996; Hackett & Betz, 1989; O’Brien et al., 1999). O’Brien, Martinez-Pons, and Kopala (1999) suggest that academic performance can be predicted by income level and self-efficacy can be predicted by academic performance and ethnicity. Other researchers have shown similar findings, such as math and science performance of ethnically diverse middle school students predicts math and science self-efficacy, which, in turn, predicts math and science outcome expectations, interests, and goals (Navarro, Flores, & Worthington, 2007). It has also been shown that mathematics self-efficacy has a strong direct effect on student anxiety, which can affect mathematics achievement (Pajares & Kranzler, 1995).

Bandura (1986) hypothesized four sources of self-efficacy, with past performances being the most influential to a person’s self-efficacy, followed by vicarious experiences or observations
of modeling, social persuasions, and the physical and emotional states of the students. Usher and Pajares’ (2006) research on incoming middle school students verified Bandura’s original assumption with male students, however, female students and African American students both exhibited stronger self-efficacy due to teacher social persuasions. Social persuasions are directly related to teacher-student relationship building and the notion of teacher care in CRMP.

Mathematics teacher actions in relationship building and instructional design are important in fostering students’ mathematics self-efficacy (Middleton & Spanias, 1999). Riconscente (2014) demonstrated that Latina/o high school students increased their mathematics self-efficacy and mathematics achievement due to the specific teacher caring actions of being effective at explaining content and promoting interest in mathematics. In addition, Lewis et al. (2012) showed that the effect of teacher caring on mathematics self-efficacy and achievement was greatest on Spanish dominant English learners whose mathematics achievement started out lower than English dominant English learners. Stevens, Olivárez, and Hamman (2006) found that Hispanic students experienced less praise, less success math experiences, and more anxiety in math class compared to White students. Lastly, Bolshakova, Johnson, and Czernak (2011) demonstrated, through qualitative means, that science self-efficacy of diverse middle school students improved when teachers were more effective at building relationships and positive classroom environments.

Besides having caring teachers, other tenets of CRMP have also been shown to be effective ways to increase mathematics self-efficacy. For example, having high expectations, honoring students’ voices, adapting instruction to student needs and interests, using cooperative learning with group decision making, examining cultural differences and minimizing biases may all improve mathematics self-efficacy (Marat, 2005; Meece, Herman, & McCombs, 2003;
Schunk & Meece, 2006). Additional factors that influence students’ mathematics self-efficacy tie directly to Bandura’s hypothesized source of self-efficacy, successful past mathematics performances. In a mathematics classroom this may include using challenging problems within a supportive environment, stressing meaning making, setting short term learning goals, giving frequent feedback, and explicitly teaching how the mathematics concepts are connected and being developed within the course (Bandura & Schunk, 1981; Marat, 2005; Meece et al., 2003; Schunk, 2011; Schunk & Meece, 2006).

Raising students’ mathematics self-efficacy through vicarious experiences or models may be done using cooperative learning with peer models, utilizing metacognitive and reflective strategies, and encouraging students to use help-seeking behaviors (Marat, 2005; Schunk, 2011). Arslan (2013) found in his study that vicarious experiences, or observations of modeling, was the strongest source of self-efficacy for Latina/os and Hampton & Mason (2003) found it to be the strongest source for students with learning disabilities. Using social persuasions to influence self-efficacy requires teachers and students to celebrate successes in their learning and develop caring classroom communities, where it is encouraged to make mathematical mistakes and learn from them (Meece et al., 2003; Relich, Debus, & Walker, 1986). Pajares and Kranzler (1995) demonstrated that students’ mathematics self-efficacy during problem solving had a strong direct relationship on students’ mathematics anxiety during problem solving and their problem solving achievement (Ashcraft, Krause & Hopko, 2007). Future research is needed in how teachers can work towards increasing mathematics self-efficacy in their classrooms, especially for students living in poverty (Cleary, 2009).
Self-regulated learning (SRL) and mathematics

Many suggestions from researchers to increase mathematics self-efficacy are tied to developing students’ self-regulated learning (SRL). As defined by Zimmerman (1986), SRL refers to specific strategies that teach students to be active participants in their own learning. It refers to a motivational, metacognitive, and behavioral process that “students use to acquire academic skill, such as setting goals, selecting and deploying strategies, and self-monitoring one’s effectiveness” (Zimmerman, 2008, p. 166). Zimmerman (2000) hypothesized that SRL is a cyclical process involving three distinct phases: a forethought phase which encompasses task analysis and self-motivation beliefs, a performance phase which encompasses self-control and self-observation, and a self-reflection phase which encompasses self-judgment and self-reaction. These phases can be taught within a mathematics classroom setting through explicit instruction and modeling (Zimmerman, 2002).

One of the main goals in teaching students SRL is to enable them with self-monitoring strategies, which will empower them to become more autonomous learners (Benard, 2004; Cleary & Zimmerman, 2004). Unfortunately, studies have shown that academic self-regulation decreases across each transition, as students move from elementary school to middle school to high school and that a lack of self-regulation predicts a decrease in mathematics achievement (Usher & Pajares, 2008). Cleary and Zimmerman (2004) hypothesize that teachers can create SRL classrooms by providing frequent assessments, giving timely and effective feedback, encouraging the practice of graphing and tracking their performance, and teaching students SRL strategies.

Having multiple avenues of feedback is key for developing self-regulated learners. Useful and timely feedback allows students to regularly self-reflect and determine how to better prepare
for their future mathematics tasks (Zimmerman, 2000). Monitoring feedback through graphing progress and assessment results has also been shown to significantly increase students learning in mathematics (Kitsantas & Zimmerman, 2006). SRL has ties to CRMP, as well. Bembenutty (2011) states that meaningful homework that applies to current real-life lessons and personalizes the curriculum to students’ experiences can increase both self-regulation and self-efficacy. Future research is needed to determine how mathematics teachers can create classrooms using SRL strategies and whether it influences mathematics self-efficacy and achievement. This is especially needed within the areas of research on students of poverty, where many students lack mathematics self-efficacy and the self-regulation strategies to monitor their own learning (Borman & Overman, 2004; Evans et al., 2005).

Feedback from teachers also helps students develop better accuracy between their mathematics self-efficacy beliefs and their actual scores on assessments or tasks, also called calibration accuracy (Labuhn, Zimmerman, & Hasselhorn, 2010). Working with students to accurately assess their self-efficacy can lead to them to be more aware of their own progress, use more SRL strategies and increase their problem solving performance. Calculating calibration analysis, as described by Pajares & Graham (1999) involves having students assess their own beliefs in how well they will do on an assessments or tasks with a rating, for example from 0 to 10. This self-efficacy score is then compared to the student’s actual score on the assessment or task, again using the same scoring range as in the self-efficacy rating. The bias (direction, such as overestimating or underestimating their performance) and accuracy (how close they rate their actual performance) are determined by subtracting the assessment or task score from the self-efficacy rating. A positive value indicates overestimation and a negative value indicates underestimation. The calibration accuracy is determined by taking the absolute value of the bias
and accuracy score and subtracting from the total number of points possible, in this case 10 (Pajares & Graham, 1999). Researchers have found that many students overestimate their abilities, which leads to lower self-efficacy and subsequently lower performance (Pajares & Graham, 1999).

**Resilience Theory**

Resilience is a topic that has been studied in great detail over the past twenty years. Definitions of resilience over this time period are ever-changing dependent on context. This study will use Borman and Overman’s (2004, p. 180) definition of resilience, “A developmental process occurring over time, eventually characterized by good psychosocial and behavioral adaptation despite developmental risk, acute stressors, or chronic adversities.” Signs of resilience fall within four main categories of personal strengths: social competence, problem solving, autonomy, and sense of purpose (Benard, 2004). In addition, these personal strengths can be taught to students to support their progress towards becoming resilient. Social competence refers to a student’s ability to be caring, empathetic, and responsive to others. Problem solving, in a general academic sense, involves being able to plan, be flexible, be resourceful, and use critical thinking. A student’s autonomy is their ability to act independently, but also to advocate for themselves when they need assistance. This is developed through a student’s self-efficacy, self-awareness, and initiative. A student’s sense of purpose is also important in their ability to be resilient, including having goals, motivations, and future aspirations (Benard, 2004).

Resilience research has determined certain factors which are important for developing resilience in children. This research, over the past twenty years, suggests that resilient children, those children that have overcome major emotional challenges, specifically within their family lives, do so primarily because their basic protective needs are being met (Masten & Reed, 2002).
These include what Maslow (1970) incorporated into his hierarchy of needs: biological needs, physiological needs, and safety needs. Students who show these types of risks tend to show the lowest achievement in mathematics and reading (Fantuzzo, LeBoeuf, Rouse, & Chen, 2012). Garmezy (1991) was one of the pioneers who merged the psychological research of resilience with the educational. He determined other protective factors that resilient students demonstrated that helped them to overcome adversities. These included having little family conflict, high parental involvement with schooling, strong relationships with teachers, good social skills, and a belief in having a sense of power over their lives. Schools, on the other hand, assisted students in becoming resilient by helping students set and achieve goals, praised students for good work and effort, and emphasized language, communication, and discussion within the classroom. These components are consistent with following a pedagogical framework of CRMP with a focus on improving students’ mathematics self-efficacy.

Benard (1991) hypothesized that three protective factors were necessary for healthy resilience development in children whether they were at home, school, or in their community: caring relationships, high expectations, and opportunities to participate and contribute. These three factors are closely related to Ladson-Billings’ (1995) components of culturally relevant pedagogy. Benard (2004) describes caring relationships as having trust, respect, and compassion for others. Studies have shown that students with stronger bonds to their eighth grade mathematics teacher and a larger friend network have a lower chance of failing their ninth grade mathematics course (Langenkamp, 2010). High expectations are a byproduct of a caring teacher-student relationship (Benard, 2004). These high expectations may initially come from the teacher, but overtime, resilient students begin to have high expectations of themselves as well.
Much research has been done on the idea of learning mindsets and academic achievement. According to Dweck (2006), people gain a perspective along a continuum of how they believe they learn. People with a fixed mindset, or an entity theory on intelligence, believe in innate ability and are more interested in looking smart to others, therefore they have a tendency to give up easily in order to save themselves from looking dumb. People with a growth mindset, or an incremental theory of intelligence, believe that if they work hard and persevere, their learning of the subject will grow and they will become smarter. Having a growth mindset versus a fixed mindset has been shown to increase achievement across transitions and completion rates of difficult mathematics courses (Yeager & Dweck, 2012). In addition, believing that your academic ability is due to effort versus innate ability has been shown to lower stress and aggression leading to increases in academic performance (Yeager & Dweck, 2012).

The third protective factor, opportunities for participation and contribution, is in regards to encouraging students to engage in creative and interesting tasks that are relevant to their lives. This includes opportunities for cooperative learning, exploring the arts, and problem solving within their community (Benard, 2004).

These protective factors can be instilled within mathematics classrooms to promote what Johnston-Wilder and Lee (2010, p. 38) describe as mathematical resilience, “A learner’s stance towards mathematics that enables pupils to continue learning despite finding setbacks and challenges in their mathematical learning journey.” According to Johnston-Wilder and Lee (2010), students can move towards mathematical resilience by mastering challenging mathematical concepts, using correct mathematical vocabulary, and using cooperative learning strategies where students have to construct their own solutions to relevant problems. This encourages students to become reflective and thoughtful thinkers. Hernandez-Martinez and
Williams (2013) noted that student reflection on their mathematical processes increased the resilience of undergraduates in a beginning mathematics course. Thornton, Statton, and Mountzouris (2012) determined that Aboriginal students’ mathematical resilience was improved through the use of mathematical models and real world contexts. Resilience has also been shown to improve when students have choice in their tasks, used collaborative methods to discuss and debate solutions, and were actively engaged in the learning process (Lee & Johnston-Wilder, 2013).
CHAPTER THREE

METHODOLOGY

This critical action research study using a convergent mixed methods multiphase design examined the use of CRMP in an 8th grade mathematics class with students living in poverty (Creswell & Plano Clark, 2011; Mills, 2011). Specifically, it explored how I utilized CRMP tenets and what influences were seen on students’ mathematics achievement and self-efficacy during CRMP tasks focused on algebraic functions. This study used critical action research to investigate how social, cultural, and political contexts in education impacted student learning and equity (Carr & Kemmis, 1986; Cochran-Smith & Lytle, 1999; Manfra, 2009). Through the use of critical action research, I strived to transform and reflect on my mathematics teaching approaches in order to empower my students to learn challenging mathematics, address social inequities through the use of mathematics, and promote more equitable practices for students of poverty.

Research Questions

The research questions that this critical mixed methods action research study addressed are:

1.) How do I use curricular elements of CRMP (e.g., high cognitive demand, cultural relevance, and social justice components) to teach algebraic functions?

2.) How do I use instructional elements of CRMP (e.g., social constructivist methods, caring relationships, and multiple avenues for learning support) to teach algebraic functions?

3.) What is the relationship between my student’s mathematics achievement and my teaching through a CRMP lens?

4.) What is the relationship between my student’s mathematics self-efficacy and my teaching through a CRMP lens?

Research Design
Mixed methods studies are increasingly being used in educational research as a way to utilize the benefits of both qualitative and quantitative approaches to address complex issues and provide potential generalizability (Greene, 2007; Johnson & Onwuegbuzie, 2004; Plano Clark & Creswell, 2010). For this action research study, I utilized mixed methods to gain both an emic and an etic perspective on issues in mathematics education related to poverty and self-efficacy, using elements of CRMP within my 8th grade mathematics classroom. Qualitative and quantitative methods can be seen as complementary methodologies, therefore this study utilized the benefits of both approaches to address issues of student beliefs and achievement in mathematics education, to provide potential generalizability, and to ensure validity, credibility, and reliability, while striving to reduce and be explicit about potential biases (Greene, 2007; Johnson & Onwuegbuzie, 2004; Plano Clark & Creswell, 2010).

Mixed methods action research was chosen for this study due to the dynamic nature of the mathematics classroom and the complexities of teaching and learning (Teddlie & Tashakkori, 2012). This study also took a critical approach by using an action research methodology to shed light on students of poverty, their successes and their challenges, through the teaching of mathematics using CRMP components. Mills (2011, p. 8) states that critical action research is “participatory and democratic, socially responsible and takes place in context, helps teachers examine the everyday, taken-for-granted ways in which they carry out professional practice, and can liberate students, teachers, and administrators.” As a critical action researcher I adopted various dialectical stances to bridge objective and subjective, theory and practice, and individuals and society (Carr & Kemmis, 1986). The overriding philosophy of this research is pragmatism, a multifaceted view which bridges dichotomous analyses (Johnson & Onwuegbuzie, 2004). John Dewey’s (1938) take on pragmatism was that by learning through the experience of others, using
inquiry and reflection, we can attempt to problem solve and find practical solutions. In this way, pragmatism fits well into research focused on the classroom and done by teacher-researchers. Pragmatism puts the importance on the problem and offers flexibility for the teacher-researcher to determine the direction of the study using the methods that they deem best within the context of their own classroom (Hall, 2013). Pragmatism in mixed methods relies on abductive reasoning, valuing both inductive and deductive reasoning, and intersubjectivity (Morgan, 2007). Through the use of this philosophy, I had the ability to choose the methodologies that best answer my research questions, with the understanding that all research is a work in progress (Wheeldon & Ahlberg, 2011). In this study, I used pragmatism, within a critical framework, to study the diversity of mathematics learners in my classroom community, utilizing action research inquiry to advance democracy, foster sympathy, and improve learning outcomes (Hall, 2013).

Through this research, I addressed issues of academic resilience by studying student self-beliefs, in hopes of determining a relationship between CRMP, mathematics self-efficacy, and algebra achievement. Students used their voice to explore their own thoughts and beliefs about learning mathematics through CRMP and how they believed the classroom and curriculum influenced their mathematics self-efficacy and achievement. It is my hope that they develop a strong mathematics self-efficacy and in turn feel empowered to take charge of their education and the tools to successfully continue learning mathematics. This study also attempted to empower teachers to take charge of their classrooms by taking a more equitable approach to mathematics education through cultural relevancy, social justice, and teaching students about their own mathematics self-efficacy.

The following description of the research design provides a brief overview of the methods and instrumentation used in this study, see Figure 2 and Appendix A for visual models.
Further details will be provided in a forthcoming section. Quantitative data was collected at the beginning and end of this study in the form of overall pre and post measurements on general mathematics self-efficacy (see Appendix C), as well as weekly task-specific student mathematics quizzes with built in self-efficacy ratings for all seventeen participants during the first weeks of the study (see Appendix D). This initial quantitative data, in phase one, informed the selection of twelve participants whose responses, actions, and behaviors were analyzed through more qualitative methods. Priority in this study was given to the qualitative methods. Qualitative methods of my teaching included observations and journaling. I kept a reflection journal throughout the study, to record successes and challenges with students, curriculum, and instructional strategies, as well as biases and assumptions I considered regarding my students and my teaching (see Appendix B). I video-taped my instruction during the teaching of the three CRMP tasks, assessed my use of CRMP in these tasks through a lesson analysis tool (TEACH MATH, 2012) and an observation scale (see Appendices E & F), and took field notes throughout. Specific details on instruments, data collection, and data analysis will be described in a later section. Additional qualitative data was collected of the twelve selected participants’ thoughts, beliefs, actions, and mathematical thinking as they proceeded through the CRMP tasks: two individual projects with group participation and one individual performance task assessment (Appendices G, H, & I). Data was collected throughout these tasks through video-taped student observations, field notes, a self-efficacy rating scale, analysis of student work, a midstudy questionnaire, and a final semistructured interview (Cleary et al., 2012) (see Appendices J, K, & L). As a convergent mixed methods study, these data sources were collected and analyzed separately, yet mixed for interpretation with an underlying critical stance of advocacy and empowerment to improve the current inequities in schools for marginalized students (Greene &
Caracelli, 1997). Johnson and Onwuegbuzie (2004, p. 18) propose that researchers follow the “fundamental principle of mixed research,” which states that “researchers should collect multiple data using different strategies, approaches, and methods in such a way that the resulting mixture or combination is likely to result in complementary strengths and nonoverlapping weaknesses.”

CRMP Tasks

For this study, I used CRMP, in three 8th grade mathematics teacher-developed algebra tasks (see Appendix G). The first task within this study introduced students to exponential functions, scientific notation, and volume of spheres and cylinders, by examining potentially hazardous viruses. Contagious viruses are a global concern and may be more serious for people in poverty due to closer living quarters, potentially less sanitary conditions, less power within the real estate system, and less financial stability to address health hazards. Viruses are an important topic of conversation in schools due to increased sexual activity among teenage students and the potential to contract sexually transmitted diseases. During this unit, students chose a virus, investigated its biology and effect on humans, and understood its rate of growth and size related to its volume. This task addressed CCSSM 8.EE.A.1 (exponent rules), 8.EE.A.3 and 8.EE.A.4 (scientific notation), 8.F.A.1 (definition of a function), 8.F.A.3 (linear vs. non-linear functions), and 8.G.C.9 (volume of spheres and cylinders) (NGA, 2010).

The second task of study on algebraic functions was an activity on buying a car, related to linear functions and systems (see Appendix H). Students of poverty may not have had education on car loans and depreciation through their families or other coursework. Being able to make positive financial choices regarding vehicles and car loans, in regards to salary and priorities is an important component to being able to provide a secure life for students’ future and their family. Topics that arose from this task are important discussion points to understanding
how career choices can impact the amount of money people have to spend on vehicles and the
relationship between loan payments and car depreciation. During this unit, students worked
through the task in a cooperative group setting using some Complex Instruction strategies
(Cohen & Lotan, 1997; Horn, 2012). This task addressed CCSSM 8.EE.B.5 (slope-intercept form
non-linear functions), 8.F.B.4 (constructing linear functions), and 8.F.B.5 (analyzing linear
functions).

The third task of study on algebraic functions was a performance assessment where
students analyzed two options for a birthday party, which related to linear functions and systems
(see Appendix I). Through the use of this last task, students used multiple representations to
determine their own choice of a birthday party in a local venue. Students were able to use price
and other factors to make their decision. Using two venues that were local and familiar to the
students allowed students to generate more opinions on the question and be more invested in the
assessment. It also allowed students to understand the amount of money that is spent on birthday
parties at these places. This performance task assessment was modeled off of tasks that these
students were expected to complete as part of the SBAC mathematics performance assessment
aligned with the CCSSM (NGA, 2010; SBAC, 2010). An additional non-contextual linear
systems assessment was also used in this study as a comparison to the Party Assessment (see
Appendix M). This task addressed CCSSM 8.EE.B.5 (slope-intercept form of an equation),
8.EE.C.8 (linear systems), 8.F.A.1 (definition of a function), 8.F.A.3 (linear vs. non-linear
functions), 8.F.B.4 (constructing linear functions), and 8.F.B.5 (analyzing linear functions), as
well as most of the CCSSM mathematical practices (NGA, 2010).

Role of the Researcher
As the teacher in this study, I examined my own practice of implementing CRMP within my 8th grade classroom with students of poverty. My background as a teacher included twelve years of experience teaching middle school mathematics to diverse students of poverty. Over the past twelve years I transformed my instructional practice from being teacher-centered, with a more direct instruction approach, to a more student-centered approach with a philosophy of social constructivism. My teaching philosophy stems from sociocultural theory where I believe that people learn through constructing their own understanding based on their prior knowledge, cultural experiences, beliefs, and values. Because of this, I have taught 8th grade mathematics for the past eight years using a social constructivist approach with a problem-based NSF-funded curriculum. Through this curriculum and my own teacher-created curriculum, I taught my students through a hands-on, discovery approach using manipulatives, technology, and cooperative learning groups (Borba, Villarreal & Soares, 2016). As a White female teacher in a majority Latina/o school, I have also gone through an internal transformation in my understanding of and care for my students and their families. Through this transformation, I began to incorporate more culturally relevant lessons and assessments into my instruction, including tasks on local places, cultural connections, and social justice. Currently, I utilize CRMP and SJM to create tasks and assessments as a way to engage my students with interesting mathematical contexts. I also strategically use formative assessments to continuously check my students’ mathematics understanding through multiple daily and weekly check-ins.

As a teacher-researcher, it is important to be explicit in my specific role during data collection, data analysis, and in regards to the relationships made with participants (Merriam, 2009). Being the primary teacher in the classroom during the study represented significant challenges that I must address. I am highly cognizant of respecting the classroom time for
student learning and worked to minimize all classroom disruptions due to the research. I also worked to respect the participants’ cultural complexities, abilities, and privacy. The interventions, instruments, and subsequent data collection and analysis used in this study provided positive contributions to the learning and awareness of self-efficacy for all students, not just those students identified as participants.

Within all phases of the study I was a participant in the study with my students. Therefore, in phase one, I administered the quantitative premeasures to all participants, but as the teacher, I made sure to be respectful of the students’ time, interest, and learning. The general self-efficacy instrument was given on one day and took no more than 15 minutes. The weekly self-efficacy self-ratings and quizzes were done primarily at the beginning of the study to gain preliminary data for participant selection. They were used as formative feedback on the students’ mathematics learning and their ability to assess their mathematics self-efficacy beliefs. My role during the quantitative data collection was to consistently administer the instruments and effectively collect the data in an efficient manner, however, during my reflections, I thought critically about the happenings of the day, including my ideas, feelings, and beliefs about my teaching, my students, and the struggles and challenges both parties may have experienced during the tasks. Phase two consisted of mainly qualitative methods, such as teacher and student observations, artifact analysis, a midstudy questionnaire, and lesson analysis. As the teacher, I examined my lessons and teaching in detail through the use of a CRMP scale and the CRMP lesson analysis tool. My role was to keep an open mind and be honest about the components of my tasks and teaching that are and are not included within the tools being used and to contemplate why those aspects may be missing. During the student observations, midstudy questionnaire, and artifact analysis, my role was to take an analytical look at the data sources, but
continue to be thoughtful of the cultural experiences, beliefs, and values that may have
influenced my students’ views and responses. During Phase three, I administered the
semistructured interviews, being respectful of my students’ time, psyche, and the power that, as a
teacher, I inevitably hold over them. My role was to utilize the trusting and caring relationship
that I had built using tenets of CRMP and clear communications to probe for answers to
questions related to self-efficacy and mathematics learning, while still making sure they
understood that every question was voluntary.

In a critical action research study, it is important to define the role of the researcher
within this paradigm. Mertens (2007, p. 212) defines the role of the researcher in transformative
mixed methods research as one who “recognizes inequalities and injustices in society and strives
to challenge the status quo.” In addition, Mills (2011) states that critical action research studies
should be democratic, participatory, empowering, and life-enhancing. Therefore, I feel my role
as the researcher was to provide a research framework that encouraged democratic participation
of my students in the study by giving them a voice and encouraged the participation of all
people, especially those traditionally marginalized by school mathematics. I also encouraged
student empowerment so students could feel they had control over their lives and their
mathematics learning by developing their autonomy in the classroom. Finally, I encouraged
student awareness and growth in their mathematics self-efficacy beliefs, which can influence
their motivation and learning.

Much research has demonstrated that many poor children have lower mathematics
achievement due to a multitude of factors (Brooks-Gunn et al., 2005; Cortesão, 2011; Darling-
Hammond, 2010; Knapp, 1995) and the current power imbalances of public school
administration in this age of accountability makes it difficult to change this status quo (Darling-
Hammond, 2010; Gorski, 2013; Milner, 2013). By using a critical paradigm, I worked to make explicit the inequities that the participants had in comparison to wealthier students, as well as the strengths that they possessed. As the teacher of the participants, I had an interactive link between the participants, showed respect for their culture and had an understanding of the influences of power imbalances, issues of discrimination, and instances of oppression felt by participants and their families. The ultimate goal in this critical action research was to learn how to empower students in a mathematics classroom, leading to improvements in self-efficacy and mathematics learning, through the use of culturally relevant curriculum and pedagogical strategies.

Setting
This study took place in an 8th grade mathematics classroom with a class size of 26 students. Students were heterogeneously mixed by ability and included a majority identified as Hispanic or Latina/o. The year of the study was the first year that this school district had participated in the United States Department of Agriculture’s Community Eligibility Provision (USDA, 2014). This relatively new program allowed school districts to provide free breakfast and lunch to all students if a certain majority percentage of students qualify for Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance to Needy Families (TANF), Food Distribution Program on Indian Reservations (FDPIR), and/or Medicaid or are identified as homeless, a runaway youth, migrant, a youth in foster care, are enrolled in the Head Start or Even Start programs. Due to this program, no income information was gathered from students and families, therefore for state and federal reporting, this school and its students were classified as 100% economically disadvantaged or living in poverty.

With a general driving philosophy grounded in social constructivism, various materials were used for instruction including, but not limited to, the class textbook Connected
Mathematics Project 3 (Lappan et al., 2014). This textbook was chosen by the mathematics teachers at this school because of the strengths the resources showed in problem solving, constructivist philosophies, manipulative use, and challenging mathematics. All adopted and supplemental curriculum used within the mathematics classes were tied directly to the CCSSM (NGA, 2010). Instructional strategies were chosen based on their ability to promote deep mathematics learning and vocabulary for diverse students of poverty and ELLs (Abedi & Herman, 2010; Kersaint, Thompson & Petkova, 2014; Moschkovich, 2013). This included hands-on learning with manipulatives, problem-based learning with cooperative groups, the use of complex instruction group work strategies, students’ use of their native language, and ties to real-life contexts that were relevant to these students (Cohen & Lotan, 1997; Horn, 2012). Proficiency based grading was also utilized at this school, as required by district policy, which required students to obtain a 70% or higher on all summative assessments (Posner, 2011).

**Access to Site**

Permission to follow through with this research was granted by the superintendent of the school district and the administrator of the school. Proper IRB approval was obtained prior to the beginning of any data collection and analysis. In addition, data was only collected from students who had completed and returned signed parental consent and student assent forms. As the primary teacher in this classroom and of these students, I provided access to the classroom, materials, and data for research purposes.

**Instrumentation**

Quantitative and qualitative instrumentation were used during this study. Quantitative instruments included an instrument to measure students’ general mathematics self-efficacy developed by Usher and Pajares (2009) and task-specific instruments that assessed both students’
mathematics self-efficacy and their mathematics achievement on weekly quizzes (Zimmerman, Bonner, & Kovach, 1996) (see Appendices C and D). Qualitative tools included a CRMP lesson analysis tool (TEACH MATH, 2012; see Appendix E), a teacher observation scale for CRMP (see Appendix F), a student observation scale for mathematics self-efficacy (see Appendix J), artifact analysis rubrics for each task being observed (see Appendix K), and a semistructured interview protocol (adapted from Usher, 2009) (see Appendix L). In order to best value the teacher and students’ classroom time, all efforts were made to minimize classroom disruptions during quantitative and qualitative data collection. Therefore, qualitative tools were created and/or adapted to be utilized with the whole class, if possible, to minimize disruptions, avoid singling out selected participants, and to determine procedures for applying specific research methods to full classrooms.

Quantitative Instruments

The quantitative instruments used in this study were primarily used to gain student mathematics self-efficacy ratings and achievement scores for two main purposes. The first purpose was to use the data analysis to choose twelve participants to analyze using qualitative methods. The second purpose was to use the self-efficacy ratings as a pre and a post measure to determine if student self-efficacy increased, decreased, or stayed the same over the course of the study. Use of all quantitative instruments was piloted with a separate group of 8th grade mathematics students in order to determine any changes in procedure, data collection, or analysis before this study began. This section serves to provide a description of each tool, sources of the tool, if any, and any relevant validity and reliability statistics that are available. Further detailed information concerning how the data was collected and analyzed will be offered in a subsequent section.
General mathematics self-efficacy scale. An instrument titled “Sources of Middle School Mathematics Self-efficacy Scale” (Usher & Pajares, 2009) was utilized in this study to assess students’ general mathematical self-efficacy at the beginning and end of the study (see Appendix C). This survey consisted of twenty-four questions using a Likert-type scale ranging from 1 (definitely false) to 6 (definitely true) (adapted from Ivankova & Stick, 2007). Usher and Pajares (2009) developed these questions to align with Bandura’s (1986) hypothesized sources of self-efficacy: past mathematics performances, vicarious experiences, social persuasions, and physiological states. Six questions that address each source were included in the scale, seventeen are positively worded items and seven are negatively worded. These items were rigorously tested through a multi-phase process that began with eighty-four total questions and was pared down through statistical tests and analyses to the current twenty-four (Usher & Pajares, 2009). These items were also validated with middle school mathematics students of various ages, genders, and races, however, students of below average and special needs students were not used in the validation of this instrument. This is of concern considering the population of the proposed study and the focus on improving achievement of all students, including students of lower mathematics and reading abilities. In addition, these items were not tested on students identified as ELLs. For this reason, questions were read, word for word, to all students, and translated into students’ native languages, if necessary. This scale was found to be psychometrically sound and reliable for middle school students from grades six through eight. Internal consistency reliability analyses showed high reliability with Crohnbach’s alpha of .95 (Usher & Pajares, 2009). Permission was granted by the first author to use these items for this study (E. Usher, personal communication, August 29, 2014).

Weekly self-efficacy ratings and weekly quizzes. Zimmerman, Bonner, and Kovach
(1996) suggest using short, consistent homework assignments followed by self-efficacy self-ratings, weekly quizzes, and teacher feedback as a way to improve student self-regulation and self-efficacy. Study participants received weekly quizzes, which I created, that assessed the mathematics concepts from the past week’s assignments and homework (see Appendix D). Prior to the quiz, students were asked to determine how confident they were that they will solve the problems correctly on a scale of 0 (not at all confident) to 10 (extremely confident) (Labuhn et al., 2010). Students had prepared for the quiz through daily assignments, exit questions, and homework assignments throughout the week. Quizzes were scored with teacher feedback and participants recorded their self-efficacy ratings and quiz scores on a recording log and graph (Zimmerman, et al., 1996) (see Appendix D). Both the task-specific student self-efficacy rating and the quiz score were collected each week as data points.

**Qualitative Tools**

The qualitative tools that were used to study my teaching of mathematics using CRMP included a teacher reflection journal (see Appendix B), a teacher CRMP observation scale with field notes (see Appendix F), and a teacher lesson analysis tool, used with permission, adapted in this study to be used as a research instrument (A. Roth McDuffie, personal communication, August 28, 2014; TEACH MATH, 2012; see Appendix E). To study student self-efficacy and mathematics achievement, I utilized the following qualitative tools and protocols: a student mathematics self-efficacy observation scale and field notes (see Appendix J), a midstudy questionnaire, and a semistructured interview (adapted from Usher, 2009) (see Appendix L), and rubrics that were used to analyze student work or artifacts (see Appendix K). All qualitative instruments were piloted with 8th grade students from a different mathematics class in order to determine any changes in wording, design, procedure, data collection, or analysis that needed to
be done prior to the beginning of the study. Again, this section serves as a description of each tool and any sources of the tool. Further detailed information concerning how the data was collected and analyzed will be offered in a subsequent section.

**Teacher reflection journal prompts.** As the teacher being studied, I kept a daily reflection journal throughout the time of the study (see Appendix B). This journal gave me a place to record my thoughts on my teaching and on my students’ mathematics learning through the use of CRMP. It allowed me opportunities to reflect on the goals of CRMP and whether I was meeting those as a teacher. It also gave me the opportunity to assess my own assumptions and biases concerning my students. Sample prompts that were used in this reflection journal are offered in Appendix B.

**CRMP lesson analysis tool.** The teacher lesson analysis tool was developed by a team of researchers to allow teachers to critically analyze and reflect upon culturally relevant mathematics teaching (TEACH MATH, 2012; see Appendix E). It is important to note that this tool was designed to be used as a reflection and self-analysis tool for teachers and not a research tool, however, due to this study being an action research study with methods that include lesson analysis, permission was granted by the development team to utilize this tool to prompt reflections and self-analysis in this study (A. Roth McDuffie, personal communication, August 28, 2014). Within this tool, a rubric is provided, with a one to five rating scale, which addressed various tenets: including cognitive demand, depth of knowledge and student understanding, mathematical discourse and communication, power and participation, academic language support for ELLs, funds of knowledge/culture/community, and use of critical knowledge/social justice support. Each of these categories addressed components that may be included in lessons that are written to be aligned with elements of CRMP. In addition, the researchers state that the last three
tenets are not a usual part of a lesson analysis tool and, therefore, teachers wishing to analyze culturally relevant mathematics teaching should be especially cognizant of these three categories and their implementation within the lesson or task. This analysis tool was used to determine how well the three CRMP tasks aligned with culturally relevant mathematics teaching, as defined by the rubric. I used the analysis tool while I observed the video-taped sessions of my own teaching and reflected about my planning of the three specific CRMP tasks (see Appendices G, H & I).

**Teacher observation scale.** The teacher observation scale included potential observations of behaviors, actions, and attitudes of a teacher using CRMP in their classroom (see Appendix F). I created this scale using tenets of CRMP, as defined by Gay (2010), Villegas and Lucas (2002), and Ladson-Billings (1995), and SJM from Gutstein (2003). This scale included five rating categories of CRMP: curriculum, instructional strategies, teacher care, cultural communication, and sociopolitical consciousness. Each category included six potential components that I rated as either a 1 (no observations of that component), 2 (some observations of that component, although not consistent), or 3 (consistent observations of that component) as I observed the video-taped lessons of my own teaching. Spaces to take notes on the observed components were also included. This scale was used to determine the presence of CRMP tenets throughout my teaching practices during the CRMP tasks (see Appendices G, H & I).

Within the curriculum components, I looked for connections in the mathematics to students’ culture, experiences, beliefs, or community values, offered students choice, promoted interesting real-life contexts, used multiple resources, explicitly tied to other mathematics concepts, and incorporated high level tasks (Gay, 2010; Ladson-Billings, 1995; Moll et al., 1992; Smith & Stein, 1998; Villegas & Lucas, 2002). The six components within the instructional strategies section were focused first on the five practices to advance mathematical understanding
from Stein and Smith (2011): anticipating and monitoring student understanding and selecting, sequencing, and connecting student work to the learning goals. Also, within this section, were ways that lessons were scaffolded or adapted to allow all students’ access to the mathematics learning, whether cooperative learning and peer models were used and encouraged, and whether feedback was frequent, focused, and meaningful (Cleary et al., 2012; Gay, 2010; Ladson-Billings, 1995; Schunk & Meece, 2006; Villegas & Lucas, 2002). Teacher care was observed through observations of relationship building and high expectations for every student, having routines and rituals in the classroom, celebrating successes, explaining content clearly with frequent check-ins for clarification, and by attempting to reduce mathematics anxiety through cultivating a positive classroom environment (Averill, 2012; Bartell, 2011; Gay, 2010; Ladson-Billings, 1995; Schunk & Meece, 2006; Villegas & Lucas, 2002). Cultural communication was viewed through teacher actions such as: addressing social inequities through classroom discourse, taking time to discuss personal interests and out of school experiences with students, having a safe and supportive mathematics learning environment which encouraged learning from mistakes, students engaging in productive mathematical discussions, making students aware of individual differences, insisting on respectful collaboration, and explicitly teaching and encouraging the use of self-monitoring strategies (Cleary et al., 2012; Gay, 2010; Ladson-Billings, 1995; Schunk & Meece, 2006; Villegas & Lucas, 2002). The final section, sociopolitical consciousness, was observed through lesson components, such as whether the lesson allowed students to use mathematics to see the world differently, included opportunities for critical dialogue, developed an awareness of social inequities, gave students the belief that they can make a difference, changed their views on learning mathematics, and honored their voices through the use of their own thoughts, beliefs, and opinions (Gay, 2010; Gutstein, 2003;
Student observation scale for mathematics self-efficacy. I designed the student observation scale to observe student self-efficacy behaviors of the four hypothesized sources of self-efficacy in a mathematics classroom: past mathematics performances, vicarious observations or modeling, social persuasions, and physiological states (Bandura, 1987) (see Appendix J). Each source category included four behaviors that may have been observed in students in the mathematics class. To use the scale, I rated each by either selecting a 1 (no observations of that behavior), 2 (some observations of that behavior), or 3 (consistent observations of that behavior) as I observed students throughout the mathematics lesson. In addition, there was space provided for me to take notes on the self-efficacy behaviors and responses seen. This tool was used as I watched the video-taped sessions of the student groups while they were working on the CRMP tasks.

Artifact analysis rubrics. I used self-created rubrics to analyze the students’ performance on the three specified CRMP tasks (see Appendix K). These rubrics consisted of a 4-point scale assessing the proficiency learning targets and mathematical behaviors identified from the CCSSM (NGA, 2010). These included standards on volume, exponential functions, scientific notation, and linear functions. In addition, students were assessed on their own analysis and critical thinking of the culturally relevant social justice contexts: including personal finance and viruses.

Semistructured interview protocol. The semistructured interview protocol was adapted from Usher’s (2009) qualitative study on mathematics self-efficacy and middle school students (see Appendix L). Some questions were deleted or re-worded to respect the time constraints of interviewing students. In addition, wording was changed to reflect that I, as the teacher and
researcher, gave the survey to my students. For example, questions that referred to “your math class” were changed to “our math class.” Questions that did not apply to the research questions were deleted and questions were added to reflect the CRMP framework, such as students’ favorite and least favorite tasks, what parts of the class help you feel most confident in your math abilities, and how do the things we have learned in math apply to your life. This semistructured interview protocol was used with eight of the selected participants at the end of the study. Additional questions or clarification of existing questions was needed at times, based on other data analyses, to facilitate a stronger, more relevant interview.

Data collection and analysis procedures

Phase one

Two main goals encompassed phase one of this study, writing entries in the teacher reflection journal and collecting and analyzing initial quantitative data on students’ mathematics self-efficacy to determine which twelve participants would be selected for further study using qualitative methods. These quantitative measures included the Sources of Middle School Mathematics Self-efficacy Scale (Usher & Pajares, 2009) and weekly task-specific mathematics self-efficacy ratings tied to weekly quizzes (see Appendices C and D). In the following sections, the data collection and analysis have been separated based on whether they were being used to study me as a participant or the students as participants.

Teacher participant. Prior to phase one, I began recording my thoughts on my curriculum, instruction, assessment, student relationships, student behaviors, student learning, and my own assumptions and biases. Once the study began, I utilized writing prompts, which were directly related to tenets of CRMP and qualities of a reflective practitioner (Stringer, 2004) (see Appendix B). This journal was used throughout all three phases of the study. It was
analyzed throughout the study to look for predetermined codes related to CRMP and as a way to be efficient in data collection and analysis while also being a practicing teacher (see Appendix N). These codes were analyzed more fully through triangulation of other data sources, in order to determine categories and themes, at the end of phase three. Further discussion on analysis of the teacher reflection journal will be reviewed in the phase three section.

**Student participants.** For this phase, all students in one of my eighth grade classes, with confirmed parental consent and assent forms, participated, 17 out of 26 total students. Convenience sampling was used due to all participants being my own students. In addition, as their teacher, it was valuable to learn more about every students’ mathematics achievement and self-efficacy needs, not just a select few, in order to better serve their mathematics educational needs. At the beginning of the study, all student participants were given the Sources of Middle School Mathematics Self-efficacy Scale, within their mathematics class, to be used as a premeasure of general mathematics self-efficacy and to be used as a factor in student selection for qualitative methods in phase two (Usher & Pajares, 2009) (see Appendix C). Students were read all 24 questions to ensure that reading proficiency was not a factor in their ability to answer the questions accurately. In addition, all questions were translated into Spanish for any students identified as beginning ELLs with a stronger reading ability in Spanish. This survey took approximately 15 minutes to administer and complete. Student answers to the survey were summed individually and collectively by the self-efficacy source, however, questions 4, 8, 9, 12, 16, 20, and 24 were reversed scored due to the negative wording (Usher & Pajares, 2009). All data were collected and entered into a secure spreadsheet for analysis.

After the general mathematics self-efficacy survey was administered, participants were given three weekly mathematics quizzes to assess their mathematics achievement (see Appendix
D). Each Friday, for three weeks, participants received a quiz worth ten points that assessed the standards and content they learned over the weeks’ time. After they received the quiz, but before they started the quiz, they were asked to rate their confidence that they would solve the mathematics problems correctly by placing a number between 0 (not at all confident) and 10 (extremely confident) in the upper right hand corner of the quiz. Once the quiz was completed and scored, both the self-efficacy rating and the quiz score were recorded by the participant on a table and graph in the participants’ math folder to be used for further classroom discussion. I collected both the self-efficacy ratings and quiz scores from the original documents and entered them into a secure spreadsheet for later analysis.

These weekly self-efficacy ratings and quiz scores were recorded only phase one. Analysis of these ratings and scores were analyzed in two ways (Labuhn et al., 2010; Pajares & Graham, 1999; Zimmerman et al., 1996). First, the bias (direction) and accuracy (closeness) between the students’ self-efficacy rating and their quiz score was determined by subtracting the weekly quiz score of each student by their self-efficacy rating for that week. The bias corresponds to whether the participant under or overestimated their belief in their mathematics ability, where a positive value indicates overestimation and a negative value indicates underestimation. The accuracy is the difference number between the quiz and self-efficacy rating. The mean of the three weeks of accuracy data points was determined and both the mean accuracy and the bias for phase one was collected in the secure spreadsheet and used with the general mathematics self-efficacy scores to determine twelve participants and the groupings for further qualitative study. Maximum variation sampling was used to determine the twelve participants by choosing students that demonstrated both overestimation and underestimation. In addition, the calibration accuracy was calculated by taking the absolute value of the bias and
accuracy scores and subtracting from ten (Labuhn et al., 2010; Pajares & Graham, 1999). The calibration accuracies ensured that all values were positive to assist with the accuracy of the data analysis.

The twelve selected participants were chosen out of the same class and were placed in three heterogeneous groups of four students each. This made video observations more practical, as well as attempted to avoid other variables that might come in to play if participants were from different classes. Maximum variation sampling was used to choose these twelve participants, by looking to provide diversity of gender, ethnicity, mathematical self-efficacy beliefs, and mathematics achievement (Merriam, 2009; Miles, Huberman, & Saldana, 2014). Additional considerations for selection of these twelve participants and their groupings included trying to lessen student distractions, such as disrupting behaviors, student friend networks, and students that are frequently absent. The heterogeneous groups were chosen by sorting the data in the spreadsheet by the general mathematics self-efficacy scale from high to low. Attempts were made to include two participants in each group that showed higher mathematics self-efficacy, one with overestimation of mathematics self-efficacy and one underestimation, and two participants with lower mathematics self-efficacy, again one with overestimation and one with underestimation.

**Phase two**

During phase two, both qualitative and quantitative data was collected from both the student participants and myself. Quantitative data collected included artifact analysis of all three CRMP tasks (see Appendix K). These were collected throughout phase two and analyzed in phase three. The qualitative data used to study my teaching consisted of my continued use of the daily teacher reflection journal, lesson analysis of the CRMP tasks, and the collection and
analysis of video-taped observations of my teaching during the CRMP tasks (see Appendices B, E & F). These methods were chosen to determine the uses of CRMP in the curriculum, instructional strategies, and teacher-student relationships. In addition, the twelve selected participants were analyzed during these same three tasks using video-taped observations (each group and the teacher were videotaped concurrently with separate video cameras) and were given a midstudy self-efficacy questionnaire. These data were collected in order to gain a better understanding of participants’ self-efficacy beliefs, their behaviors and mathematics understandings during the CRMP tasks, and to gather student perspectives on their self-efficacy beliefs and mathematics learning.

**Teacher participant.** Analysis of my teaching with CRMP took place using three methods: my daily reflection journal, the CRMP lesson analysis tool (TEACH MATH, 2012), and observations of my teaching using a CRMP scale (see Appendices B, E, and F). The daily reflection journal was a continued practice from phase one and was continued through phase three. Observations of my teaching were done by video-taping during the three specific CRMP tasks (see Appendices G, H & I). The video camera was placed in a corner of the room for multiple days prior to the beginning of observations, to lessen discomfort or distraction from students due to the camera being in the room. Observations and field notes from the video recordings were done within a week of the original observations to facilitate remembering of important occurrences during the day. I created the scale by using tenets of CRMP: including curriculum, instructional strategies, teacher care, cultural communication, and sociopolitical consciousness (see Appendix F). I used this scale to critically reflect on positive and negative aspects of my teaching and took notes on what aspects of CRMP were included, which were not included, and why some aspects may have been missing.
These three CRMP tasks were also analyzed for CRMP lesson content and instructional strategies using a lesson analysis tool developed by team of researchers to be used by teachers to discuss and reflect on elements of CRMP in mathematics teaching (TEACH MATH, 2012; see Appendix E). This tool was not developed to be a research instrument, however, because of the context in which it was utilized in this study, permission was granted by the researchers (A. Roth McDuffie, personal communication, August 28, 2014). Using planning documents, task artifacts, and video-taped observations, I used the lesson analysis tool to critically reflect on and rate the categories listed in the rubric on a 1 to 5 scale: cognitive demand, depth of knowledge and student understanding, mathematical discourse and communication, power and participation, academic language support for ELLs, funds of knowledge/culture/community, and use of critical knowledge/social justice support (see Appendix E). Descriptions and ratings for each task were recorded in a secure spreadsheet. I also included my co-teaching partner in conversations about my results in order to get a second perspective on the CRMP elements in my teaching and curriculum on both the scale and the lesson analysis tool. Analysis procedures for these data sources are described in a subsequent section.

**Student participants.** During phase two, data was collected on the twelve selected student participants during three specific CRMP tasks (see Appendices G, H & I). These participants were placed in the same heterogeneous groups of four throughout both projects, although during the assessment they were seated separately. Each of their groups was video-taped and observations were taken using a scale based on the four sources of self-efficacy. I recorded the observations and took notes on other instances of self-efficacy realizations to which participants referred (see Appendix J). These observations and field notes were again completed within a week’s time of the original recording to help me remember other instances that may
have occurred during the class period. Video-taped recordings were used to observe the participants closely without distraction and without further classroom disruption. In addition, the video camera was set up at various times prior to and during the time of the study to help students feel more comfortable and less distracted by the idea of being filmed.

The final product from each of the CRMP tasks was collected as artifacts from each of the twelve participants for analysis using rubrics that were created to determine students’ understandings of the mathematics concepts, their proficiency on mathematical skills, their use of the CCSSM mathematical practices, and their ability to critically think and evaluate the real world contexts built into these tasks (see Appendix K). The rubrics were tied directly to the CCSSM (NGA, 2010). Data was collected on the descriptions of the rubrics, as well as the scores the students received.

All of the qualitative data described above for the student participants was initially analyzed during phase two. First, each data type was thoroughly read or watched and listened to, then transcribed into HyperRESEARCH, a Computer Assisted Qualitative Data Analysis (CAQDAS) program. All data was initially coded using coding schemes which were determined based on the data that emerged and by the use of predefined codes that were developed through the use of the frameworks on CRMP and self-efficacy in Figure 1 (see Appendix N). For data that emerged through initial analysis, descriptive coding, in vivo coding, and evaluation coding were all utilized (Miles et al., 2014). Observations were initially coded by the responses initiated on the ratings scale and any notes taken. Transcriptions of dialogue between students and I were added to HyperRESEARCH and coded specifically for self-efficacy statements and references to CRMP (see Appendix L). Artifact analysis rubrics and scores were initially coded and added to the data set according to the scores participants received for their work and the descriptions for
those scores (see Appendix K). All data was organized by code and analyzed to look for similarities and discrepancies in the data and coding. Additionally, during all phases of data collection and analysis, I wrote analytic memos to help clarify any knowns and unknowns in the study, be aware of potential biases in the analysis, and to brainstorm potential themes in the data (Merriam, 2009; Miles et al., 2014).

Next, the initial coding segments were analyzed for similarities within each case and resorted into a smaller number of categories (Merriam, 2009; Miles et al., 2014). These coding schemes emerged according to the data findings and were analyzed to expose patterns within each participant, such as themes, relationships, and explanations of student self-efficacy and difficulties and successes with learning mathematics. Such themes included issues with the curriculum, assessments, mathematics beliefs, problem contexts, group learning, cultural discrepancies, and teacher-student relationships. These secondary coding schemes were placed into a matrix display for each participant in order to reevaluate the findings from all data sources and determine overarching themes in the data (Miles et al., 2014).

**Phase three**

Phase three included both quantitative and qualitative data collection and analysis, as shown in the research design diagram (see Appendix A). Quantitative methods included data collection and analysis of the postmeasures of the same general mathematics self-efficacy scale that was administered at the beginning of phase one, as well as final analysis of the student’s course grades for each quarter throughout the school year (see Appendix C). Qualitative methods included collection and final analyses of my entries in the teacher reflection journal and a semistructured interview administered to eight of the twelve selected student participants (see Appendices B & L).
**Student participants.** Since the teacher reflection journal was the only method used in phase three to record data from my perspective, which has already been described, this section will only focus on data collection from the student participants. Administration of the general mathematics self-efficacy scale was unchanged from phase one. All student participants were given the scale with approximately 15 minutes to complete, with all questions read and/or translated (see Appendix C). The last piece of data collection that was administered during this study was the semistructured student interviews (see Appendix L). These interviews were given to eight of the twelve participants with the goals of the interviews being to explore the students’ perspectives in regards to their self-efficacy beliefs and their thoughts on the mathematics curriculum, pedagogy, and self-regulation approaches that were utilized. These interviews were completed after all observations, reflections, and artifacts were initially analyzed, therefore slight modifications and additions to the questions in the interview protocol were made to personalize the interview for each participant and reflect on the data and analysis from the first two phases (Merriam, 2009). I conducted the interviews individually during the student’s lunch and recess period for one day, which lasted no more than thirty minutes. Questions for the interview were adapted from Usher (2009), and touched on the sources of self-efficacy as described by Bandura (1986) and Usher and Pajares (2008). These questions asked students to describe their background, past experiences in mathematics, their mathematics self-efficacy, our mathematics class, mathematics and other people, and any physiological responses they have had when learning or being assessed in mathematics, either during the study or in their past experiences. Each student was reminded that they have the choice to refuse to answer any question.

Before the qualitative and quantitative data could be analyzed together, the semistructured interview was transcribed and analyzed and the general mathematics postsurvey
was recorded and analyzed statistically with the presurvey. The semistructured interviews were transcribed, coded using predefined codes on self-efficacy and CRMP or other codes that emerged in prior analyses, and entered into HyperRESEARCH (Merriam, 2009; Miles et al., 2014) (see Appendices L & N). These codes were added to the final codes from phase two for final analysis, described in the next section. Secondly, the presurvey and postsurvey measurements of the general self-efficacy scale were analyzed for possible differences between the beginning of the study and the end (Yin, 2004). The difference between the presurvey and postsurvey measurements was determined for each of the selected student participants to add to the final mixed methods analysis by subtracting the postsurvey measurements from the presurvey measurements for each participant. Means were also calculated for each measurement.

**Mixed methods analysis.** All qualitative and quantitative data obtained from the selected student and teacher participants were analyzed together using a mixed methods approach (Creswell & Plano Clark, 2011). At this time, all data for the study had been initially analyzed: quantitative presurvey and postsurvey measurements, calibration accuracies from the weekly self-efficacy ratings and quizzes, student observations, artifact analyses, teacher reflection journal entries, teacher observations, CRMP lesson analyses, and semistructured interviews. Using Onwuegbuzie and Teddlie’s (2003) seven steps toward analyzing mixed methods data, these prior analyses were combined to determine final inferences or conclusions. The first and second steps, data reduction and data display, were completed during phase two and three. The third step, data transformation, involved qualitizing the quantitative data, including the pre and postsurvey measurements, observation scale ratings, CRMP lesson analysis ratings, artifact analysis scores, and the student grades for each of the twelve participants. Qualitizing refers to the process of taking quantitative data and transforming it into textual data that can be analyzed
qualitatively (Onwuegbuzie & Teddlie, 2003; Teddlie & Tashakkori, 2009). This was done by using qualitative codes that reflected the items and ratings in the above data sources and transcribing them into HyperRESEARCH for mixed analysis. All qualitative and qualitized data was then reanalyzed to look for similarities, patterns, and categories, a process defined as data correlation. Next, all of the correlated or reanalyzed data was consolidated together into a final data set. Data displays were created to assist in final mixed methods analysis. This final data set was analyzed through data comparison, data integration, and triangulation to form final categories and themes from which the final results or findings of the study were identified and inferences and conclusions were made (Teddlie & Tashakkori, 2009).

**Reliability and Validity**

Validity of this study was attempted by keeping a clear focus on obtaining credibility, transferability, dependability, and confirmability through the research process (Stringer, 2004). There were many ways that credibility was developed in this study. As the teacher of these students, I developed strong relationships with the students over the five-month period prior to the start of the study. This relationship, with the extended knowledge I have of the school context, demographics, and families, helped me to establish credibility. In addition, my data collection spanned another four-month period and was adequate to gaining the data that was needed to respond to my research questions. Maximum variation sampling was used to select the twelve student participants and place them into heterogeneous groupings, which also may have increased the credibility of the study (Merriam, 2009). Many methods of data collection were used in this study, including initial and final triangulation of both quantitative (qualitized) and qualitative data. Participants were debriefed individually by myself, the teacher researcher, as well as by my co-teacher at a separate time, in an effort to ease concerns about the study, being
videotaped, or being interviewed (Stringer, 2004, p. 58). Member checking was also used after the interviews to allow participants to verify the data and findings and ensure them to be correct replications of their beliefs (Merriam, 2009; Miles et al., 2014). Lastly, participants’ voices were used throughout the results and analysis to assure that their exact words were heard throughout for adequacy of the findings.

To enhance the possibility of transferability of this study to other settings, I used thick descriptions throughout the results section to clearly state the findings, as well as make sure that the setting and participants were fully described, along with the sampling procedures (Gertz, 1973; Merriam, 2009; Miles et al., 2014). Confirmability of this study was enhanced through creating an audit trail, securing all sources of data so others may be able to review the data sources and analyses to come to similar conclusions. Due to this being a doctoral dissertation study, an external audit has also been done by my dissertation committee on the research design. Lastly, I explicitly referred to future research needed, expressed any difficulties I experienced in the study, and used peer debriefing to verify potential findings with close colleagues (Merriam, 2009; Miles et al., 2014).

Reliability, or dependability, is a factor of consistency within the data and findings resulting in “quality and integrity” of the study (Miles et al., 2014, p. 312). Reliability was attained in this study by an “inquiry audit” which described the details of the research process (Stringer, 2004, p. 59). The research questions were explicitly related to the research design throughout, describing paradigms and theories related to the design, explicitly stating how they are linked throughout the study, and identifying areas of uncertainty. I used the teacher reflection journal to record notes and analytic memos concerning the research design, data collection, and analyses, as well as reflected upon my own role as a teacher and researcher, the potential struggle
between these two positions, and how it may have influenced the study findings. I also used the
teacher reflection journal to describe my own assumptions and biases within the study and how
these may have influenced the findings. Merriam (2009, p. 219) defines this as reflexivity and
describes it as clarification that “allows the reader to better understand how the individual
researcher might have arrived at the particular interpretation of the data.” Lastly, I used a peer
review process with colleagues to confirm potential findings (Merriam, 2009; Miles et al., 2014).

Although, I have created many tools and instruments used in this study, I have done so
with clear guidelines using theoretical frameworks from CRMP and self-efficacy theory to have
consistency throughout my instruments and data collection. All instruments and tools, self-
created or created by other researchers were piloted with a different set of students than the
study’s actual participants, at least one month prior to the beginning of the study. This was done
in order to test the instruments with other students in my population and make changes as
necessary. In addition, I have pursued permission to use all instruments and tools that were
created by other researchers, clearly cited any adaptations, and have documented high reliability
for unchanged instruments that have been rigorously tested statistically.

**Limitations**

Limitations of this study include:

1. Due to this transformative mixed methods case study having been done solely within one
   school and within one of my classes with a small number of students, the findings may
   not be generalizable to other schools or populations.

2. Student self-efficacy self-ratings were done throughout the study and may be problematic
due to students’ overconfidence, misunderstanding of the questions, or indifference
towards the particular task.
3. Potential bias may exist, as I conducted this study as a teacher-researcher who is also the primary mathematics teacher for these students. In addition, approximately 40% of these students had me as their teacher the previous year and may be more comfortable with my teaching styles than other students. This may also mean that they have formed a stronger relationship with me because of this additional time.

4. There may be some response error because students may have responded to questions in the way they think I wanted to hear versus being more truthful.

5. Non-participation may have been a factor due to parental or student discomfort with the study, difficulties getting consent forms returned, as well as potential language barriers.

6. Qualitative data analysis is open to multiple interpretations by various reviewers.

**Ethical considerations**

Researching human subjects, particularly minors, requires many ethical considerations. I completed the training requirements, as described by the Washington State University Institutional Review Board (IRB), for conducting research on human subjects in August of 2013. This included the Basic/Refresher Course – Human Subjects Research and the Social and Behavioral Responsible Conduct of Research Course through the Collaborative Institutional Training Initiative (CITI) (https://www.citiprogram.org/). In addition, I applied for and was granted IRB approval to conduct this study in January, 2015, as well as an extension in January, 2016.

In keeping with the requirements for research on human subjects, all potential minor participants received assent forms and all parents or guardians of these potential participants received consent forms. All forms were written in both English and Spanish, per the requirements of the school district and to facilitate communication between myself and the
parents. Consent and assent forms clearly stated the goal of the study, the time commitment for each participant, the potential risks to those participating in the study, confirmation that all data collected is kept confidential and secured in a locked cabinet, and assurance that no identifiable markers are contained within the data analysis or final reports of this study. All participants were assigned numbers and pseudonyms to protect their identity. Classroom time is highly valued, therefore only research activities that benefitted all students were allowed to be done during class time. Individual interviews were done outside of class time during students’ lunch and recess time. In addition, participants were notified that they may refuse to participate at any time without retribution, in order to ease any anxiety among students that non-participation would result in negative consequences. Clear guidelines were provided to all potential participants that stated that participation or non-participation in this study had no bearing on grades, such as requiring extra work, gaining extra credit, or losing classroom points. Students that did not participate were still involved in all aspects of the curriculum, including the self-efficacy instruments, midstudy questionnaire, and weekly self-efficacy ratings and quizzes, however, their data was not collected as a part of this study.
CHAPTER FOUR

FINDINGS

Findings for this study will be discussed in reference to the four research questions:

1.) How do I use curricular elements that are consistent with CRMP (e.g., high cognitive demand, cultural relevance, and social justice components) to teach algebraic functions?

2.) How do I use instructional elements that are consistent with CRMP (e.g., social constructivist methods, caring relationships, and multiple avenues for learning support) to teach algebraic functions?

3.) What is the relationship between my students’ mathematics achievement and my teaching through a CRMP lens?

4.) What is the relationship between my students’ mathematics self-efficacy and my teaching through a CRMP lens?

This chapter will begin with a short description of four student cases: Lara, Olivia, Yasmin, and Carlos. These cases, along with both qualitative and quantitative data, will be referenced throughout the findings separated into seven overriding themes: academic demand, community and cultural relevance, teacher support, cooperative learning, student status, growth mindset, and mathematics self-efficacy. The findings will discuss the three CRMP tasks, which I designed, and how they fit within the tenets of CRMP and the CCSSM for teaching algebraic functions in grade eight. I will also provide evidence of CRMP influenced instructional strategies used during the teaching of these curriculum resources and how they supported the students in their algebraic understanding. Additionally, findings will examine students’ mathematics self-efficacy while using the CRMP tasks and any relationships that emerged between students’ mathematics self-efficacy and their mathematics achievement during the study.
Student Cases

Lara. Lara was a female 8th grade student who was active in school leadership, robotics and sports and enjoyed swimming, shopping, and doing nails with her friends. She had strong family support in mathematics. For example, her mother, a single mother, had shared with her the family bills, how much they were, and how she paid them. Lara expressed multiple career options during her interviews and questionnaire, including becoming a writer, a teacher, and a contractor that builds schools.

To Lara, this math class, that used CRMP developed curriculum, seemed easier than her math class last year. “Last year math was harder for me. It was starting to get into algebra and now it's coming easier” (Student interview, May 2015). She also attributed this to having assignments that were more hands-on and visual.

When we do just like a packet or a problem and we don't really see what is actually going on, it’s just like easier for me when it’s like here are three marbles. I don't know how to explain it. Hands-on stuff is best” (Student interview, May 2015).

She also expressed a great interest in the project-based learning that we had done. “We've done lots of projects where I've actually learned how to solve it. I feel more comfortable with learning math now. Like at the beginning of the year I didn't like it.” (Student interview, May 2015). Lara also expressed a dislike of worksheets because as she puts it, “Like you’re just using your brain to finish it, not your actual imagination on realistic things” (Student interview, May 2015). Her grades in math class were fairly consistent throughout the year with first quarter earning an 87%, second quarter earning an 88%, third quarter earning an 81%, and fourth quarter showing a large jump to 97% (see Table 1). The CRMP tasks and data collection in this study were only completed during the third and fourth quarters.
**Olivia.** Olivia was an 8th grade girl who enjoyed being active through sports and dancing with an elite troupe. School was always difficult for her, especially math, partly because she had an identified learning disability for both reading and mathematics and partly because she had been diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). Her known disabilities in mathematics learning were in working memory and processing speed. These deficits caused her difficulties with learning new concepts, connecting new learning with past learning, and memorizing math facts. Her ADHD caused her to have difficulties staying focused on the mathematics learning expectations. She was easily distracted and lost focus quickly when she did not understand the mathematics lesson.

Her family consisted of her brother, her mother, and herself. Her mother was vocal and supportive of her daughter’s special needs. Being an elementary special education teacher, she worked with Olivia at home on her understanding of math. Olivia expressed “My mom tells me that sometimes even if I’m bad at math that I should still try hard because I have to learn and you have to practice more than other kids sometimes” (Student interview, May 2015). Olivia believed in the value of practice, homework, and study guides. She seemed to have a willingness and a desire to learn and understand, but struggled with making mathematical connections. It is possible that her disabilities and low math confidence may have constricted this at times. Due to Olivia’s fondness for being active, she also enjoyed any lesson where she could move around the classroom or go outside.

Due to her disability in processing speed, Olivia took much longer to complete assignments and had to think about the mathematics for an extended amount of time to make the connections and to understand the concepts and processes. She believed that she was not good at math “because there are people in math that just get the stuff like right away and I'm still barely
on the first question” (Student interview, May 2015). On a student questionnaire at the end of the study, Olivia expressed her difficulty with integer operations. “Those were kind of hard, but I do know them a little bit. I mean, it’s kind of hard when it goes so fast and you have to learn a bunch of stuff, because I feel like when I go home I don't remember it after that” (Student questionnaire, May 2015).

Throughout the school year, algebra teaching and learning in this class had been focused on both conceptual understanding and step by step procedures using traditional algorithms and memorization of rules. Having to remember multiple rules, steps, or directions was difficult for Olivia. She says, “It’s really hard for me to follow the steps because in math sometimes I just don't pay attention and then other times I don't get it, so I don't focus on it cause it gets too hard for me, so I just don't get it” (Student interview, May 2015). She also equated her math ability to her test scores. According to Olivia, “last year my tests were easier so I got better grades” (Student interview, May 2015). Her grades in math class were just above passing for most quarters with first quarter earning a 56%, second quarter earning a 73%, third quarter earning a 70%, and fourth quarter earning a 75% (see Table 1).

Yasmin. Yasmin was an excited ELL student, fluent in Spanish, with Mexican heritage. According to the ELPA, she no longer needed specialized instruction in the English language and was considered advanced proficient. She was interested in History and her favorite subject in school was PE, “It's like 45-48 minutes of just doing an activity like outside or something and you can get your mind off of work” (Student interview, May 2015). Relationships with her friends, boyfriend, and teachers were important to her, as she felt that she could not tell her family things about her life “because they just don’t care” (Student interview, May 2015). She had always struggled in math, recalling moments in elementary school when she cried because
she “didn't want to go to math time” (Student interview, May 2015). Her favorite part of this math class was doing projects and working in groups and her least favorite part was doing “algebra, because sometimes it’s just hard with all of those letters and dealing with a lot of like numbers and it gets kind of confusing” (Student interview, May 2015). Yasmin’s quarter grades declined through the year with an 80% in first quarter, 86% in second quarter, 72% in third quarter, and 73% in fourth quarter (see Table 1). It is important to note that her lowest two quarter grades were for the same two quarters where the CRMP activities were utilized, which suggested that the content, context, or instructional choices were more challenging for her to express her understanding of the mathematics.

Carlos. Carlos was a fluent Spanish speaking student, from a home of Mexican immigrants, who wanted to be a mechanic or a tattoo artist in the future. Much like Yasmin, he was an exited ELL student, however, unlike Yasmin, he maintained a strong bond with his family. His relationship with his family included the responsibility, at times, of taking care of his younger Autistic brother and working with his Dad on painting and landscaping jobs. His Dad talked with him about math and made sure that Carlos was responsible with his school work and grades. Speaking about his Dad, Carlos said, “He talks about what we learned in math and if I understand it because my Dad's really good at math because that was his favorite subject when he was little” (Student interview, May 2015). Carlos also had strong friend relationships. “I've known them since grade school. They always have had my back with problems and they help me with work at school and work outside of school” (Student interview, May 2015). Carlos liked to stay active and would rather play sports, do art, or help his Dad than play video games. He also had a strong sense of responsibility. When asked about his grades, he responded, “It depends on me doing the work and if I don't do the work I end up getting a bad grade. So I make the decision
of having good grades or not” (Student interview, May 2015). Carlos’ believed his best subject in school was P.E. “because I’m really active and my parents tell me I’m athletic” (Student interview, May 2015). His most difficult class was science because of all the scientific vocabulary to understand and remember.

Carlos stated that math was his favorite subject “because it’s fun. We do projects with cars, kites, and I get to work in groups with my friends” (Student interview, May 2015). He believed that “this math class had been a little more of a challenge” than last year and he seemed to enjoy the real world contexts that we used in class (Student interview, May 2015). Carlos’ quarter math grades were fairly steady after earning a 71% first quarter. In second quarter Carlos earned an 85%, then an 80% in third quarter, and an 82% in fourth quarter (see Table 1). These grades reflected both Carlos’ commitment to coming in to work during lunch times and his Dad’s insistence that Carlos keep his grades up.

**Academic Demands**

The first category of findings relates to the academic demands of the three CRMP tasks and will be reviewed within two sections: cognitive demands and language demands. More specifically, I will review the cognitive and language demands of both the curricular and instructional components of the CRMP tasks and how they influenced my teaching of algebraic functions, students’ mathematics achievement, and students’ mathematics self-efficacy.

**Cognitive demands.** Cognitive demand in mathematics tasks has been previously described by Smith and Stein (1998, p. 347) as being “high” if the procedures within the task make “connections to mathematical meaning,” if the task explores mathematical relationships, or if students are seen as “doing mathematics.” All three of the CRMP tasks for this study required students to make mathematical connections within a real world context and explore the
mathematical relationships using multiple resources and representations. The three CRMP tasks, the Virus Project, the Buying a Car Task, and the Party Assessment (see Appendices G, H & I) emphasized understanding the differences between linear and non-linear functions in multiple representations of words, tables, equations, and graphs, and the ability to move between these representations to solve problems. In my classroom, I strived to provide a balance in my curriculum of mathematics understanding, procedural fluency, and problem solving with cultural interest, engagement, meaningfulness, and relatability.

**CRMP tasks.** I designed these three tasks to encompass many of the tenets of CRMP. The Virus Project was a three-part set of activities developed for students to learn about the mathematics of one virus in-depth (see Appendix G). This project took approximately four to five hours to complete. After choosing one human virus from a list, students created a one- to two-page statistical and informational flyer about the virus using multiple internet resources. They also examined the virus’ basic reproduction number, or $R_0$, as an exponential function by creating a table, a graph, and writing a short analysis of the reproduction rate and its significance in different parts of the world. To understand size and shape, students investigated the virus’ volume, using measurement conversions and scientific notation, in comparison to other cells and viruses.

During the Buying a Car Task, student’s explored linear relationships and investigated linear systems within the context of buying a car using a loan (see Appendix H). This task took approximately three hours to complete. Students researched the value and depreciation of new and used cars that fit within their predetermined budget. They then calculated car values, based on a set depreciation rate, and their monthly car loan payment, based on the current rates. The mathematics used in this project included understanding the differences between linear and
exponential functions, using percentages, determining slope and y-intercept of the various situations, and creating and analyzing tables, graphs, and equations to answer questions about buying a new or used car.

The last of the three tasks given as part of this study was a summative assessment on linear systems about choosing a party location. I gave the Party Assessment to students after the Virus Project, the Buying a Car Task, and a set of linear system problems which used real world contexts, for example, renting videos versus online streaming memberships, health club memberships, and cell phone plans (see Appendix I). The Party Assessment required students to evaluate two places in their community to have a birthday party: a bowling alley and a skating rink. This assessment was designed to incorporate cultural relevance and real world significance into the mathematics of linear systems with multiple representations. It was designed with these specific places because they were local places most frequented by middle school students for birthday parties. The students evaluated these options using multiple representations of the linear functions (using words, tables, graphs, and equations), solved questions relating to the linear system, and analyzed which place they would rather have their birthday party using mathematical evidence from their algebra work.

**High cognitive demand.** The CRMP lesson analysis tool (TEACH MATH, 2012) was used to rate each task in six areas of CRMP (see Appendix E). Using this tool, I scored all three CRMP activities at the highest level in cognitive demand which suggested that “the majority of the lesson included task(s) that required close analysis of procedures and concepts, involved complex mathematical thinking, utilized multiple representations, and demanded explanation/justification” (see Table 2). Table 2 shows the ratings from the CRMP lesson analysis tool using the descriptors “High, Medium-High, Medium, Low-Medium, and Low.”
These descriptors were used to maintain consistency across all rated data sources because not all sources had the same rating scale; for example, for this tool from one to five.

The teacher observation scale was used to rate the implementation of the CRMP tasks in thirty areas related to curriculum, instructional strategies, teacher care, cultural communication, and sociopolitical consciousness (see Appendix F). I rated observations of “Mathematics curriculum incorporates high level tasks” at the highest level for all three CRMP tasks (see Table 3). These were all rated high due to the complexity of the tasks using real world data, the application and transfer of mathematics concepts to various contexts, and the analysis and justification needed to complete the tasks.

In the Virus Project students researched a completely new topic to them and had to bring together an analysis of their new knowledge about their virus. The task required students to use internet resources to locate data about their virus using tables, graphs, maps, and complex medical references. They then used these data to create information for others, express mathematics in different forms, and use it as evidence for a written analysis. An example of the mathematical thinking in the Virus Project is this part of a student’s analysis response on their virus Roseolovirus, which causes Sixth Disease.

It’s important to know how fast a virus may spread to keep ourselves healthy and not get the virus. The Roseolovirus is not a major problem in the U.S. because it has a small reproduction number and it can be treated (Artifact analysis, March 2015).

The Buying a Car Task required students to analyze yearly loan payments and depreciation using multiple representations and to explain the meaning of the solution to the system within the context of buying and selling cars. One student explained the meaning of their solution as “it means that you have paid more money than your car is worth” (Artifact analysis,
April 2015). During the Party Assessment, students expressed their understanding of linear systems using multiple representations justifying their decision with mathematics. When answering the question “Which party would be cheapest?” for five people, one student wrote, “The bowling alley. It is $5.00 cheaper than skating cause bowling is $125 and skating is $130” (Artifact analysis, May 2015). These tasks all exhibited high cognitive demand, according to the CRMP lesson analysis and my own observations of the lessons, due to the use of real world data, mathematical connections, multiple representations, and having to evaluate and justify their own thinking with algebra.

**Depth of knowledge.** In analyzing the depth of knowledge for these three CRMP curricular resources, I again scored each at the highest level, using the CRMP lesson analysis tool, due to most students sustaining “a focus on a significant topic” and demonstrating “complex understanding by arriving at a reasoned, supported conclusion” (See Table 2). During the Virus Project, students sustained their focus on their chosen virus in regard to exponential growth, volume of cylinders and spheres, and scientific notation operations. They demonstrated their understanding of the mathematics of the virus through their own research and mathematical calculations and analysis. For example, after students found the dimensions and volume of their virus, they answered questions, such as, “How many viruses could fit inside one lymphocyte?” and “How many times larger is Pithovirus than your virus?” One student found that approximately 2,744,640 Herpes 6 viruses could fit into one lymphocyte and one of the largest viruses known, Pithovirus, was 70 times larger than the Herpes 6 virus (Artifact Analysis, March 2015).

During the Buying a Car Task students were expected to sustain their focus on the concepts of linear relationships involved in buying a car and they demonstrated this through their
function representations and reasoning related to the amount paid on the car versus its depreciation. Students had to explain what the solution point, the point of intersection between both lines, meant about the car loan and the value of their car. One student stated, “At that point I am paying more for my car” (Artifact analysis, April 2015). Another student stated, “It means the car loses value slowly” (Artifact analysis, April 2015). These students’ explanations of their solution show a beginning understanding of depreciation and the solution as the point where the car begins to have less value than the amount of money paid into it.

The Party Assessment required students to transform a written context into two equations, tables, and graphs, and then analyze the two options to make a decision. Their analysis was explained and choice was justified using mathematical evidence from their representations. When asked, “Knowing what you know now about cost and what each party offers, which party would you choose and why?,,” one student stated, “I would pick the bowling alley because I would only have a small party and the bowling alley would be less money” (Artifact analysis, May 2015). Another student answered, “I would pick the bowling alley. It would be more expensive for lots of my friends to go, but I don’t know how to skate” (Artifact analysis, May 2015).

These tasks demonstrated both high cognitive demand and high depth of knowledge as students focused their mathematics on their choice of topic and used their mathematics to analyze the situation (virus reproduction or buying a new or used car) or justify their personal choice (choosing a party location). Students were seen creating their own algebraic understanding of functions using real-world contexts, including that linear functions have an additive pattern and exponential functions have a multiplicative pattern, which can be seen in their tables, graphs, and equations. Students were also able to describe their algebraic
understanding in relation to the contexts using appropriate mathematical and contextual vocabulary, analyze their mathematical representations, evaluate what they meant in terms of both the algebra and the real world context, and justify their own choices using their mathematical representations and evaluation.

**Case study.** One example of the cognitive demand and depth of knowledge of the students’ algebraic learning that occurred during the Virus Project was Lara’s experience. During the Virus Project, Lara did not seem to have much interest in the topic of viruses, due to her seeming to daydream or talk off topic, however, she worked diligently and sought help when she needed it, either from one of two teachers in the room or a group member (Student observations, March 2015). Lara encountered some frustrations while working on this project, specifically related to using the technology and the difficulties she had formatting. Her informational flyer on Foot and Mouth Disease was complete, but limited in statistics. She was able to create the exponential table and graph for the virus’ reproduction rate and explain the meanings in basic terms, what a graphed exponential function looked like and the effects of the reproduction rate on the spread of the virus, but did not expand it to an understanding of the multiplicative pattern. “In this Virus Project, my graph is exponential because it’s level and then increases by a lot” (Artifact analysis, March 2015). Her mathematics of the virus’ size and volume showed a solid understanding of scientific notation format, how to calculate the volume of a sphere shaped virus, and how to use multiplication and division operations with numbers in scientific notation format. Her only mistakes within these problems were missing the measurement units. She also asked for a lot of confirmation from me that she was doing the mathematics operations correctly, but overall, she scored an average of 92% on the Virus Project with points deducted for minor mistakes related to formatting and insufficient analysis. She showed proficient knowledge of the
expectations of the task and understanding of exponential functions, scientific notation, and volume, but her analysis lacked in providing sufficient evidence of the multiplicative properties of exponential functions and how that relates to the dangers of viruses. Lara’s experience was similar to most of the students in the class on the Virus Project. The high cognitive demand and depth of knowledge gave students opportunities to learn about exponential functions in an engaging way using discovery through research. However, the technology expectations were at times frustrating, the virus information was not always easy to find, and the mathematics connections and applications between scientific notation and volume were difficult for many students.

**Task challenges.** The high cognitive demand of the Virus Project caused some students to become discouraged, to stop working on the project, and to distract other students. “Once students had a hard time finding something in their research, then they became unfocused and distracting” (Teacher Reflection Journal, March 2015). As in Lara’s case described above, students showed they could do the mathematics, but their analysis, what the numbers meant within the context of the problem, was much weaker. For example, when asked “Why is it important to know how fast a virus spreads,” one student responded, “cause there could be an epidemic,” but little to substantiate mathematically why or how there could be an epidemic.

Students also encountered challenges with the Buying a Car Task. They had difficulties translating their loan and depreciation data from a table into coordinate points and then graphing them within a large number scale. It was difficult for them to understand and explain the overriding real world problem that was being posed in this task, “At what point in time was the amount paid equal to the value of the car?” They were able to translate the significance of having a higher paying career to having more car choices to choose from and many differentiated
between budgeting priorities (Teacher Reflection Journal, April 2015). For example, quite a few students skipped these questions and most students who did answer them were unable to show a full understanding of the ideas. One student wrote, “That’s where my car and loan are together,” which shows that they understood that the solution was where the two lines intersected, but they did not fully understand the concept of depreciation and loan payments within the linear system representations.

Overall, students did well on the Party Assessment. “With this assessment in particular, many students did better than they normally had done on assessments” (Teacher Reflection Journal, May, 2015) (see Table 1). They did encounter difficulties with writing the equation correctly, especially in regard to the addition of a free $5.00 arcade card, which did not need to be added into their equation. A couple of students added it onto the end of their equation, for example, “y=15x+50+5” and some students added it to the per person price of $15 making it $20 (Artifact Analysis, May 2015). Due to this confusion, I deleted the $5.00 value for the arcade card in further revisions of the assessment. Some students also showed misunderstandings when explaining their final party choice using their mathematical evidence. For example, one student mentioned “The bowling is the cheapest so I would pick it,” but failed to mention the number of people he would have at the party that would make bowling cheaper than skating (Artifact Analysis, May 2015). I did have concerns that the assessment “didn’t challenge my high students” or provide enough higher level thinking (Teacher Reflection Journal, May 2015). Due to this assessment being primarily about the multiple representations of linear functions and an introduction to the concept of linear systems in a real world context it did not require the solving of linear systems algebraically. Algebraic solving of linear systems was assessed in the non-contextual assessment given after this task.
In summary, all three CRMP tasks, which I created for this study, met the highest expectations for cognitive demand and depth of knowledge according to the CRMP lesson analysis tool and the teacher observation scale. Students showed progress in their understanding of linear and exponential functions using multiple representations, but all students were met with some difficulties and frustrations that they worked through to complete the tasks with accuracy and understanding. Some students struggled with number sense in regard to scientific notation operations, graphing within a large number scale or translating a real world situation into an algebraic equation. However, the largest percentage of difficulties came from their misinterpretations of the mathematics in context and being able to express their mathematical analyses and conclusions in writing. These problems are more related to the students’ struggles with using language in the tasks and is built upon in the next section on the language demands of the CRMP tasks.

**Language demands.** Language demands in the classroom encompassed both the “language of curriculum materials” and the language of “classroom participation” (Chamot & O’Malley, 1987, p. 236). Language demands can pose struggles for all students, but especially those students with identified special needs, ELLs and students living in poverty. The language demands for these three CRMP tasks was high due to the expectations of reading, writing, listening, and speaking throughout the lessons. One example of the high language demands in these tasks is this analysis response from a student during the Virus Project showcasing his understanding of the basic reproduction number and the spread of his virus.

The graph and table above are an example of an exponential function. The Human Papillomavirus is slow spreading because the $R_0$ is 1.89. It is good to know the $R_0$ value and how fast the virus spreads in case someone is diagnosed with this virus so that we
can prevent an outbreak or epidemic. As shown in the map above the HPV virus is a big problem in the U.S. with 126 million cases or an average per year of 3 million (Artifact analysis, March 2015).

This analysis required multiple steps for this student. He researched HPV through reading scientific internet articles, had to understand the mathematics vocabulary related to exponential functions and the contextual vocabulary related to virus biology, analyzed his mathematics representations of his virus, and related them to current events about the spread of the HPV virus in the United States and the around the world.

Language support and strategies. Using the CRMP lesson tool, I rated the area “Academic language support for ELLs” in the medium-high range for all three CRMP tasks, which suggested a “sustained use of at least a couple of language strategies” throughout each lesson (see Table 2). During all three activities:

Support was given to ELL students through various ways. Students in need of translation were given translated project guidelines and websites used for research were translated using Google translate. Students were paired up with other bilingual students or a high school assistant to assist in working through the projects. I provided media, visuals, and step by step examples to support their mathematics understanding of these difficult concepts. In addition, frequent check-ins and feedback were provided to these students in need of extra support (CRMP lesson analysis, March 2015).

Both the Virus Project and the Buying a Car Task allowed multiple opportunities for students to experience and use the four language skills: reading, writing, speaking, and listening. This included the sharing and expanding of students’ own funds of knowledge (discussed more fully
later in this chapter) and provided a place for students to discuss their life priorities and career choices.

Language support was given through group discussion, interaction, and teacher feedback.

Mathematics and other academic vocabulary was discussed daily, prior to the start of the activity. Teacher interruptions during class were made if there was a need to clarify instructions and/or vocabulary (CRMP lesson analysis tool, April 2015).

Through my observations of my own teaching, it was seen that I devoted more time during the Buying a Car Task to discussing and developing the new language of car buying and the somewhat familiar language of linear functions. Both mathematical and contextual language types were used and discussed daily, prior to the start of the activity, to lessen confusion and provide clarity. Interruptions during class were made regularly if there was a need to further clarify instructions and/or vocabulary related to the mathematics or the context of the task. Less technology resources were needed in the Buying a Car Task than the Virus Project and more scaffolding was written into the design of the task and student assignment. Because of this, the Buying a Car Task had less of a need for sentence starters, teacher check-ins, and vocabulary clarification than the Virus Project. The Party Assessment provided language support for ELLs by accessing and building students’ funds of knowledge and utilizing critical knowledge. Reading and writing were key components to this mathematics assessment. “Language support for this assessment included deliberate modeling of vocabulary, translation into Spanish, and a prior discussion about the context. No grouping or sharing between students occurred because it was an assessment” (CRMP lesson analysis tool, May 2015).

**Critical dialogue and discussion.** Developing students’ mathematical and contextual language was seen as a priority throughout these tasks. This included encouraging Spanish
speaking students to use their preferred language to discuss the mathematics and the task, yet also working to develop their English vocabulary. The observation area “Lesson includes opportunities for critical dialogue, including developing arguments, justifying answers, and validating ones’ own perspective” rated at the medium level for the Virus Project and the highest levels for both the Buying a Car Task and the Party Assessment (see Table 3). The area “Students engage in productive mathematical discussions as if they partake in this type of activity regularly” was also rated at the medium level for the Virus Project and the highest level for the Buying a Car Task. This area was not rated for the Party Assessment since no discussion was allowed during the independent assessment. In one example, an ELL student was having a difficult time understanding the transmission of his virus, H1N1. One of his group members, a student with a mathematics IEP tried to help him. “When a mosquito bites you he infects you.” “How?” “Because he is infected and it infects you.” Looking at a computer image, “This bites this. It’s everywhere dude.” “Do you die?” “You can. You’ve seen a mosquito right?” (Student Observation, March 2015). Another example of a student discussion was another student in this same group asking the ELL student for help. “For this, did you put the radius as ten or just the half of it? Five?” “Just five,” he said (Student Observation, March 2015).

The Virus Project rated slightly lower in the observation and CRMP tool categories on communication and discourse (see Tables 2 & 3). It was noted that “the project needed to be structured in a better way that supported more discussion and analysis about viruses” and that “we didn’t get into the kind of discussion that I really wanted to because of time restrictions” (Teacher Reflection Journal, March 2015). We did, however, have some whole class discussions centered around the recent news on the Ebola and Measles viruses. One student, whose virus was the Ebolavirus, enjoyed teasing his group members that he had the best virus. “Ebola is better
than any of them in here. It’s the worst one. Mine kills people. How fast does your virus spread? Mine is worse because it spreads fastest” (Student Observation, March 2015).

Within the Buying a Car Task, language support and opportunities to use language mathematically and critically was rated higher than in the Virus Project (see Tables 2 & 3).

Language support was given through group discussion, interaction, and teacher feedback. Mathematics and other academic vocabulary was discussed daily, prior to the start of the activity. Teacher interruptions during class were made if there was a need to clarify instructions and/or vocabulary (CRMP lesson analysis, April 2015).

Also, during the car task, I expressed to the students the need for us “to work on vocabulary because of the standardized test that was coming soon” (Teacher observations, April 2015).

During the Buying a Car Task, students were able to experience the lack of funds that sometimes occurs when we want a car that is too expensive for our budget. They had to make decisions related to the age and mileage of the car in terms of price and what they wanted. Students had really good conversations on this piece throughout the task (Teacher Reflection Journal, April 2015).

Other conversations observed centered around money because many of them did not have enough money to purchase the vehicles that they really wanted. These conversations were eye opening to students as they started to understand that in the real world you have to make a lot of money to get expensive cars and many of the careers that they were wanting were not going to give them the funds that would allow them to buy those types of cars.

We had good conversations about trade-offs, such as do I really want a career where I don’t make more than $30,000 a year? Maybe I do if it is where my passion in life is, for example, racing motorbikes or styling hair. In those cases, the trade-offs are doing what
you love versus having enough money for an expensive car (Teacher Reflection Journal, April 2015).

Due to the Party Assessment being an independent and individual assessment, language support and student discourse was at a minimum. “Language support for this assessment included deliberate modeling of vocabulary, translation into Spanish, and a prior discussion about the context. No grouping or sharing between students occurred because it was an assessment” (CRMP lesson analysis, May 2015). Sharing did occur between the students and I through the written parts of the assessment and the written feedback I provided to the students. The only language skills utilized were reading and writing as students weighed different factors including cost, number of people attending, and their own likes and dislikes as evidence to why they made the choice they did.

Case studies. ELL students, students with designated learning disabilities, and students living in poverty were most affected by the high language demands in these CRMP tasks. Olivia and Carlos both had difficulties with the language expectations of the task. Students like Olivia and Carlos are at a double disadvantage in regard to language because they have special learning needs due to Olivia’s learning disabilities and English being Carlos’ second language, but they both have grown up and are living in poverty circumstances. Olivia’s work on the Virus Project and Carlos’ work on the Party Assessment show the difficulties that these students encountered with the language demands in these tasks.

On the Virus Project, with support from the special education teacher, Olivia was able to earn an original score of 72% (see Table 1). After she redid some sections, she improved her score to 88%. She struggled greatly with being able to siphon through the information about her virus on the internet and understand the relevance and big picture of virus reproduction in regard
to human health. Her informational flyer included appropriate descriptive statistics about her virus, Orf Virus, but she showed a lack of attention to detail by not including the units of nanometers, did not use capital letters and periods for most of her sentences, had multiple spelling errors, and made a significant error in relaying her information in her writing. For example, she stated that her “virus kills 12,000,000 people per year” and then stated, “With my virus, people can’t die from it, only goats and sheep” (Artifact analysis, March 2015). She did well with using the technology to produce tables and graphs, but struggled with using the volume formula for cylinders and determining the answer to “how many times larger” type questions that used division of numbers in scientific notation. Her analysis of the virus reproduction was insufficient, with very little discussion on the virus’ reproduction rate and whether or not the virus was a “major problem” in the United States or other areas around the world.

Carlos was noticeably fidgety and distracted at the start of the Party Assessment. During the assessment, I walked around the classroom and as I got closer to him, he did begin to work more intently on the assessment. As he continued, throughout the class period, he seemed to gain confidence. He worked harder when he reached the questions that utilized a table and a graph. He wrote his answers very neatly and was seen erasing and revising his initial answers to the explanation and analysis questions. His assessment showed his strength in taking the party choices and creating the tables and linear system graph. He was also able to answer the analysis questions completely, however, he did not elaborate on his answers to further justify his choices. Carlos had misunderstandings when writing his equations in slope-intercept form, as he placed the y-intercept with the variable instead of the slope with the variable. He also left the question “What is the solution to this system?” blank. This suggested that he was not sure either how to find the solution to the system using his tables or graph or what the question meant when it said
to write the solution in \((x, y)\) format. He finished quite a bit after the majority of the students in the class, but scored an 80\%, with no additional support. His score on the non-contextual linear systems assessment was an 88\%, showing that he understood how to solve multi-step algebraic equations, which, in interviews, he mentioned were hard for him and a reason why he felt he was bad at math. The non-contextual linear systems assessment also showed that within the time since the Party Assessment, he had learned how to find and write the solution to a linear system from a graph as a coordinate \((x, y)\) point. It also demonstrated that Carlos was able to show his understanding of linear systems in a proficient manner with either contextual (CRMP) or non-contextual assessments.

In summary, the high language demands throughout the three CRMP tasks added to the difficulty that students experienced during the tasks in reading and writing, especially within the Virus Project. The Virus Project posed additional frustrations because “much of the vocabulary was also new, which posed extra struggles and difficulties for students that had low English language abilities” (Teacher Reflection Journal, March 2015). After reflection, I noticed a need to spend more time explicitly teaching the reading and writing skills needed for scientific reports, analyzing information, and writing and justifying conclusions based on evidence. In addition, my reflections on the Virus Project instigated me to put more structured and purposeful discussion and dialogue in to the Buying a Car Task. This led to more deliberate and organized group and whole class discussions about the task. Initiating critical dialogue was seen as a priority throughout all three tasks and led to an increased understanding of the mathematics and contexts within the tasks. Throughout all three CRMP tasks, students were given multiple opportunities to practice all four language skills, an important factor for all students growing up and living in poverty situations, but especially for ELLs and students with special learning needs. These
opportunities to practice language helped them develop their own mathematical understanding of the algebra topics related to exponential and linear functions.

**Community and Cultural Relevance**

One of my goals in the creation of these CRMP tasks was to teach students about algebraic functions in a relatable way, giving students access to new worldly knowledge. This section will discuss findings related to the real world connections in the CRMP tasks and how the tasks allowed students to utilize and expand on their own funds of knowledge.

**Real world connections.** Using the CRMP lesson analysis tool I analyzed the area of “use of critical knowledge/social justice support” and found the Virus Project to score in the medium-high range, signifying that there is “at least one major activity in which students collectively engaged in mathematical analysis within a sociopolitical/authentic or problem-posing context” (see Table 2). The Buying a Car Task and the Party Assessment both scored in the highest category of the rubric, which indicated that they both demonstrated “deliberate and continuous use of mathematics as an analytical tool to understand an issue/context, formulate mathematically-based arguments to address the issues and provide substantive pathways to change/transform the issue.” The Virus Project scored slightly lower than the other two tasks primarily because of the limited opportunities for students to discuss the viruses in relationship to poverty around the world and how they could impact the issues in a positive way. These limited opportunities were due to curricular, instructional, and classroom constraints. Students took longer than I estimated to complete the research and calculation portions of the Virus Project, therefore, some of the guided group and classroom discussion pieces were shortened. It was also difficult to organize the timing of these discussions when students were in various stages of the project. In my reflection journal I spoke of the time constraints faced during the Virus Project.
I could have done a better job with exploring with the students, but I made the decision to let students work at their own pace instead of going step by step with them and ultimately, they were either too focused on getting the work done, too frustrated with the internet or computer applications, or I moved too quickly with a specific timeline in mind for when this project needed to be finished by. We didn’t get into the kind of discussions that I really wanted to because of time constraints and students being focused and unfocused (Teacher Reflection Journal, March 2015).

Throughout all three tasks, students were able to see the relationships between the mathematics and the sociocultural contexts being studied in each task, but I had the desire to do more. For example, during the Virus Project, I related the recent outbreaks of Measles and Ebola to the basic reproduction number. I asked the students, “Why is it important to know that measles is fast spreading and Ebola is not fast spreading?” A student responded, “So we can know if there will be an outbreak” (Teacher Observation, March 2015). I went on to discuss this further. “The basic reproduction rate for Measles is huge. It is one of the most contagious viruses out there. That’s why we vaccinate people for it” (Teacher Observation, March 2015). Reflecting back, I would have liked to have more discussions like this throughout the project time.

*Real-life contexts.* Through observations of my teaching, I rated the areas “Curriculum promotes interesting real-life mathematical contexts,” “Lesson allows students to see the world through mathematics,” and “Mathematics curriculum connects to student culture, experiences, beliefs, or community values,” all at the highest level (see Table 3). In my reflection journal I spoke of developing tasks that were more relevant to my students based on their own experiences and backgrounds.
I look at the textbook, which is a problem based textbook, and many of the problems are relatable to many American students, fundraisers, airplane flights, club memberships, summer camps, etc..., but are not necessarily relatable to students of poverty. Therefore, I plan lessons and activities that relate to their current [lives] and interests and important topics for their future lives” (Teacher Reflection Journal, March 2015).

There was some loss of interest during the Virus Project in comparison to the other two tasks, possibly because of the scientific context and research requirements. Students also had a more difficult time relating the project to their own personal lives, again reflecting on the limitation of time to discuss the importance of viruses to communities, especially communities of poverty. Students were able to discuss the recent outbreaks of the Ebola and Measles viruses and explore epidemics, outbreaks, symptoms, and vaccine availability in different geographic areas, but these ideas did not seem to translate directly to their own health or the health of the family members. However, not once during the Virus Project did I hear, “When am I ever going to use this?” In my reflection journal I spoke of why I felt viruses were an important topic for these students living in poverty.

Viruses give us an opportunity to talk about science, as well as health, which in a high poverty community can be of utmost importance. Some of my students are homeless, moving from one family friend to another. Some are hungry and their only consistent meals are the breakfast, lunch, and supper that are served Monday through Friday at our school and during the summers (Teacher Reflection Journal, March 2015).

While working on the Buying a Car Task, students worked through finding a car within the budget of their chosen job. They experienced and analyzed affordable choices and realistic options for their salary and also experienced the concept of depreciation and the difference in
depreciation rates on new and used cars. We discussed the ramifications of buying an expensive car on a small budget and the students engaged in deep and constructive conversations related to keeping within a budget, choosing a lucrative career, and priorities related to whether it is more important to make a lot of money or have a job you love. “I’m not gonna buy a new one. Cause with that I could buy my own house and with that I could rent out my house and from that I could buy a new car” (Student Observation, April 2015). I also made statements such as, “Guys, its real life right now. You have to pick a car that can fit within your budget” to keep them focused on the realistic nature of the task (Field Notes, April 2015).

During the Party Assessment, math was used throughout the assessment as a tool to make an informed decision about two party venues. Students weighed different factors including cost, number of people attending, and their own likes and dislikes as evidence to why they made the choice they did. This assessment was unique as it included an aspect of student choice, agency, and interests that are traditionally not included in a summative assessment. “This assessment involves real places in the students’ local community.” “These tasks allowed students to think about math in very concrete ways, relatable to their immediate world. I believe that this helps them see themselves in the real world, not just see other people living in the ‘real world’” (Teacher Reflection Journal, May 2015).

**Multiple resources.** Using the teacher observation scale, I scored all three tasks at the highest level for “Multiple resources are utilized to ‘create’ culturally relevant mathematics curriculum” (see Table 3). The Virus Project and the Buying a Car Task both utilized internet resources for students to gather information about their chosen virus or car. Comparing this class to his previous math classes, one student mentioned, “This is harder, but more fun. We get to go to fun websites that are tricky, but fun” (Student questionnaire, March 2015). All three tasks
utilized multiple representations of equations, tables and graphs, however, the Virus Project was the only one that utilized both word processing and spreadsheet software for students to create tables and graphs and write their analysis. Students were also able to draw on their own knowledge of viruses, cars, and party locations as they worked on the tasks and have a choice in what virus, car, or party option they chose to analyze. The tasks required multidimensional work involving both mathematics, but also language, with expectations of research, analysis, and justification.

**Changing student views.** Using the teacher observation scale, I rated the area of “Lesson may change students’ views on mathematics, encouraging future mathematics learning” in the medium range for all three tasks (see Table 3). I also scored the area “Lesson allows students to develop social agency, the belief that they can make a difference” within the medium range for both the Virus Project and the Buying a Car Task and only within the low range for the Party Assessment (see Table 3). Students saw both the Virus Project and the Buying a Car Task as important for their future and their family’s future. The Virus Project was directly related to the reproduction of viruses and included analyses of disease symptoms, prevention, and possible treatments. When asked if they liked the Virus Project, one student responded, “With that I like it not really, but it helps you in math and in knowing everything to not get the virus” (Student questionnaire, March 2015). They related the learning about viruses as a path to preventing sickness. “It is important to know how fast a virus can spread because you need to be careful so you won’t get sick” (Artifact Analysis, March 2015).

The Buying a Car Task directly related to car loans and the depreciation of car values. Students analyzed and discussed future decisions and their priorities. By understanding how loans and depreciation work, the students could have a jumpstart on developing personal
financial awareness. They also could use this knowledge to help their friends and families when they need to make these types of decisions. When asked how they liked the Buying a Car Task, one student responded, “I liked that. I think it was great because it helped me understand more about money and payments” (Student questionnaire, April 2015). When asked, “How do the things we have learned in math this year relate to your life?” one student responded, “They can help now or when I am older because I will need to know it to get good jobs” (Student interview, May 2015). Another student answered, “It taught me how much stuff I need to pay for when I get older and when I should start saving up my money” (Student interview, May 2015). These quotations demonstrate that students did make connections to their future, to the importance of mathematics to their future, and to potential positive changes in their future because of their knowledge of mathematics. During the Party Assessment, students analyzed two different locations, understood how prices affected their choices and justified their own choice, something that is important to be able to do in real life. However, the Party Assessment had very little in the way of formative feedback and teacher or peer discussion and had minimal potential influence on changing the future pathways of students.

Social inequities. Two areas analyzed that address social inequities were, “teacher addresses social inequities within classroom discourse” and the “lesson develops an awareness of social inequities.” Both areas rated at the medium level for the Virus Project, high level for the Buying a Car task, and low level for the Party Assessment (see Table 3). The Virus Project was rated lower than the Buying a Car Task for each of these because adequate time was not given to discussing the issues of poverty in regard to the social issues of human viruses. “I feel like this is an important topic because it reflects on something that affects every person and educating students on these issues helps society as a whole by encouraging safe preventative practices”
(Teacher Reflection Journal, March 2015). More time was given to the reproduction and spread of potentially dangerous viruses, but not enough.

I want these students to think outside of their small town community, as well as inside. I also wanted them to explore why viruses spread quicker in other countries, specifically third world countries and countries near the tropics. This helps them understand the link between cleanliness, safer decisions when it comes to sexual relations, and why we require vaccinations. All of these things help keep many viruses limited in the U.S. (Teacher Reflection Journal, March 2015).

One student’s response that addressed this was in their analysis on Polio. “I would consider my virus to be a major problem in other countries because now in the U.S. everyone gets the vaccine” (Artifact analysis, March 2015).

When completing the Buying a Car Task, students were able to connect the responsibilities of car ownership to linear functions and systems. One student response was, “It means the car’s value is going down” and “It is better to buy a used car because you’re not losing a lot of money” (Artifact analysis, April 2015).

I wanted them to see that linear systems are a really important topic that relates to real life. They were able to learn about car loans, monthly payments, what percentage of your salary is reasonable to use to buy a car, and the idea of depreciation and how much a car depreciates over time. It also gave them an opportunity to see how much things cost in real life in relation to the careers that they are interested in and get a look at what it might be like when they are older and needing to buy a car (Teacher Reflection Journal, April 2015).
Since the students chose their own career prior to starting the Buying a Car task, they related their potential future with future opportunities for car ownership. “I did like it because it helped me to see how much money I could save, also how to buy a car, and how much would I pay each month” (Student questionnaire, April 2015).

The differences in the costs and types of cars within a group were determined most by the students’ career choices and how much money they had to spend, so there was some learning that occurred which added to their own understanding of culture and the job market (Teacher Reflection Journal, April 2015).

With the party task, students were assessed on their ability to use linear tables, graphs, and equations to make informed decisions. The assessment did not address social inequities and it scored low using the teacher observation scale. However, I do believe that the culturally relevant context, the use of multiple representations, and the opportunity for students to make a choice and justify it made this assessment a successful one for most students. The average score for the Party Assessment among the seventeen students in this study was 93%, compared to 81% for the non-contextual linear systems assessment. More comparisons can be seen in Table 1.

I hope that by creating real world culturally relevant curriculum and assessments, students are learning how mathematics is all around them and how important it is to their future lives. I also believe that my students are stronger in problem solving, using multiple representations, and in overall understanding of linear functions and relationships then if I chose to teach this content more traditionally” (Teacher Reflection Journal, May, 2015).

Case studies. During all three CRMP activities, Yasmin stayed engaged most of the time. The Virus Project was her favorite activity in math class this year because she was able to learn
about the virus in-depth. “It actually gave us time to learn what the virus was and then we had to do the math on it and it was pretty fun” (Student interview, May 2015). During the Virus Project, she had some frustrations that she worked through with me and her group members concerning her use of technology and the mathematics concepts and calculations. Her informational flyer on Rhinovirus was thorough and complete, but revisions were necessary due to plagiarism from internet resources. Her table and graph were done nicely and her analysis was complete, yet weak in explaining the reproduction rate, possibly because of her somewhat limited academic language skills. Her understanding of the mathematics of virus size and volume was good with a small part missing, some inaccuracies with following the scientific notation formatting rules, and remembering to include the units of measurement. When answering the question, “How many viruses (of her virus) could fit inside of one lymphocyte (with a volume of \(1.15 \times 10^{-14} \text{ m}^3\))” she set up the problem correctly, but wrote the answer in incorrect scientific notation form, \(0.8 \times 10^6\), and did not relate this answer to meaning that 800,000 of her viruses could fit within one lymphocyte. She ultimately completed the project with a 90%.

Yasmin also shared that she enjoyed the car task because of the connection to having to buy a car in her future. “I actually liked it because it was fun. It actually gives you a good image if you want to buy a new car for the first year of working” (Student questionnaire, May 2015). She was observed having excellent discussions related to the context and the mathematics, “We only get a little money. They are hella expensive” (Student observations, April 2015). She showed an understanding of setting up her tables, graphs, and equations, showing both the slope and y-intercepts in her equations. Her calculations were correct and she attempted every question. Her only misunderstandings came within her graph accuracy, which caused her to misidentify the solution. She did have difficulties graphing her “total paid on loan” amounts (\$0,
$444, $888, $1338, $1776, $2220, and $2664) on her graph that increased by a scale of $5000. The solution should have been between year 4 and 5, but because of her graph inaccuracies and confusion, she labeled her solution at (2, $2000). She scored a 98%, however, it was observed that she did get a lot of support from her peers and myself due to her help-seeking strategies.

*Cross-case analysis.* In regard to CRMP instructional strategies utilized in this classroom, two consistencies were apparent through the analysis. All four case participants enjoyed working in groups and stated that, in one way or another, working in groups helped them feel more confident. Three out of the four students stated that they enjoyed working on projects or “hands-on” math activities. When asked “What activities did we do that you think help you learn math best?” Lara said, “Probably project like things that you visually can see instead of just like a problem” (Student interview, May 2015). When asked, “How would you make it a better class for students like you?” Yasmin stated she would “do projects based on the math skills” and “put the students in groups that they were comfortable in” (Student interview, May 2015). The same sentiment was stated by Carlos, “I would have them work in groups with other students and have them do projects, but show them, like demonstrate to them how to do the things on the project” (Student interview, May 2015). Olivia did mention that she enjoyed doing projects, but she did not mention that projects helped her learn mathematics better. Her answers on what helps her learn math best, what helps her feel most confident, and how she would make a better class for students like her, all revolved around extra practice on skills. When asked about making a better class, she responded “Maybe I would practice it more. Do practice worksheets and so people will understand it more” (Student interview, May 2015). This is consistent with her belief that she needed step by step modeling and lessons. With her processing speed and working
memory disabilities, it was difficult for her to learn new concepts and processes quickly and make multiple mathematical connections at once.

*Task difficulties.* The real world data used in these lessons was, at times, “messy” for students, as they involved larger numbers in decimal and scientific notation forms. The internet resources were often written at a high cognitive level and the technology tools, word processing and spreadsheet software, were sometimes confusing for students because of their limited experience using them.

I try and make my culturally relevant lessons as true to real life as possible, therefore, they many times have “messy” numbers that are harder for students to deal with. I also like to utilize technology, specifically documents and spreadsheets for them to use to display their work and also because they will use these programs in future classes and careers. Even though these students are very technologically literate when it comes to cell phones and applications, they are not very literate with documents, spreadsheets, and internet research. These are skills that are important and take time to learn. They also grow student’s problem solving skills and perseverance (Teacher Reflection Journal, March 2015).

There was also some disconnection between the context being studied and the mathematics that we used to study them. This was especially true during the Virus Project as some students did not show interest in the topic and more time was needed for thoughtful discussion and analyses of the current issues and trends in relation to virus reproduction. Stronger connections needed to be made to virus reproduction in relation to communities of poverty and what can be done locally and globally to assist these communities.
Students were exposed to the ideas that viruses spread more frequently and more quickly within communities that do not or cannot practice good personal hygiene, safe sexual relations, suffer from hunger, and do not have access to vaccinations. These issues could have been brought to the forefront of the discussion even more, specifically how these things could affect outbreaks in the students’ own community. (CRMP lesson analysis, March 2015).

As the first year of a new state required standardized assessment, I was concerned that these three CRMP tasks may not prepare my students for this important test.

With the Smarter Balanced testing coming up for the first time, I worry that these project type activities will not teach the students enough of the material. These activities cover many mathematics topics and are high level, but they certainly are not skills driven and many times these types of standardized tests are skill driven (Teacher Reflection Journal, March 2015).

Finally, in regard to the Party Assessment, “it was interesting how many students had never been roller skating or bowling, even though these places are in the surrounding community” (Teacher Reflection Journal, May 2015). Being that this was a summative assessment, I had not anticipated this and had not planned for the longer discussion about these two choices prior to the students taking the assessment. This reality also caused a much more varied response to the final question of which party would you choose and why.

In summary, all three CRMP tasks showed community and cultural relevance through real world connections to a high degree. The Virus Project was scored slightly lower for the use of critical knowledge not continuously connected to the mathematics of the task and connections to social inequities being less than anticipated due to limitations of time to fully discuss the
pertinent social health issues of human viruses. The Buying a Car task scored high in most areas, yet there was still a disconnection for some students between the ideas of car loans and depreciation and the linear function concept of systems. The party assessment scored high in most areas for the connections to the real local places represented in the task, but it scored low in the opportunities we had to discuss social inequities. As seen in Yasmin’s case study, most students appreciated the opportunities to learn about the topics embedded in these tasks and enjoyed sharing their interests and opinions with their peers and myself. They demonstrated their ability to take a real world context, research a chosen topic, collect data, analyze multiple representations of the function models, and justify their conclusions regarding the topic.

**Funds of knowledge.** Funds of knowledge refer to a students’ cultural backgrounds, experiences, and knowledge that can be used within mathematics tasks to increase interest, engagement, and belonging in the classroom (Moll et al., 1992). Using the CRMP lesson analysis tool, all three CRMP tasks were rated at the highest level for the area “Funds of knowledge/culture/community,” which suggested that the lessons “involved intricate connections to community/cultural knowledge and permeated the entire lesson” (see Table 2). These tasks gave all students the opportunity to discuss multiple representations of algebraic functions in a context that was somewhat familiar and relevant to their future. For example, I used Rotavirus as an example of using multiple representations during the Virus Project.

Rotavirus is very fast spreading and because of this many of you have had it. It’s a stomach bug. The reproduction number is 16.5, so it is very fast spreading. The table we do will have really large numbers, probably larger than yours, and the graph we will do will have a sharp curve (Teacher Observation, April 2015).

During the Buying a Car Task,
Students shared their knowledge, interests, and understandings about cars, car loans, and depreciation. This created a collective knowledge on these cultural topics. Analysis was completed on the car amount paid versus the depreciation in years as well as the mathematics of linear systems in multiple representations (CRMP lesson analysis tool, April 2015).

Within this activity, most students were able to share their own knowledge and experience about cars with their group members. One student decided he would choose an older truck like the one he was restoring with his grandfather (Student Observation, April 2015). Students also shared their own expertise on using the technology correctly to research their vehicles and loan payments. Each student became an expert on their own vehicle, the specifications, the costs, and the loan required to pay for it, then was able to share this knowledge with their group.

The Party Assessment was developed using real places in the students’ own community. “This assessment involved real places in the students’ local community. In addition, it incorporated bowling and roller skating which most kids have done or at least have seen.” (CRMP lesson analysis tool, May 2015). Students were told that they could choose their party location using their mathematical evidence and their own opinion, so some students chose the activity they liked the best, but substantiated it with the fact that it was or was not the cheapest. One student’s explanation about why they would choose the skating center as their party choice for a big party was, “The skate center. I want lots of friends and the line for the skate center is lower so it’s cheaper” (Artifact analysis, May 2015).

**Developing a collective understanding.** Using the CRMP lesson tool, I analyzed the area of “mathematical discourse and communication” and rated both the Virus Project and the Buying a Car Task within the medium-high range for having “many sustained episodes of sharing and
developing collective understandings about mathematics in which many students (20%-50%) participated” (see Table 2). Throughout both of these activities, there were many opportunities for sharing and learning among students.

Due to each student having their own specific virus to work with, none of the students had the same data. This was done purposefully so all students were expected to do their own work, but it may have created less sharing as some students quietly worked by themselves instead of working within their group and sharing their understandings (CRMP lesson analysis, March 2015).

During the car task, students shared, discussed, and helped each other. They shared their interests about cars and discussed car loans and depreciation in relationship to linear functions and systems. “I picked a convertible. A black one! Except it’s $47,000. That’s a lot of money. Still too much. Oh, I think I found one. That’s a nice ride. Did you find a good one?” (Student Observation, April 2015). They also discussed their use of technology and the types of cars they could afford due to their given salary. “You’re not going to be able to get your dream car when you’re only making $25,000 a year” (Field notes, April 2015).

For the Party Assessment, mathematical discourse and communication was given a rating of low-medium because the “sharing and the development of collective understanding among a few students (or between a single student and the teacher) occurred briefly.” During this summative assessment, the only communication was between the student and the teacher. Therefore, they shared their knowledge with me as they analyzed their choices, made a choice, and explained and justified their mathematics and final party choice.

**Sharing interests.** The area of “teacher takes time to discuss personal interests with students” was rated at a medium level for both the Virus Project and the Party Assessment and at
a high level for the Buying a Car Task (see Table 3). At times, this happened outside of class, before or after school, and during passing times, but being that I was most focused on the mathematics and the CRMP tasks, I did not take much time during these projects to discuss student’s personal interests, outside of what was relevant to the tasks.

I wish that I had more time to speak to students about their personal lives more, but at our school, I only get to see my students for less than 50 minutes a day and that time is definitely focused on mathematics (Teacher Reflection Journal, March 2015).

I spent more time during the car task discussing students’ own car choices, their experience with cars, and their rationale about adult priorities involving car buying and careers.

Throughout this task, some of those conversations were specific to their likes and dislikes pertaining to vehicles. Some students wanted to get trucks or motorcycles, so I allowed them to do that. They told me stories of the cars and trucks that they are restoring at home with their family members. They expressed interests in fast and expensive cars, such as Porsches and Lamborghinis” (Teacher Reflection Journal, April 2015).

For students to be able to share their personal interests in the classroom with me and their peers the classroom climate needed to be positive, comfortable and honor their voices. The observation area “lesson honors students’ voices through their mathematical thoughts, beliefs, and opinions” rated at the medium level for the Virus Project and the highest levels for both the Buying a Car Task and the Party Assessment (see Table 3). Again, this was due to time constraints and the discourse structure not entirely supported and successful. In the Virus Project, “students were asked to become experts on the knowledge and mathematics of their virus. The teacher and students shared in their growing understanding of viruses, their reproduction rates, and their sizes” (CRMP lesson analysis, March 2015). In all of these instances, the student
became more knowledgeable about the topic than I was, yet I guided the activity and facilitated
the learning of the mathematics. “Every student had their own set of numbers and data to work
with allowing everyone to be an expert in their own assignment” (CRMP lesson analysis, April
2015). One discussion between two students went like this. “What’s your virus?” “Foot and
Mouth Disease.” “Is there a cure? Is it bad?” “Mostly little kids get it.” “Can you die from it?
You can die from mine.” “I know” (Student Observations, March 2015). During the Buying a
Car Task, “the students, especially many of the boys who were really interested in cars, liked the
idea that they could choose their own car to pretend to buy. It was really interesting and engaging
to them” (Teacher Reflection Journal, April 2015). One student was very excited as he explained
to his group member that he was going to buy a “Harley Davidson Sportster Iron 883” (Student
Observation, April 2015). During the car task, students not only got to choose their car to buy, but prior to the task, they “chose their own career and from that I gave them a salary” (Teacher
Reflection Journal, April 2015). This made the activity resonate even further because they could
relate buying a car to a real salary that they could potentially have one day.

**Becoming experts.** Through the sharing of knowledge and developing a collective
understanding of the mathematics and the task context, students became experts on their specific
topic. “When I think up lessons, projects, tasks, etc… I want them to be of interest to students
and help them learn about some topic that they may not have learned much about before.”
(Teacher Reflection Journal, March 2015). All three of these CRMP tasks have a central focus
on independent choices, becoming an expert in their own knowledge, and making informed
decisions. From the CRMP lesson analysis tool, power and participation was rated and analyzed
for all three CRMP activities. The Virus Project scored within the medium-high range, as “math
knowledge was shared between students and the teacher,” “multiple forms of student
mathematical contributions” were encouraged by both teachers and students, and “some strategies to minimize status differences among student (and specific subgroups) throughout the lesson” were seen (see Table 2). In this project, students were asked to become experts on the knowledge and mathematics of their chosen virus as I took on a more facilitator type role. The students and I shared our growing understanding of viruses, their reproduction rates, and their sizes, and developed a collective knowledge on viruses throughout the classroom. Using knowledge from a short video the class just watched to relate to the project question, I facilitated the following discussion. “Is Ebola a big problem in the United States?” “No.” “Is it a big problem in West Africa?” “Yes.” “Yes, thousands of people are dying from Ebola right now. Why is it a big problem there, but not here?” Students then contributed their knowledge about cleanliness, weather, and wildlife in Africa. Discussions such as this transpired in whole class discussions, group discussions, and in their projects.

Power and participation scored within the high range for the Buying a Car Task. This indicated that “the authority of math knowledge was widely shared between teacher and students,” “the mathematical contributions were actively elicited by both teachers and students,” and “multiple strategies were used to minimize status among students” (See Table 2). In this project each student was given their own job, salary, and budget to use to buy their own car. This gave every student their own set of numbers and data to work with allowing each student to become an expert in their own car choice and the mathematics involved. Status will be discussed in a later section of this chapter. For the Party Assessment, power and participation was rated at a medium level due to “the authority of math knowledge between teacher and students being sporadically shared.” The authority in the assessment was mostly with the teacher in order to assess the students’ knowledge and understanding, however, “students did get to have the final
choice of the party they would choose after analyzing, evaluating their data, and justifying their conclusion and choice. This gave the students some power and choice through the assessment” (CRMP lesson analysis, May 2015).

**Case studies.** Carlos’ experience during the Virus Project was different from his experience during the Buying a Car Task, primarily because his own funds of knowledge and expertise on cars increased his interest. During the Virus Project, Carlos had some difficulties staying focused on the activities. He demonstrated a lot of off task talking, had to ask the same questions multiple times, and distracted his group members at times by rapping. His information flyer about the Monkey pox virus was mostly complete, but missed some required details on treatment options and statistics related to transmission and outbreaks. His table and graph were well done, however, his analysis was minimal and did not explain exponential functions and reproduction rates. He did a good job of relating why this virus was a larger problem in areas outside of the United States. Monkeypox is “still a major problem in Africa because they don’t have the same treatment, doctors, and hospitals” (Artifact analysis, March 2015). Carlos’ understanding of the virus’ size and scientific notation was done initially at a minimal level. He found the dimensions of the virus, converted nanometers into meters, and found the volume using the sphere formula, but he did not complete the questions that required multiplication or division operations. When given a chance to revise and raise his grade, Carlos finished this section with accuracy for the quantities, and only missed the units of measurement for his answers. He stated that he liked the Virus Project “because we got to learn the shape of a specific virus,” possibly playing in to his affinity for visual arts (Student questionnaire, March 2015). He originally scored a 58% on the Virus Project, but after revising his mistakes and completing the project fully, was able to score a 90%.
The Buying a Car Task was Carlos’ favorite activity in math class this year because, as he said, “I really like cars” (Student interview, May 2015). During this activity, Carlos was more engaged, less distracted, and had thoughtful discussions with his group members about cars, budgets, and his future career goals of becoming a mechanic. “I did like the personal finance task because it helped me understand and do things for my life. For example, I didn’t know about the car payment until we learned about it” (Student questionnaire, May 2015). He also expressed:

This one taught me how to use a computer and do that project on financing and stuff.

Like I didn't know anything about that until now. And it really helped me by knowing what I earn when I get older and have a job (Student questionnaire, May 2015).

He spent a lot of time deciding on which car to “buy,” which may be why his assignment was not completed, but he did work well, although more independently, through much of the class time. The work that was completed was done well. He showed that he could find the percent of a number to determine his car buying budget. His tables, graphs, and equations were nicely done and correct. However, he did not complete the depreciation table, graph, and analysis questions for the used car section of the task and with some similarity, he did not complete the equation and analysis for the depreciation of the new car. He scored a 70%, but there was little evidence that he understood linear systems, how to find a solution to a system or what the solution represented within the context of the problem. It was not clear why he left parts of the task undone. One possibility was that he spent more time finding and researching possible cars to choose than getting to the mathematics. Another possibility is that he did not understand the questions related to linear systems, system solutions, and analyzing the solutions. This, coupled with running out of time, caused him to only complete what he was able to finish within the time constraints of the assignment. Even though Carlos scored just at proficiency, he listened during
whole class instruction more intently, had stronger focus, and showed a much deeper engagement than in the Virus Project.

Cross-case analysis. Three out of the four case participants stated that they had strong family support in mathematics. For Lara it came in the form of her mother discussing the family bills with her. For Carlos it came from working with his Dad in painting and landscaping. For Olivia it came from going grocery shopping with her mother and brother. Yasmin shared that her family never discussed math and that she felt like she could not talk to her mother and father about school because “I feel like they just don't care” (Student interview, May 2015). Throughout the study observations, Yasmin was the only student of the cases that consistently made negative comments about herself and her ability to do mathematics: “This is hard,” “I suck at math,” and “Sometimes I just give up because it’s hard” (Student observations, March 2015; Student interview, May 2015). The other three students also had moments of frustration throughout the CRMP tasks, but had few, if any, negative comments about themselves as doers of mathematics. Each stated in some way, during the study, that they felt that if they continued to practice and work hard that they would continue to get better at mathematics. Further, Yasmin had the lowest overall mathematics self-efficacy, low quarter math grades, and the lowest score on the traditional linear systems assessment. However, she did do well on the CRMP tasks. This suggested that strong family support in mathematics may contribute to more positive math self-talk, lower math anxiety, and a higher mathematics self-efficacy. It also suggested that CRMP tasks may be more accessible for all students to learn cognitively demanding mathematics, even students living in poverty with less family support.

Task difficulties. Utilizing students’ funds of knowledge was a powerful motivator and bridge to the mathematics of algebraic functions for these students. The only difficulties I
encountered during these tasks in this area was time constraints. Students struggled to stay focused at times because of their own interest and excitement over the tasks. This was especially true during the Buying a Car Task when students had to pick a new and used car from an internet website which had an expansive number of vehicle choices.

In summary, lesson analysis and observations validated that these lessons all allowed students to share and expand their funds of knowledge in regard to their culture and their community to a high degree. As was seen through Carlos’ case study students were given opportunities to become experts in their topic of choice and use their own expertise to develop collective understandings with their peers in relation to the mathematics and the context. The buying a car task demonstrated the highest observations of student discourse related to the mathematics of functions and the students new and old knowledge about the problem context. The virus project had ample opportunities for students to share and learn from each other, however, the group norms and expectations for productive discussions were not as strong as in the car task and time constraints lessened the quantity and quality of the students talk. The party assessment lacked in this area due to it being an independent summative assessment that did not allow student talk, but opportunities to analyze data to make informed decisions based on mathematics and personal interests was built in to the assessment.

**Teacher Support**

This category consists of findings related to three primary methods of teacher support in this classroom which utilized tenets of CRMP: scaffolding, feedback, and building relationships. All three of these teacher practices were of utmost importance to my students’ motivation, algebraic understanding, and mathematics proficiency throughout all three CRMP tasks.
**Scaffolding.** According to Van de Pol, Volman, and Beishuizen (2010), scaffolding from a teacher to a student consists of three main characteristics: contingency (adapting levels of support to each student), fading (lessening of the support gradually) and transferring of responsibility so the student understands and can complete the expectations independently. Scaffolding is a teaching approach that is used for all students, but for students with special needs, legally mandated accommodations can be considered one form of scaffolding. Due to the high cognitive level of these tasks, some accommodations were made for students with special learning and language needs. These included directing the students towards easier internet resources to gather data and giving students flexibility on how they show their work, do their calculations, or the format of their answers. These accommodations kept the high cognitive demand for all students, but allowed for some flexibility to ease stress and anxiety related to using complex real world data. Other forms of teacher-student scaffolding observed in this study will be discussed in the next sections, including modeling, questioning, scaffolding the task structure and student choice.

**Modeling.** Using the teacher observation scale, the Virus Project scored lower than the Buying a Car Task and the Party Assessment in the area “Lessons are scaffolded or adapted, as needed, to assist all students in their own mathematical meaning making.” The Virus Project scored in the medium range, whereas the Buying a Car Task and the Party Assessment both scored in the highest range (see Table 3). All three of these CRMP tasks were deliberately scaffolded in multiple ways in an attempt to build the students’ knowledge and confidence gradually. For example, beginning with prior knowledge, I built the tasks from concrete mathematics in familiar contexts, such as how much is your salary and your budget for buying a car, to the more abstract algebraic topics of equations and linear systems. However, the Virus
Project, being done first, was not as successful for all students due to the openness and complexity of the activities. One student expressed this difficulty in her questionnaire. “I honestly didn’t like because it got confusing a lot. Today, I’m still not done with it. I can actually say this was the most difficult project that I have done” (Student questionnaire, March 2015).

In the area, “teacher models mathematical expectations and understandings through the selection, sequencing, and connections of student work,” I rated all three CRMP tasks in the high range (see Table 3). I created and taught each task with attention to how the context fit within the CCSSM standards of algebraic functions. I sequenced the task so students could access their prior mathematical knowledge to start the tasks and build towards continued understanding of more advanced concepts, such as exponential functions and linear systems. This was seen through the multiple ways that I explained, questioned and clarified my students’ understanding of algebra, as well as some modeling of mathematical procedures in a clear, step by step fashion that many students reported was helpful. “I helped students by clarifying the questions, questioning the students on their steps, and giving praise and general feedback” (Teacher Reflection Journal, May 2015). At times, it was necessary to review previously learned concepts and skills, such as operations with integers and scientific notation. This was normally done quickly with a more direct approach, in order to maximize the students time on the CRMP tasks. “My instruction is very explicit and direct when explaining prior knowledge that students have learned in the past” (Teacher Reflection Journal, April 2015). “This math class compares with other math classes because in this class I like how she teaches step by step” (Student Interview, May 2015). It was also seen in the multiple representations I used to teach students about algebraic functions. “I also believe that my students are stronger in problem solving, using multiple representations, and in overall understanding of linear functions and relationships then
if I chose to teach this content more traditionally” (Teacher reflection journal, May 2015).

Modeling is the primary avenue for improvement in vicarious experiences which can lead to an increase in mathematics self-efficacy. Many students grew in this as reported in their general mathematics self-efficacy survey ratings (see Table 4).

The Party Assessment was created with careful attention to context selection, question creation, sequencing of complexity, and connections to real life in their community. It assessed the students’ basic understanding of using multiple representations of linear functions to solve problems, including using a system to make decisions using mathematical evidence.

I created this assessment to bridge the basic linear relationships and functions concepts into linear systems. This can be an easy bridge, but many times it is too quick and progresses fast into solving systems algebraically. I feel that by slowing this transition to systems down, I am advocating for all of my students to feel successful in this content and gain a better understanding of what linear systems are and mean, especially in the context of real world problems (Teacher reflection journal, May 2015).

Although I did not directly model to the students the concepts in this assessment, the structure, content and processes were chosen because they had been modeled in the past and students were familiar with the use of these multiple representations to analyze linear systems.

The area “Teacher explains content clearly and checks in with individual students to clarify” was again rated by myself in the highest range for all three CRMP tasks (see Table 3). When asked the question, “What parts of our class help you to feel more confident doing math? Be specific,” three students responded with the word “explain.” “When she goes slow and explains the homework or tasks more clearly.” “When the teacher explains more.” “Where she explains it and the posters” (Student questionnaire, May 2015). Throughout each task, the field
notes from the teacher observations show that I work to “speak clearly and slowly, with understandable language and high level content specific vocabulary” (Field notes, March 2015). During each task, “I read the questions clearly and clarified any potentially confusing sections” (Field notes, May 2015) and continuously “checked in on my students that easily gave up or had a difficult time understanding directions or the mathematics” to help them see that I have high expectations for each of them (Teacher reflection journal, April 2015). I also checked in with them “frequently to keep them motivated to continue working, to answer questions if they had any, and to keep them focused and not distracting other students (Teacher reflection journal, April 2015).

**Questioning.** Throughout these tasks, I tried to strike a balance between giving too much support or not enough support in order to help the students feel competent in the mathematics that they were working through. Questioning was a key factor in this method. As students encountered difficulties and I gave them support, instead of telling them what to do I would ask them leading questions about their own mathematical knowledge and the context of the questions so they can develop their own answers. For example, one student was having trouble finding the average basic reproduction number of his virus. Instead of telling him how to find the average between two numbers, I asked him, “What does average mean?” He said, “The middle.” “So if the range of your virus’ reproduction number is two to five; how could you find the middle?” (Teacher Observation, March 2015). This helped the students bring their own voice and understanding in to their analysis answers and show them that they can understand the mathematics. In addition, because they were in groups, the questions that I asked were starting points for group discussion and stated in such a way so that the questions become a platform for the groups to work together to answer the questions. Once, when students in a group were
struggling to format their virus information onto one page, I asked if they had ever used a table in a document. A couple of them said yes. I explained to them that a table can have words, pictures and graphs in them and it can help keep their document organized. They then proceeded to work together and use tables to format their virus flyer.

*Task structure.* After the difficulties that students experienced during the Virus Project, I decided to make some adjustments to the other two tasks in the way of task structure. These adjustments included additional scaffolding written in to the curriculum in the way of guiding questions and structures for tables and graphs inserted in to the assignment. Students struggled with the openness of the Virus Project and how to manage their time effectively. Because of this I began to use time limits during the car task to provide more additional structure. For example, during the car task, I used the statement, “10 minutes to find your car” to try and prevent students from spending too much time looking through the multitude of car options (Teacher Observation Field Notes, April 2015). I also used the statement “I’ll give you 1 minute and then we are going to go on” to let students know that we were moving on to a new section and they needed to finish up what they were working on quickly so they did not miss the next part of the lesson (Teacher Observation Field Notes, April 2015).

*Choice.* Using the teacher observation scale, I analyzed the area “Curriculum offers students choices in their mathematics activities.” This area scored in the medium range for the Virus Project and the Party Assessment, but in the high range for the Buying a Car Task (see Table 3). The medium rating for the Virus Project was due to the choices of viruses being somewhat limited to a list I created that students had to choose from. This approach was used to ensure that each student had a different virus and that only viruses that affect humans were
chosen. Other choices that students had to make within the Virus Project included the openness of which resources to use and the flexibility and creativity in designing their flyer. However, allowing them to be creative, make their own choices, and possibly make mistakes, was difficult for them to grasp. This included using technology and research to help them become experts and helping them to develop student agency by giving them the tools, but not making all of the formatting choices for them (Teacher reflection journal, April 2015).

Some students were excited to choose their own virus and have creative control over their project and some were hesitant about which virus to pick and the formatting choices they had to make. They would have rather seen an example and copied the formatting so they knew they were doing the project correctly.

In comparison to the Virus Project, during the car task, the students had more flexibility in choosing from any vehicle that met their budget constraints, including the option to choose a motorcycle, truck, or even a classic car. “A lot of students, especially boys, were really interested in cars, and the idea that they could choose their own car to pretend to buy was really interesting and engaging to them” (Teacher reflection journal, April 2015). Sometimes the students ran into situations similar to what they may experience as an adult.

Students were allowed to choose their own career and from that I gave them a salary. They were then allowed to use a certain percentage of their salary to buy a used or a new car. While doing this, students were able to experience the lack of funds that sometimes occurs when we want a car that is too expensive for our budget. They had to make decisions related to the age and mileage of the car in terms of price and what they wanted (Teacher reflection journal, April 2015).
Choice was also included within the summative Party Assessment. “Students were given the opportunity to choose their party choice and provide analysis using evidence from the task activities” (Field notes, May 2015). Some students ultimately chose the more expensive choice, but justified it as personal preference. “I hate bowling. I would go skating even if it’s more money” (Artifact Analysis, May 2015).

Case studies. Yasmin was a student that was not afraid to ask for help and used the scaffolding that she was given in productive ways to work towards real understanding of the mathematics concepts. “Some things can be easy for me and some things can be hard. Like sometimes when the teacher presents something new it’s easier if I learned it from the past and sometimes I forget it over the summer” (Student interview, May 2015). Her work on the CRMP tasks suggested that she did not have a strong foundation in algebraic variables and equations in past grades and that she needed stronger conceptual understanding to move forward with more advanced concepts in mathematics. To feel confident in mathematics she needed to learn concepts well and she believed that a teacher modeling the concepts and examples one to one to her was best for her to feel confident. In this class, in particular, she mentioned the extra supports she received. “The teacher motivates you to try harder and can help you a lot” and “This class feels like it has a lot of support, like whenever you need it” (Student interview, May 2015).

Olivia was also a student that needed a lot of scaffolding, although she was not as willing to ask for help as Yasmin. Olivia strived to do her math independently, but her identified learning disabilities restricted her ability to do this at times. Scaffolding became important for her to gain her independence. “This class kind of helps me better because I know what I have to learn and get better at and sometimes when I don't get it, it kind of helps me when someone just explains it instead of in the other classes they just give it to you and tell you to do it” (Student
interview, May 2015). She was a very visual learner and felt that she needed a model (teacher, peer, or technology) to demonstrate steps and procedures to her first. She believed her confidence in mathematics grew, “When I understand how to do it so I don’t have to ask classmates every time” (Student questionnaire, May 2015). Practice with her math skills also made her feel more confident. She relates this back to the extended time we spent on graphing over the year. She says, “Like how we did the graphs. We practiced those a lot and I’m better at it and I like the homework so I can practice it on my own so I know that I can figure it out without somebody else having to be by my side” (Student interview, May 2015).

During the time of the study that the students were working on the car task, the special education teacher was not able to support Olivia, because she was pulled out of the classroom to proctor state required standardized testing. With one less adult in the classroom, Olivia was not able to have a high level of support on this task. Therefore, she struggled with understanding the directions, with her number sense, and with completing the task fully. She did ask me and her peers for help throughout the task, but the time spent waiting for help caused her to have less time to complete the analysis questions. Olivia showed understanding of writing linear equations in y=mx+b format when she wrote “y=1500x+0 or y=1500x” showing that she understood that the 0 for the y-intercept could be written as the b or could be not included in the written equation. There was some confusion for Olivia in her table where she included too many zeros in her amounts paid on the loan, when adding $1500 monthly she wrote $0 then $1500 then $30000. Similar to Lara, Olivia also skipped answering the questions “What is the solution to the system?” and “What does this point mean about your car?” which suggested that she did not understand how to answer those questions. Ultimately, she did score an 85% on the task. “The car one was a little difficult because I had to figure out what the price was and I had to figure out
how to put it on my graph, and I didn't know what to do” (Student interview, May 2015). Her inability to “know what to do” could have been due to her difficulty with focusing on the task directions, her math anxiety and the limited amount of support from her special education teacher during this task.

Task difficulties. There were a few difficulties that I encountered during the CRMP tasks in regard to teacher-student scaffolding, first being that there was a need for more scaffolding throughout. “I know they can do the mathematics, but it might be too much, too fast, with too little support and scaffolding.” (Teacher Reflection Journal, March 2015). After the Virus Project, adaptations were made to the car task to make it more scaffolded; such as directions were more explicit, direct, and given in a more step by step format, prior knowledge and vocabulary were addressed more frequently, technology resources were limited to only a few necessary components, students’ had more choice in their topic. Because of these changes, the students had much less difficulties in completing the task successfully. “This project was much clearer and easier than the Virus Project, but there were still many questions related to not understanding the assignment, not knowing how to work the technology aspects, and getting clarity that they were moving in the right direction and getting the right answers.” (Teacher Reflection Journal, April 2015). One student who had some difficulties with the Virus Project, mentioned the car task is this statement from her questionnaire. “I like it because it was easy for the most part” (Student questionnaire, April 2015). There was much less confusion about what to do next, “but there were still some ‘I give up’ or ‘I don’t get it.’” (Teacher Reflection Journal, April 2015).

There was also scaffolding needed in the use of technology. During the Virus Project, the technology use was too open ended for many of the students, without enough structure to guide
them to internet resources that were more suited for their abilities. One student’s frustrations were seen during observations of both the Virus Project and the car task. During the Virus Project she says, "Geez, how did you do that so fast?" and "I hate computers. This thing is pissing me off." (Student Observation, March 2015). When trying to find her loan payment amount for the car task, she asked, “Why isn’t this thing working.” (Student Observation, April 2015). Another problem we encountered with technology was that “Some students were easily distracted and to choose a car was difficult because there were so many choices and ways to get off task using technology” (Teacher reflection journal, April 2015). Therefore, a need arose to have more time allotted to scaffolding the use of technology, software programs, and internet research and providing differentiated resources or expectations that could be used to allow students of differing abilities multiple ways to show their understanding of the mathematics.

In summary, scaffolding through the means of modeling, questioning, task structure and choice were stated multiple times by students as parts of the class that helped them feel more confident. Teacher modeling was used throughout the CRMP tasks to provide students with multiple ways of understanding and learning the mathematics concepts and both sections of the teacher observation scale on modeling and explaining were rated highly for all tasks. Visual, hands-on, verbal explanations, and step by step models were all used to promote learning of algebraic functions. Questioning was used to guide students and their groups to increased understandings and advancing their mathematics knowledge within the contexts being studied. The structure of the tasks was adapted through the study to lessen the complexity and refine the expectations. Additions to the tasks included guided questions, table and graph frames and short time limits meant to motivate students to continue working and not get distracted by the internet resources and engaging topics. In the virus project, students had a limited amount of choice of
their specific virus topic, but more choice in the resources they used and how they presented their final project. The buying a car task had more student choice in a more structured task with limited resources and choices in the final project, however, because of this, the task was easier for the students to complete independently which reduced the amount of peer collaboration.

Scaffolding was an important piece to blending the real world context and the mathematics of algebraic functions in an accessible way so all students can benefit from the CRMP tasks.

**Feedback.** Giving students multiple opportunities for feedback was an important part of my teaching with CRMP. Feedback can come in many forms dependent on the task, class structure, and class timing. It includes these multiple forms, as well as the teacher anticipating the needs of the students, monitoring the students understanding and behaviors, and setting up structures for students to self-monitor, self-evaluate and reflect on their own learning.

**Feedback opportunities.** Analysis of the teacher observation scale showed high ratings for all CRMP tasks for “Teacher has specific and consistent routines and rituals” and “Feedback on mathematics understanding is frequent, focused, and meaningful” (see Table 3). I also rated the area “Teacher anticipates and monitors students’ mathematical understanding,” in the high range for both the Virus Project and the Buying a Car Task, yet rated in the medium range for the Party Assessment (see Table 3). These ratings reflect more consistent observations of anticipating and monitoring during the first two tasks and considerably less within the independent summative assessment. All three of these were seen daily throughout the class time, from beginning to end. Each day consisted of a somewhat structured daily schedule of feedback which included whole class, group, and one on one feedback instances all within a central focus on goal setting, progress monitoring, and student reflection (see Figure 3). “I teach in a very
structured and supportive way. We had a specific starting and ending routine” (Teacher Reflection Journal, April 2015).

**Identify goals and warm-up.** Each day, at the beginning of the class period, students wrote down their math goals for the day on a form they kept throughout the week. These were the specific goals that I expected them to reach before the end of the class and a review of any past learning that was relevant for the day’s work (Field notes, March 2015). This allowed for a consistent way to start class and an opportunity for students to discuss with me and their groups what their intentions for the day were. With multi-day projects, the goals sheet also helped the students monitor their progress on each part of the project, discuss difficulties that they encountered, and reflect at the end of the class on our observations and learning from that day. I began class each day with a whole class warm up that consisted of the learning objectives for the day, I reviewed this prior knowledge for approximately five minutes, as well as any tricky or confusing elements that they might encounter with the lesson or the technology (Field notes, March 2015). Feedback during this warmup time consisted of checking on students’ mathematics understanding and possible misconceptions. I facilitated the warmup by first asking students to try the math problems alone and then they shared their thoughts with their group. “You have one minute to try this by yourself and then you can share your ideas with your group” (Teacher observations, March 2015). While the students worked on this, I circled the room looking for correct algebraic understanding, as well as misconceptions. As a class, we then discussed any misconceptions. After the warm-up, I introduced the lesson and the task that we were working on that day (see Figure 3). This was discussed, for approximately five minutes, as a class first and then I asked the group to clarify together the mathematics we will be learning and the expectations for the task.
Anticipating and monitoring occurred one on one and within class and group discussions. When asking a question to the whole class and not getting an answer, at times I would change the question slightly to encompass prior knowledge that the students were more proficient with. One whole class discussion focused on calculation operations with numbers in scientific notation. “What do we do with the exponents when we are multiplying these numbers?” After some wait time, “I’m waiting.” “Ok. I’ll give you another question then, a to the fifth times a to the fourth. What’s that answer?” “I’m going to wait.” A student volunteers her answer of a⁹. “Yes, a to the ninth power. What did _______ do with the numbers? Remember our exponent rules?” (Teacher Observation, March 2015). This scaffolding helped me check their conceptual understanding of working with exponents and scientific notation and may have helped them push their current knowledge to a deeper or more advanced understanding of the concept. When working with individuals in groups that needed help, I would address the group and ask them to help the individual. If an individual had a question that I felt would benefit the entire class, especially if the student was a traditionally lower-status mathematics student, then I would address the whole class with the question, such as “_________ asked a good question,” ask for answers, and give other tips that the students may need to think about (Field notes, March 2015).

**Task work and check-ins.** From there, students worked in their groups and I checked in with each group throughout most of the rest of the class to see if there were any underlying confusions. Throughout the task I used a model of feedback (see Figure 3). First, I circled the room to support everyone in getting on task. I asked questions like “Does anyone need anything?” “Does everyone know where to start?,” and I asked the groups to be in charge of making sure that everyone in their group was getting started on the task (Teacher Observations,
March 2015). The responsibility was put on the group and I worked to initiate this. I then put my attention towards students who were struggling to get started. After I made sure that everyone had begun working on the task, I then circled the room to check in with groups to make sure that they understood the mathematics we were working on and the task expectations. Again, the responsibility is first with the group to help each other. When I would come to an individual that asked for help, my first question is, “Did your group help you?” If not, I would ask the group to work together and help the student (Teacher Observation, March 2015). If they did try and the student is still struggling, then I would step in and support the student with their misunderstandings.

I try to express high expectations to every student, by checking in with all of them, but because I have so many special needs students in this class, it is hard to give all of them the type of attention I would like to” (Teacher reflection journal, April, 2015).

After it seemed that most everyone was working on the mathematics task, I circled the room again checking in on students who were not participating or putting in their full effort. Choosing not to do the tasks was not an option. “I was present and attentive to the students the entire class period” (Teacher reflection journal, April 2015). These students tended to be students who were unmotivated, students who liked to distract others, or students who were slower and got lost easily in the task. “I helped students with and without their hands raised and checked in with students who I knew would need extra help with calculations, vocabulary, focus, etc…” (Teacher Observation Field Notes, April 2015). I asked questions such as, “Do you need help?” “What have you finished so far?” or “Let me see where you are” to begin to redirect their behavior (Teacher Observations, March 2015). Once it seemed that all students were working on the task, I circled the classroom again checking on the students’ work that had been completed,
looking for accuracy and misunderstandings. When I found a student that needed further guidance, I would give feedback such as, “Your budget seems high. Show me how you got that amount?” or “Your table and graph don’t seem to match. Did you find your basic reproduction number?” (Teacher Observation, April 2015). “Frequent one on one, group, and whole class check-ins were done to check for understanding and correctness.” (Field notes, April 2015).

Interruptions were made to the whole class when necessary (see Figure 3). These were normally tips and reminders, taking what might have been an individual or small group difficulty and using it to provide feedback to the whole class.

**Reflecting.** At the end of each class, we came together and reflected on what we learned during that class period, where we were within the time frame of the task, and what we plan to work on the next day (see Figure 3). This was normally done by asking the students to discuss these questions as a group first, then record their thoughts on their reflection paper, and then asking some of them to report what they wrote. Many times I would specifically ask someone to share who I knew had a well thought out or interesting reflection, especially if they were a student with traditionally low status in math.

**Self-monitoring.** Using the teacher observation scale, I rated the area “Teacher explicitly teaches and encourages self-monitoring strategies, such as help-seeking behaviors, metacognition, and reflection” in the medium range for both the Virus Project and the Buying a Car Task, yet the Party Assessment was rated in the high range (see Table 3). These ratings show a concerted effort on my part to teach and encourage the use of these strategies throughout the study, such that on the last CRMP task the students were more comfortable asking for help, thinking about their mathematics thinking and reflecting on their mathematics learning.
One dimension of self-monitoring is help-seeking. There were many documented occurrences of help-seeking within group members, mainly when a student needed help understanding the next step in the task, the mathematics, or the use of technology. “I encourage them to ask for help, but with the understanding that I will not give them the answer” (Teacher reflection journal, May 2015). An example of one student asking for help with a specific problem with her graph was, “That doesn’t look right. It goes off the graph. I need help” (Field Notes, April 2015). One area where there was not as much attention given was explicit teaching of metacognition and reflection during the first two activities, although these thinking processes were used routinely at the end of the class period to summarize what was learned and accomplished each day. One student who used these thinking processes aloud quite a bit had these examples. "I can't find if there is a vaccine available." "I still don't know what someone should do if they have this." "I'm done with that part, now what do I do?" "So am I done?" "Mine's slow." "How do you not get it?" "Does this mean that I did it all wrong?" (Student Observations, March 2015). A reflection question given at the end of one of the class periods was,

Think about the cars that you and your group picked. Think about how their value is going down and how much you are paying every year for the car loan. Do you think it would be better to buy a more expensive car or a cheaper car? (Teacher Observation, April 2015).

One tool that I developed to assist students in self-monitoring during the more open and complex Virus Project was a check list. I created it as a response to the confusion students had with the many steps and dimensions in this task. This checklist was a list of all graded elements of the project and was especially important for students towards the end of each section, helping
them to confirm that they were not missing any required elements. Students used the list to self-evaluate their assignment, to discuss the requirements with their group members and to know what questions to ask if they needed help. It also assisted me in helping to communicate to students when parts of the project were not done thoroughly or with adequate mathematical understanding. This feedback allowed students and me, to target any mathematical misunderstandings and discuss them together.

**Case studies.** All four students showcased in this study experienced all types of feedback listed previously. Lara received feedback more from her peers than from myself and stated that her confidence in mathematics was highest when she could help others or when she can get help from others. This was apparent throughout the CRMP tasks, as she asked and received help from her group members and myself on many occasions and she spent a large amount of time helping her group members, one being an ELL student and one being a student on a math IEP. It is interesting to note that even as a part of a highly diverse group of learners, Lara still believed that this math class was easier because the students seemed to be around the same level. Carlos did moderately well listening to the teacher expectations and the feedback from his group, but he was generally shy to ask for help. He mentioned that he felt more confident with his mathematics abilities when a teacher sat with him and “talked about math face to face” (Student questionnaire, March 2015). Unfortunately, there was little time for such encounters with the complex structure of the tasks and the number of questions from students. Olivia and Yasmin both utilized some self-regulation techniques, such as metacognition and reflection. Olivia was observed thinking about her math work and discussing her ideas with her peers and teachers. She also was observed reflecting on how and why she solved problems in a certain way. During the study, Yasmin was also reflective and metacognitive. She was a good listener to both the teacher and to her peers.
and utilized her experiences and ideas to have thoughtful discussions with her group members about the mathematics. Yasmine was observed talking through her problems and catching her own and others’ mistakes.

**Task difficulties.** Giving feedback on these CRMP tasks had its challenges. Due to the independent nature of the tasks, where everyone had a different virus or vehicle they were working with, anticipating and monitoring each students’ understanding was not an easy task. With each student having a different topic, it was frustrating for them to not be able to check their answers. The only way they would know if they were on the right track was to confirm with me. It was difficult to address all of these students’ questions because of a lack of time and support in the classroom. This led to concerns about the number of students with questions about the assignment and whether the lack of teacher support could impact their mathematics self-efficacy negatively.

Something I noticed today is that students were getting frustrated because I could not get to them quick enough and give them the feedback that they wanted. Most of the time I got two questions, ‘How do I do this?’ and ‘Did I do it right?’ I wonder how much the longer time to get questions answers and to hear that they did it correctly is affecting their self-efficacy as doers of math? (Teacher reflection journal, March 2015).

By this time in the school year, spring, most students are willing to raise their hand and ask for help. They have learned that it is the fastest way to get my attention and to let me know that they are struggling. Yet there are still some students, extremely shy students, unmotivated students, and students that want to complete tasks independently, that refuse to say, in one way or another, “I need help.”
The difficult part is when these students, for whatever reason, do not want to raise their hand and ask for help. This causes a loss of possible time for them to work. I wish I could get them to be ok with asking for help and get them to realize that getting help is what is needed sometimes to learn or get past whatever barrier is in their way (Teacher Reflection Journal, March 2015).

Another difficulty seen in regard to feedback was students not trusting in themselves that they can achieve the correct solutions to the tasks. One student spoke often about her own self-evaluation and metacognition through the tasks. "I don't even think it's right." “Oh, I was right." "I'm not sure which one it is." "I'm not sure. I'm not even sure how I did that.” "I'm not even done because my numbers are so big on here” (Student Observation, April 2015).

It was difficult to set up ways for students to self-evaluate and grading the task was difficult. I like how the project allows them to pick a vehicle of their choosing, but it makes it more difficult when it comes to grading and helping them know they are right in their answers (Teacher Reflection Journal, April 2015).

The last difficulty encountered with this project was the challenge of grading multiple representations of differing data from different viruses. All students in the class had different answers to the tasks and I had to take the time and gain the knowledge to evaluate the correctness of the information and the mathematics.

In summary, all three CRMP tasks showed frequent and focused feedback delivered through anticipating and monitoring students’ algebraic learning in multiple ways. Daily goals, warmups and reflections helped to form routines and self-monitoring tools helped students stay on track with these complex tasks. These tasks proved challenging in many ways, such as providing feedback when every student had different answers, students no trusting in their
abilities and therefore having many questions and students that do need more support not asking for help. In addition, more explicit use of metacognition and reflection processes were needed throughout. Giving students feedback in multiple ways worked to help the students feel more successful by continuously having small bits of success, which may build a higher mathematics self-efficacy (see Table 4). “Giving feedback immediately and being right there at their desk, seems to give the students comfort that I am there when they need me and that my job is to help them understand the work, not just assess them and give them a grade” (Teacher reflection journal, April 2015). Results from both the student general mathematics self-efficacy surveys and the student observations show that successful mathematics performances did increase over the time of the study in both data sources (See Table 4).

**Building relationships.** Building stronger teacher-student relationships is a fundamental piece of the CRMP framework. I worked to build relationships with my students by providing a supportive classroom environment in which every student was and felt supported in their learning of mathematics. “My students are generally very happy when they enter my room and I feel like I try to provide a safe and comfortable place for learning” (Teacher reflection journal, March 2015). This was done through developing mutual respect for their learning and their time, positive academic and social interactions and expressing high expectations and beliefs in all of my students’ abilities.

I want to show them that I will do whatever it takes to help them learn mathematics and help them like mathematics, or at least see the value in it. To me, this means I need to show them that I care more about them than to sit at my desk and let them work through their frustrations by themselves. They need a support person, a cheerleader, so to speak, and that is my role, besides being a teacher. (Teacher reflection journal, April 2015).
I worked on being patient, motivating, and being a good listener. Some students saw these qualities and commented on them in their questionnaires. “The teacher motivates you to try harder” (Student Questionnaire, May 2015). “She is actually patient” (Student Questionnaire, March 2015). “This class is much better for learning things slow, but we still learn it well. She is patient with us” (Student Questionnaire, March 2015). “I liked how she explained it to us and how she was going over it together as a class” (Student Questionnaire, May 2015). Teacher qualities that students expressed helped them to feel more confident and successful in the mathematics class are showcased in Figure 4. This included my support, patience, interest, enthusiasm, positivity, motivation, and respect for them as individuals.

Using the teacher observation scale, I rated the CRMP area “Teacher works to build relationships with each student” in the medium range for the Virus Project and in the high range for both the Buying the Car Task and the Party Assessment (see Table 3).

Throughout the Virus Project there were many ways in which I worked to build relationships with my students.

I built relationships with my student when I met with them one on one and helped them understand difficult vocabulary or mathematics concepts that they were struggling with. I also added in some of my own experiences when I spoke to them. I asked them how their weekend was and if they needed help. I offered my room before school, at lunch, and after school for extra help and work time” (Teacher reflection journal, March 2015).

I rated my implementation of the Buying a Car Task within the high range for “building relationships,” showing an increase in my growth as a teacher in this area (see Table 3). I demonstrated positivity and enthusiasm for the topic and the use of algebra to complete the task and showed genuine interest in the students’ car choices and the decisions that they made related
to choosing a vehicle. I tried to always treat my students with respect, for example, by “apologizing when I could not get around to each group” or when I had to be gone for a few days during one week’s time (Field notes, April 2015). During this task, I also worked to learn more about them personally.

I built relationships through my one on one conversations with students. Throughout this task, some of those conversations were specific to their likes and dislikes pertaining to vehicles. Some students wanted to get trucks or motorcycles, so I allowed them to do that. They told me stories of the cars and trucks that they are restoring at home with their family members (Teacher reflection journal, April 2015).

The Party Assessment was rated in the highest range for “building relationships” because I continued to work on this aspect of my teaching (see Table 3). This assessment was a straightforward activity, with no complexities or distractions related to internet research or cooperative groups. The concrete application and the local places made this task highly accessible to all students. “I think by choosing to include culturally relevant or community related tasks” in my assessment, “students may find me to be more real or approachable, therefore helping to build that relationship even further (Teacher reflection journal, May 2015). The connections in this assessment to students’ personal experiences, local or world issues, and potential life lessons were engaging and relatable for students. “I want to teach material that is relevant to students and make them see a purpose for the mathematics they are learning. I also want it to relate to what they are going to have to deal with in their future” (Teacher reflection journal, May 2015). This was a much different type of assessment than what the students had normally seen, but “I think students know that they will learn mathematics in my class and it doesn’t have to be boring or tedious” (Teacher reflection journal, April 2015).
Praise. Frequent positive feedback and praise helped me to build strong academic relationships with my students. I rated “Teacher celebrates small and big successes” within the medium range for both the Virus Project and the Buying a Car Task and at the highest level for the Party Assessment (see Table 3). I tried to “praise students when they had put in good effort and had worked hard, especially if they were not normally a student that puts out 100% effort” (Teacher reflection journal, March 2015). “You’re doing just fine,” “It looks good,” and “Perfect” were just some of the instances that were recorded during this study (Field notes, March 2015). Due to this area only being rated in the medium range, I worked to provide more consistent praise during the next two tasks, especially because praise is the main element of Bandura’s self-efficacy source, social persuasions, which can influence students’ mathematics self-efficacy (Bandura, 1987). Table 4 shows that social persuasion ratings decreased over the course of the study in student surveys, but increased in the student observations. This may indicate the difference in perceptions of praise from the students’ perspective versus my perspective.

For the Buying a Car Task, the medium rating showed that

I still was not able to show consistency in providing praise. I tried to offer encouragement to most of my students with motivating praise and checked in specifically with students that had shown high needs in the past (Teacher Reflection Journal, April 2015). My focus during this task, at times, was more about classroom management and mathematical understanding, praising students became secondary.

I rated the Party Assessment in the highest range for “celebrating small and big successes” because I felt I had improved upon this area with more consistent observations seen through this task (See Table 3). During this assessment I “gave lots of encouraging praise and
motivating pats on the back to some of my more struggling students” (Teacher reflection journal, May 2015). I tried to encourage them throughout the assessment time, “to keep working until they were finished. This was to help keep them focused and on track to finishing within the time allotted” (Teacher reflection journal, May 2015). For my students in special education or ELL programs, I praised their effort while I “checked in with them and questioned them on their work to help guide them to question their own answers” (Teacher reflection journal, May 2015).

**High Expectations.** Throughout the study, I tried to consistently express my belief that all of my students could do high level mathematics. One of my main goals was that “when they leave my classroom, they feel stronger and more confident in their mathematics understanding and skills” and that they believe in themselves as doers of mathematics (Teacher reflection journal, May 2015). One way that I did this was by giving all students the same high level CRMP tasks and only scaffolding or accommodating based on individual needs, not group needs. In addition, I tried to ensure all students were participating in the task through checking in, supporting their needs and telling them how much I believed in their math abilities. “I will not allow them to sit in class and not do work. Through this project, I constantly checked in on students that easily give up or have a difficult time understanding the directions or the mathematics” (Teacher Reflection Journal, April 2015). My observation ratings for the area “Teacher shows high expectations for every student” was scored at a medium level for the Virus Project and high for both the Buying a Car Task and the Party Assessment. This shows that there were some observations of high expectations for all students during the Virus Project, but it was not as consistent as in the other two CRMP tasks (See Table 3). The complexity and length of the Virus Project made this task especially difficult for some students and harder for me to express my high expectations for every student.
Students that are consistently absent, are quiet and/or shy, and students that have a tendency to disrupt the classroom and do not show much interest in learning are the students that I tend to not build those stronger relationships with, but I still do believe that I express high expectations for them” (Teacher reflection journal, March 2015).

Due to the Virus Project being the first of the CRMP tasks to be taught, the task and class structure were more open form causing some confusion and classroom management concerns, such as some students not participating and distracting others. After reflecting on this experience, I made adaptations in how my expectations were expressed and followed through during the last two tasks. For example, after the Virus Project, one adjustment I made was to give short time limits to get different sections completed instead of having a more open timeline. During the car task, I demonstrated “strong relationships with my students” because they “understood my expectations and I understood where they were as people and students, allowing flexibility in how each of them worked on the task” (Teacher reflection journal, April 2015). For example, I said “I’ll give you one minute to finish, then we are going to go on” (Teacher Observation, April 2015). This helped to keep students focused and progressing on the mathematics tasks. In addition, I also included more reviewing of necessary prior knowledge and I increased my frequency of reminders and refocusing to exhibit my belief that all students could be successful given the right supports. This helped students be more motivated to tackle the mathematics, be more willing to persevere, and ultimately show me more of their understanding of algebraic functions by completing more of the tasks.

**Task difficulties.** Through this study, I found that “it could be hard to build relationships with students who were shy, quiet, or did not raise their hands to be helped. The more persistent students got more attention” during the Virus Project (Teacher reflection journal, March 2015).
“Students that are consistently absent and students that have a tendency to disrupt the classroom and do not show much interest in learning” were also difficult for me to build stronger relationships with (Teacher reflection journal, March 2015). However, I did see improvements with these students over time as our mutual respect for each other grew. Other difficulties which I encountered within the area of building relationships during these tasks were the busy and sometimes chaotic nature of the work. At times I was too busy helping students make sense of the mathematics and making sure students were acting appropriately than giving praise, sharing my high expectations or expressing my belief in each student.

In summary, there were many occurrences of my building relationships with my students throughout these three CRMP tasks. Relationship building was a continuous and growing process throughout all three tasks that included developing mutual respect through working together on academic and personal issues. Specific praise and encouraging messaging was used throughout to celebrate student successes and reward effort. Celebrating students’ successes was a consistent focus through the study as I worked to improve this facet of my teaching and, ultimately, did increase the regularity of my praise efforts. Sharing my own high expectations for my students to my students was also noted to have increased from the beginning of the study to the end again showing how I worked to improve my focus on building relationships with my students, forgoing some attention and focus on classroom management and mathematical understanding. The end goal of understanding algebraic functions still occurred, however, with the increased focus on building relationships, by the end of the study, students were more engaged in the mathematics, more invested in their learning, more motivated to work together and more respectful of the learning process.

**Cooperative Learning**
Cooperative learning, at its most fundamental level includes “instructional programs in which students work in small groups to help one another master academic content” (Slavin, 1996, p. 200). In this study, students were placed into heterogeneous groups based on their initial scores on a general mathematics self-efficacy survey, their prior quiz grades and their math confidence ratings from the weekly quizzes, based on whether they overestimated or underestimated their math confidence. I attempted to include two participants in each group that showed higher mathematics self-efficacy, one with overestimation of mathematics self-efficacy and one underestimation, and two participants with lower mathematics self-efficacy, again one with overestimation and one with underestimation. I was also cognizant of not placing students with peers they may have had a positive or negative history with.

Using the teacher observation scale, I rated the area “Cooperative learning is used with a model that encourages participation of all group members, including group decision making, in the mathematics activity” in the medium range for both the Virus Project and the Buying a Car Task. However, I did not rate this area for the Party Assessment due to the individual nature of the assessment (see Table 3). The medium ratings were due to the lessons being individually assessed and the sometimes lack of student accountability to ensure their participation in their group. The CRMP lessons used in this study were created specifically to have independent accountability for the student, but be done within a group setting. This had many advantages, as each student was ultimately responsible for their own work, yet still had the comfort of working together to accomplish the end goal. “Working together in groups allowed the students to grow as learners and as independent people as they expressed their thoughts and ideas to each other about their viruses and the mathematics that described them” (Teacher reflection journal, March 2015). Students saw the value in cooperative learning too. “We all help each other and learn
together” (Student Questionnaire, March 2015). “I feel like I'm in the highest group. I try to help other students so they can get up there too” (Student Interview, May 2015).

Cooperative learning was used throughout the Virus Project and the Buying a Car Task and it was expected that all students worked together in their heterogeneous groups. “Students worked in groups, not to complete the task together, but to use each other as resources for help when they needed it” (Teacher reflection journal, April, 2015). It also gave struggling students hope that they too could do algebra.

Cooperative learning helped these students work together and see that they can be successful like the people in their group, as well as see that everyone in their groups struggles sometimes. It’s not just them. Also, it gave them more confidence to persevere when they have people around them that they trust to help them when they get stuck (Teacher reflection journal, March 2015).

Another area I rated using the teacher observation scale was “Peer models were used within small groups to facilitate autonomous mathematics teaching and learning,” I rated this area in the highest range for the Virus Project, but only in the medium range for the Buying a Car Task (see Table 3). Again, I did not rate the Party Assessment in this area due to the lack of cooperative learning during the assessment. These ratings show that there were more consistent observations of peers working together to understand the mathematics in the Virus Project than in the Buying a Car Task. This was primarily due to the complexity of the Virus Project in terms of the scientific knowledge and data that students had to work through, as well as the openness of the project. Peers had to work to locate reference materials and understand and apply the mathematics to complete the task. When discussing their basic reproduction number and creating their table, two group members said, “I found mine” “What your average?” “Mine is 5.35. I just
keep timesing 5.35 to make my table” (Student Observations, March 2015). In comparison to the Virus Project, the Buying a Car Task was written in a more structured, clear and step by step format. The reading required was less scientific and more easily understood for all students. The peer models were seen through my use of cooperative learning and explicitly teaching the students how to help each other learn. Remarks such as, “Help each other out if someone can’t find it, just for a few minutes,” “Ask your neighbor if you are not sure” and “Don’t be shy, ask for help if you need it” were common place in this classroom (Field notes, March 2015; Field notes, April 2015). Students also expressed their thoughts on cooperative learning and peer models in their questionnaires and interviews. “Math is challenging, but like if I get help from other students then it helps me understand it so it’s kinda easy” (Student interview, May 2015). “I know that if I think something and everyone else thinks that then I can know that we are doing it right” (Student interview, May 2015).

Case studies. All four student cases shared their positive responses towards cooperative learning. Olivia seems to value the opportunity to work in groups “I try to participate sometimes, but other times I usually ask my friends to help me when I don't get stuff because it’s hard to pay attention and try to do it by myself” (Student interview, May 2015). She also tried to help others, for example, when she helped other students find the correct information about cars on the internet websites (Student observation, April 2015). Yasmin believed that groups were better for getting help from each other. She said the in this class the teacher and students “always try to help the other students that need help and like in other math classes they usually don't have time to help one another” (Student interview, May 2015). Unlike the other students, Yasmin also reflected on a potential downfall of working in groups. “Sometimes I get pressured while being around some peers and it makes me not want to try” (Student questionnaire, April 2015). Carlos
really enjoyed being able to help other students, even if it was not always with the mathematics. He felt that the more he gives to people, the more he will get in return. “I participate and help others. I sometimes help them with math problems they don’t get and in return I get help from them. So like I help them and they help me with things I don't get” (Student interview, May 2015). Carlos stated that he felt most confident in math “when we were in groups because if you don't understand something another member of your group can help you with that and if they don't understand something and you know it, then you can help them” (Student interview, May 2015).

Lara stated that her confidence in mathematics was highest when she worked in groups or with a partner. She expressed that she feels most confident when she had “classmates that help” and when she had “classmates ask her for help” (Student questionnaire, March 2015). She was never afraid to ask for help herself and regularly gave others in her group help, whether they asked for it or not. At times, she was seen checking in on her group members to make sure they understood the questions and were making progress (Field notes, April 2015). Lara’s willingness to help her group members was at times both positive and negative. In some ways, helping her group members, one who was an ELL and one who was a special needs student with a mathematics IEP, helped her better understand the mathematics and the real world contexts. She had productive conversations with her group, which included virus shapes and symptoms, the budget they each had for buying a car, and how to set up the technology tools to complete the tasks. She was friendly and supportive towards her group members, “Guys, this is your car. That’s good” and patiently gave them step by step directions for the tasks they were working on (Student observation, April 2015). Unfortunately, at times, her attention towards her group members took her attention off of my instruction and off of her own work. It also seemed like
Lara used helping others as a way to procrastinate on doing her own work. “I help people once in a while, but I don't really like doing it myself” (Student interview, May 2015). Eventually, during the Buying a Car Task, she had to begin to ignore her group members’ requests for help to catch up, however, she did not get caught up and ended with a less than proficient grade on the task.

**Cross-case analysis.** All four students expressed the importance of working in groups to their learning of mathematics and to their confidence in doing math. Carlos stated that the opportunity to work in groups was one of the reasons why math was his favorite subject in school. In his interview, he spoke of having a reciprocal relationship with his friends, where he could always ask them for help and they could, in turn, always ask him for help. Lara mentioned that what helps her feel most confident in math class is “having classmates ask me for help” (Student questionnaire, March 2015). Olivia also felt that groups helped her learn best. When talking about doing math assignments, she stated, “I try to take my time because I know that there are other people around that can probably help me and try to help me understand it.” Due to her attention disorder, she sometimes asks friends to help her when “it is hard to pay attention and try to do it by myself” (Student interview, May 2015). Yasmin also believed in the value of groups and helping one another understand the mathematics, however, she had some reservations. She believed that students should get to pick their own groups so they can be more comfortable, but understood that “sometimes, if they do that, they become less focused” (Student interview, May 2015). She also mentioned that in group settings, “sometimes I get pressured while being around some peers and they make me not want to try” (Student questionnaire, March 2015).
**Task difficulties.** Difficulties arose within groups when some students would not cooperate with their group members. They may have been disruptive, distracting, or just unwilling to help their peers. Other difficulties arose when students spent too much time helping others, putting the completion of their own task in jeopardy.

Certain students in their group took on the teaching for these students, taking a lot of time away from their own work, which I think led them to have lower overall scores on the task. Cooperative learning and group work are sometimes a difficult balance of helping others, but getting your own work done, and it’s especially hard when you have distracting group members that are not willing or don’t understand how to do the assignment and are constantly asking for help (Teacher reflection journal, April 2015).

In summary, many students mentioned that this class was more challenging than their previous math class, but more fun and easier to understand because of the greater support from peers and myself. Cooperative learning was a positive structure that allowed for the individualistic nature of the tasks and provided the group support to work together and learn about algebraic functions. Observation ratings could have been higher if the group structures and expectations would have been stronger. I was unable to consistently and successfully manage a few students that tried to derail other students work through distraction. I also needed to put more effort into explicitly teaching the students how to better work together in groups, including being able to trust each other more as problem solvers.

**Student Status**

Student status in the mathematics classroom is the assigned or assumed value of importance that each student and the teacher perceives about themselves and their peers (Boaler, 2016). By minimizing status, I worked to make all students feel like their contributions were
important and their learning valued. The CRMP lesson analysis tool section “Power and participation” included analysis on status. The ratings in Table 2 show an increase in the use of “multiple strategies to minimize status among students (and specific subgroups)” from the Virus Project to the Buying a Car Task. My primary framework for doing this was using Complex Instruction strategies as a guide (Cohen & Lotan, 1997; Horn, 2012). Another piece of analysis related to my use of Complex Instruction to minimize status was the teacher observation area “Teacher makes students aware of individual differences in the classroom and insists on respectful collaboration.” This was rated high for both the Virus Project and the Buying a Car Task, but was not rated for the Party Assessment because there was no collaboration between peers during that task (See Table 3). These high ratings were due to my use of Complex Instruction and the group norms. Examples of these include when I said to students “you have the right to ask anybody in your group for help and they have the duty to give help to anybody who asks.” (Field notes, April 2015).

What was seen through the use of Complex Instruction group norms during these CRMP tasks was that the differences in students’ mathematics abilities became blurred. “I think that some are good and others need help, but all of us can do it” (Student questionnaire, March 2015). Many students commented that everyone in the class is capable, has similar abilities, and is smart. One student mentioned that it was hard to tell who the “smart” ones were because all students worked together and all students asked questions of each other. “Everyone in this class is capable to solve problems” (Student questionnaire, March 2015). No longer are the lower ability students the only students needing help. “We are all pretty smart, I think, and we are always on the same level” (Student interview, May 2015). When students felt that they were on the “same level” they were more willing to listen to each other’s ideas, were more willing to
persevere through difficulties or frustrations and seemed more motivated to learn the mathematics.

Throughout the study, I worked to minimize status in my classroom through the use of cooperative learning, teacher questioning, professing my belief that all students were highly capable of learning the mathematics and completing the tasks, and “praising traditionally lower achieving students work, effort, and understanding” (CRMP lesson analysis, March 2015).

“Status was minimized in this way as all students had to work together, yet independently. The students’ status seemed to benefit from them discussing their ideas with each other, modeling their mathematics with each other, and helping each other problem solve through their difficulties. When asked the question, “What parts of our class help you to feel more confident doing math?” many students spoke of working in groups. One student stated, “When we were in groups…we can ask other classmates for help” (Student questionnaire, March 2015). Another student reiterated this, “We all help each other and learn together” (Student questionnaire, March 2015). During the Party Assessment, status was minimized by “explaining the assessment in detail to all students before they began” (CRMP lesson analysis, May 2015). Technology also seemed to improve some student’s status as they were able to help others in their group with the research tools and programs when others had difficulties. “Some students who had lower math skills had higher technology skills and they could help other students that maybe were used to helping them” (Teacher reflection journal, March 2015).

**Case studies.** All four student cases spoke positively on working in cooperative groups and, in their own way, described the status that they saw and experienced in the classroom. Lara stated:
It seems easier in here, like I understand it better, because I feel like I'm in a class with people that know math almost exactly the same as me. Like I don't feel like I'm working with harder people, like if someone knows math that I am near, I don't get frustrated when I don't know how to do it (Student interview, May 2015).

In this statement, Lara expresses her difficulties when one of her peers understands the mathematics better than her and how in this math class it seems like everyone is about “the same,” which leads her to having less frustrations.

Even with his quarter grades showing proficiency and math being his favorite subject, Carlos still believed that he was not very good at mathematics. He related this to his difficulties with equation solving.

I have a poor ability to solve math problems because I don’t know how to solve equations. Some equations are really easy, but some can get really confusing to me. I get tired of really focusing on the equation. Sometimes I really focus on one equation and how to solve them and some I need…, it's difficult for me to solve” (Student questionnaire, March 2015).

After a productive discussion in viruses, Carlos mentioned to his group members that they looked “so smart,” insinuating that because he was not involved in the conversation that he was “not smart” (Student observation, March 2015). Later, during the virus project, he became frustrated with some degrading comments from his group members and said, “I’m not stupid” (Student observations, March 2015). This demonstrates how status was expressed and developed within the cooperative group settings. Yasmin also mentioned that groups can make her feel less smart because “Sometimes you have a smart person with you or something and they say they
need help and you don't want that person to say that you are retarded or something” (Student interview, May 2015).

Prior to the Party Assessment, Yasmin showcased a lot of negative self-talk and expressed that she had test anxiety. “Sometimes when it’s time for a test my mind goes blank” (Student interview, May 2015). However, during the Party Assessment, Yasmin seemed confident about her work, focused and worked hard to finish it with only minimal support, just my encouragement and confirmation. She started working on the assessment while I gave initial instructions and went over the assessment questions. She confirmed with me only once that she was completing the questions correctly. Her analysis answers were complete, yet she could have added more explanation and elaboration. For example, her answer to “If you only wanted to invite 4 people (for a total of 5, including you), which party would be the cheapest? Explain” was “The bowling alley cause its only $110.” A more complete answer would have included the cost at the skate rink and how much less it would be at the bowling alley. Yasmin scored a 94% on this assessment, yet she only scored a 60% on the more traditional linear systems assessment that focused on solving systems with graphing and solving equations. This may play towards Yasmin’s tendencies towards test anxiety, possibly showing that some students, especially ELL students or student with high math anxiety and/or low status in the math classroom, may do better on CRMP designed assessments.

Cross-case analysis. Student status seemed to play a role in the groups, the students’ participation in the CRMP tasks, their frustration levels, and their mathematics self-efficacy. Yasmin, having the lowest mathematics self-efficacy, also struggled to find a good balance of success with the mathematics and her anxiety within her group. Yasmin worried about looking “dumb” to her group members. She would try hard to work on the project, participating with her
group and engaged during class discussions, however, she continuously had to check with me or her peers to make sure she was doing the tasks correctly. Carlos participated freely with his group socially, but rarely did he engage in the mathematics of the CRMP tasks with her group members. With a low overall mathematics self-efficacy, his avoidance of working on mathematics with his group members may have been a sign of low status and a way to keep himself from looking “dumb,” as Yasmin said. Olivia’s self-efficacy dropped and rebounded during the study, ending with the second highest mathematics self-efficacy of the cases. Within her group she kept to herself unless she needed help and at times would go to a friend in another group to get help. Her social persuasions ratings were very low which suggested that she did not receive much praise from her peers, from me, or from herself. This may have caused her status within her group to decrease, however, she did not seem as anxious or frustrated as Yasmin did, possibly because of her tight friendships and other students understanding of her special needs. Her high ratings in vicarious experiences and physiological state suggest that she was comfortable working within the group settings. Lara took on a leadership role in her group, helping others and encouraging them to keep working on the tasks. Even though she did not have the highest math ability of any student in her group, she did seem to have a status within her group. Students in her group would freely ask her for help and share their own interests and work with her. Being the only case that did not drop in her past mathematics performances rating over the course of the study may relate to her high status and her high overall mathematics self-efficacy.

In summary, I worked to minimize status during these three CRMP tasks through the use of heterogeneous groups and Complex Instruction group norms. The mostly high ratings using the CRMP lesson analysis tool and the teacher observation scale confirm that there were many
consistent observations of minimizing status throughout the study. Specific elements of minimizing status included praising lower status, using culturally relevant tasks, and encouraging students to help each other. Due to this work, students reported that the differences between them in mathematics abilities seemed to be less pronounced. Many students commented that they believed that all students were capable, smart and at the same level.

**Growth Mindset**

Many of the choices I made as the teacher during this study were not chosen to effect students’ growth mindsets, however, findings indicate that students’ mathematical mindsets did move towards growth (Dweck, 2006; Boaler, 2016). These included many of the topics already covered in this chapter, such as relationship building based on encouragement, praise, and genuine interest in students’ future wellbeing, having and exhibiting high expectations for students, and offering additional opportunities to learn and assess their mathematics (Boaler, 2016). Using the teacher observation scale, I rated the area “Classroom has norms for having a safe and supportive learning environment, which encourages learning from your mistakes,” specifically looking for signs of working to develop a growth mindset. I rated the Virus Project within the high range for this area due to the messaging given to the students throughout the project and the multiple opportunities to learn from their mistakes within their groups and grow in their understanding (see Table 3). The Buying a Car Task was rated in the medium range because there were less consistent observations of these norms due to the task being written with more scaffolding, which led to less frustrations and less opportunities to make mistakes. I scored the Party Assessment in the highest range because there were many observations of positive messaging encouraging students to persevere, to check their representations for mistakes, and to do their best throughout the assessment. “I also tried to keep away from statements that
mentioned how smart a student was or how good they were doing with the mathematics and instead tried to focus on their effort and perseverance” (Teacher reflection journal, May 2015). In addition, students were given multiple opportunities on all three tasks to review and revise their mistakes. “I felt that I was an advocate for my students’ mathematics learning by pushing them to continually improve and see math class as a learning opportunity, not just right or wrong. I tried to develop in them a growth mindset” (Teacher reflection journal, March 2015). I saw many of them begin to develop more of a growth mindset in mathematics through the sharing of their own opinions, thoughts, and conjectures of the mathematics, and as their belief in themselves as teachers grew.

Students in my class exhibited knowledge on their own growth and were able to articulate why and how they grew in their mathematics understanding and skills. Student responses that show the development of a growth mindset include when asked “In what ways do you think you are better at math now than when the year began?” a student responded, “We didn't understand y=mx+b equations, but now we do. Using them throughout the year helps” (Student interview, May 2015). When asked, “In what ways do you think you are better at math now after having finished the Virus Project?” one student responded, “I think I can do harder assignments” (Student questionnaire, March 2015). When questioned about whether her grades had improved this year, a student responded, “They went up because at the beginning of the year I was getting F’s in this class and now I have an A because I am learning it better” (Student interview, May 2015). Many students spoke of how practicing helps them learn more. “Somethings in math are really easy to me, but others are harder, but after a few times I get how to do it” (Student interview, May 2015). Working to develop a growth mindset also included learning help seeking strategies, such as this student’s. “I'll try to figure it out. I'll try to keep figuring it out. I'll keep
looking back at the equations. I'll keep looking back to how to solve the equations and if I still can't figure it out, I'll ask for help from a neighbor and if they can't help me then I’ll ask the teacher. (Student interview, May 2015).

**Perseverance.** With complex tasks and multiple opportunities to show proficiency, there was a need to develop greater perseverance in my students. I hoped that by working on growing positive math mindsets that I also instilled in my students a growing sense of perseverance, or mathematical resilience. However, I discovered there was a fine line between developing perseverance and having frustration that is difficult to define. “I have to remember that perseverance is good, but frustration is not always good” (Teacher Reflection Journal, March 2015). Building perseverance in mathematics was important during this class for two reason, to build up my students’ beliefs in themselves as math doers and because it may help them have more confidence and success on state standardized testing.

I know the Smarter Balanced tests are supposed to be different and have more communication and problem solving type problems, but if the students don’t know the skills and do not have the belief in themselves that they can persevere through a difficult problem, I fear that they will not do well (Teacher Reflection Journal, March 2015).

Perseverance seemed to increase through the tasks as students gained confidence in asking others in their groups for help and trusting that others around them would help them when they got stuck. “Sometimes when we are just in groups or something, it is easier for you to ask someone for help or like instead of being in rows you can be in groups” (Student interview, May 2015). Due to the complexity of the Virus Project and the difficulties that students encountered with the openness of the task, I structured the Buying a Car Task into shorter, more scaffolded sections. This was done in an attempt to lessen anxiety and provide more success in working
with the mathematics for every student. “Having shorter, more focused assignments helped students stay focused and feel more engaged, but it might have taken away from the problem solving and perseverance piece that I was trying to get at with some of these projects” (Teacher Reflection Journal, March 2015). Examples of perseverance were seen in many student observations throughout all three CRMP tasks, which will be showcased in the case study section below. I also made statements regularly such as, “Are you helping each other? I see a lot of hands up in the same group” (Field notes, April 2015). At times, students did have difficulties with the complexity of the data, analysis, and mathematic calculations, but were still able to successfully complete the tasks with support from their peers and myself. “This is a difficult concept for many of the students to understand, but we have built a relationship through the year that they know that I will support them in the classroom through these difficult analysis type problems” (Teacher reflection journal, April 2015).

**Lessening math anxiety.** In my reflection journal I shared that to lessen student anxiety I tried to extend the message that “mistakes are ok, feedback is important, and support is all around you” (Teacher reflection journal, April 2015). The observation area “Math anxiety is reduced by the classroom being a positive environment for mathematics learning” was rated in the medium range for the Virus Project and the Buying a Car Task, and within the high range for the Party Assessment (see Table 3). The Virus Project was rated in the medium range due to my lack of knowledge on certain viruses and their research and the student confusion at times over this same complexity. A medium rating in this area was given to the car task due to continued frustrations among students with the technology and mathematics calculations. The Party Assessment scored in the highest range for reducing math anxiety showing my own growth through the study on lessening anxiety and frustrations. This higher rating was also related to the
assessment being a shorter task with less mathematical connections and contexts for students to discern than the more difficult intricacies of the multi-day tasks.

Even with the medium rated marks in these areas, there were still many positive occurrences of lessening anxiety to promote a positive classroom and encouraging a growth mindset.

Through my instructional strategies, I wanted students to enjoy mathematics class and I believed that they all could do grade level mathematics. I tried to accomplish this by having engaging tasks, offering a lot of support and feedback, and having a safe, collaborative, and caring classroom environment (Teacher reflection journal, April 2015). One way I promoted a positive classroom environment was with an open door policy. Students used the classroom as a place to work on homework, ask questions, or just have some quiet social time before school or at lunch. The tasks we used also helped to accomplish a positive environment as students were able to be open with each other and share their interests. When asked “How does this math class compare with other math classes you have had in the past? Be specific” students responded, “In my other math classes from 6th and 7th grades, I felt stupid because I was in a class where everyone knew how to do math and I sucked at it.” “This class is different because there’s more kids that get confused, but even though they pass tests and ask for help” (Student questionnaire, March 2015). When asked about how math tests make them feel, a student responded, “In the beginning I am nervous to do it, but as I work on it, I get happy and excited because I know I can do it” (Student interview, May 2015). Finally, flexibility was built in to the classroom to support student needs and help them feel more comfortable in the classroom. Students were given choice in their task options, working spaces, and in the presentation of their final products. One student who was allowed to work in the back of the
classroom with his group commented, “I feel confident doing math at the back table because doing math in my table and with people makes me nervous and I feel pressure” (Student questionnaire, March 2015).

**Proficiency grading.** This school’s policy on proficiency grading also promoted a growth mindset. This policy required teachers to give students multiple opportunities to show their understanding, so part of my work was building in these opportunities and working with students to get them the help they needed. I rarely modified these tasks. I believed it was more important to support my students in their learning of high level mathematics and helping them feel successful at grade level then by requiring less than their potential. Accommodations were utilized, however, such as one on one support, additional time for tasks and assessments, alternative environments, and the use of technology. I believe that when students complete tasks proficiently, that have multiple levels of understanding and require written analysis, then I can better assess their understanding of the mathematics. My primary expectation is to get all students to understand the mathematics. “If they understand the mathematics then I believe more students would enjoy mathematics and would want to pursue mathematics further” (Teacher reflection journal, April 2015).

Students received a weekly progress report of their own grade data on assignments and assessments so they could also be part of the decisions about whether they needed additional opportunities to learn the content (Field notes, May 2015). According to the grading policy, students should meet a minimum proficiency level of 70% on all assessments or they will need opportunities to retake those assessments. “I do require all of my students to retake tests and quizzes that resulted in a score of less than 70%. This is to get them to show proficiency before the end of the grading period” (Teacher Reflection Journal, March 2015). Once the project or
assessment was completed, I graded it as quickly as possible and returned it to the students for a first round of feedback. All students that scored less than a 70% on projects were required to review mistakes, revise their work, and turn in the project for regrading. For assessments, students were required to complete extra practice, review their original mistakes, fix their mistakes, and take a similar retake assessment within a week’s time. All students, even those with a 70% or above were given this same opportunity with the same requirements. Most students completed these requirements and/or retakes because I built in these opportunities into the scheduled class time, instead of students having to take their personal out of class time to complete them. If after the in-class work the student was still not showing proficiency at the 70% level after one retake, the student was placed into Intervention Friday. “At the end of the class, I discussed Intervention Friday, a one-hour time to work on missing assignments and get their grades up” (Field Notes, May 2015). During the Intervention Friday time, students were able to get more individualized learning time with me and another opportunity to revise or complete tasks or retake assessments.

Proficiency, or successful completion of problem, tasks and assessments, is one way students can show successful past mathematics performances, the most influential source of improving self-efficacy according to Bandura (Bandura, 1987). Therefore, giving students additional opportunities to understand and learn the mathematics may improve their mathematics self-efficacy because they were having success. Figure 4 shows that successful mathematics performances for students during this study grew in both the student surveys and in the student observations. Due to the contextual, individualistic nature of these CRMP tasks, the opportunities for students to get feedback and revise or retake the tasks/assessments did provide additional understanding. Although Yasmin did not think it was fair grading. “I don't think it’s
fair because sometimes when you turn in work it’s just a little bit of points and then on the tests it’s like your whole grade. So sometimes when you do the test in there and you fail the test then your grade goes down because of your test” (Student interview, May 2015). For example, six out of the seventeen students in this study came to the Intervention Friday time to get additional time and support to better understand the mathematics and expectations for the Party Assessment. Once they retook the assessment, they all scored above a 70%, showing proficiency, according to the school grading policies, but they also showed an increased understanding of linear equations, analyzing systems in tables and graphs, and justifying their choice with mathematical evidence. I did have concerns that proficiency grading may have put too much emphasis on getting the right answers and not enough emphasis on the learning, as well as it can devalue the importance of daily class work. It also may be potentially discouraging to some students like Yasmin who feel more confident having a strong conceptual understanding.

**Case studies.** All four student cases showed some aspects of developing a growth mindset. Olivia’s thoughts on her mathematics learning, initially promoted by her special education teacher mother, were that she needed to continue to practice to get better at math and because of her learning disabilities, she felt she needed to practice more than other students. Yasmin grew in her growth mindset with a decrease over the study in her negative self-talk and her math anxiety. While most students in the study had very positive responses to questions related to their stress or anxiety about mathematics and the classroom, Yasmin showed much frustration and signs of anxiety, especially regarding testing. She was easily frustrated when things went wrong or when she could not figure something out, especially with technology. She got stressed when she got behind where she was expected to be in the project and spoke many negative comments. Carlos was not shy about coming in at lunchtime or after school to review
and revise tasks or retake assessments. His dad encouraged him to get help from his teachers. Carlos described this with, “I was in 7th grade and I went in there during recess and got help from him and when he wasn't around to give me help other students would” (Student interview, May 2015). Carlos was also open about working on getting better grades and doing better in school. “I’m trying to change myself around and not be as stupid as I was last year. Trying to get stuff done” (Student observation, March 2015).

From the Buying a Car Task to the Party Assessment, Lara seemed to grow in her mathematics understanding, but also in her willingness to complete the tasks with solid analysis. Lara expressed that she liked the Buying a Car Task. “I loved that because you actually are learning about real life and it’s hands-on and you get to pick your stuff” (Student questionnaire, May 2015). Unfortunately, she did not finish all components of the task and showed misunderstandings in forming a linear equation from a table and/or graph. One of her equations for the yearly amount paid to her car loan was $y=2664$, showing she understood how to determine the correct slope ($2664$ each year of loan payments) and potentially understood that the $y$-intercept value was 0, but she left out the variable ($x$) that represented the number of years. She left the questions blank for “What is the solution to the system?” and “What does this point mean about your car?” for both the new car section and the used car section. This suggested that she did not understand the idea of a “solution” and how to analyze what the solution meant within the context of car buying or that she ran out of enough time to ask for help from her group members or myself. With these mistakes and missing pieces, her final score on the task was a $78\%$, much lower than what she scored on the Virus Project (see Table 1).

During the Party Assessment, Lara somewhat listened to my initial instructions and our class discussion on the assessment, but seemed to get started early on the task. She showed
perseverance from beginning to end and only once raised her hand to get clarification about what the formatting expectation was when writing the solution to the linear system, a difficulty that she also expressed during the Buying a Car Task. She completed the assessment with a 100%, showing that she understood how to take the information from the two party locations, create linear equations in \( y=mx+b \) format, create tables for both party location, create a linear system graph and locate the solution, analyze the party locations for different numbers of guests and justify her own choice of where she would choose to have a party. “I would choose to go skating because I would want to invite all my friends and Georges is the cheaper place for seven or more people” (Artifact analysis, May 2015). In addition, she scored a 98% on a more traditional assessment on linear systems soon after the Party Assessment. During this assessment, she showed that her understanding of solving algebraic equations and linear systems was strong whether given a real life context or a no algebraic context.

Throughout the study Olivia seemed very unsure of her own abilities and knowledge. She exhibited many moments of tiredness, boredom, disengagement, and nervous tendencies, such as playing with her hair, tapping her pencil, humming, and singing. When Olivia did not understand the assignment fully, she tended to lose focus and become distracted, however, with the help of her group members, was able to get back on track with her learning. Her confidence also seemed to grow when she could help others, like the example referred to earlier with technology. Olivia confided in me that tests make her nervous, scared, and upset, but she said, “I still try to do my best even though it makes me feel nervous” (Student interview, May 2015). Olivia spoke of one particular instance during the study when students were given an algebra test for their high school math course placement. “When I got my test back, I thought I did well, and I saw that I didn't do a good job I didn't take it very well. I was really sad” (Student interview, May 2015).
During the Party Assessment, Olivia seemed stressed, unfocused, and was easily distracted by movement and noises in the classroom. She was seen stretching, yawning, and trying to chat with a neighbor, asking them “Is this a test?” (Field notes, May 2015). Due to the activity being an assessment, the level of support allowed was minimal, but after I gave her some initial guidance, she refocused and began to work on the task. Multiple times throughout the assessment she stopped working completely when was confused. She raised her hand to get help, but spent more time waiting for me or the special education teacher to help her, than actually trying to work on the problems. She was very unsure of her abilities to write the equations in slope-intercept form and create the tables and the graphs, possibly due to her math anxiety and low mathematics self-efficacy, not necessarily her understanding of linear equations. Eventually, she was able to complete the tables and the graphs correctly and write the correct equations for each party location. This did take some minimal prompting and supportive messages from me to get her started and in the right direction to persevere to the end of the assessment. She was able to determine the solution to the system when answering the question “About what number of people coming to the party do both places charge the same amount?” but did not write and explain the same solution in ordered pair format. At the end of the testing period, she turned in her assessment, without completing the final analysis questions or choosing which party location she would prefer. She scored a 76%. Finally, she scored a 62% on the more traditional assessment on linear systems soon after the Party Assessment (See Table 1). She was able to graph the linear equations given and find the solution to the systems within the graph. She was also able to complete some of the algebraic equation solving needed to solve systems using substitution, although she did not get any of the final answers correct. This may indicate that the more concrete and contextual Party Assessment may have been easier for her to demonstrate her
understandings of linear systems. For Olivia, CRMP influenced assessments may be able to influence additional positive development to her growth mindset.

**Cross-case analysis.** Two out of the four students stated they liked math (Lara and Carlos), whereas the other two stated that they did not (Yasmin and Olivia). Yasmin stated “Math is the hardest for me” where Olivia stated “I don't like it when I get my test back and it’s like a low score” (Student interviews, May 2015). In contrast, Lara expressed, “It's like not a drag to go to math class. I actually want to go to math” (Student interview, May 2015). When asked what his favorite subject in school was, Carlos answered, “Math, because it’s fun. We do projects with cars, kites, and I get to work in groups with my friends” (Student interview, May 2015). It is interesting to note that the two students who expressed liking math class, Lara and Carlos, had the higher quarter grades of the four case participants with end of quarter grades of A’s and/or B’s (see Table 1). Olivia and Yasmin earned end of quarter grades of low to mid C’s for each quarter, however, their grades on the each of their individual tasks were higher than that. Even though Yasmin ended each semester with a low C, her interest in the CRMP tasks was quite high, earning her A’s for all three CRMP tasks. Since end of quarter grades have multiple assignments and assessments included, the relationships between the grades on the CRMP tasks and the end of quarter grades is not always related. Lara and Carlos’ grades on the CRMP tasks, do seem to relate more closely to their end of quarter grades of A’s and B’s. One large difference is the achievement shown on the more traditional linear systems assessment given after the CRMP Party Assessment (see Appendices I & M). Lara and Carlos both did comparable or better on the traditional linear systems assessment than the CRMP Party Assessment, showing that their understanding of linear systems was strong with both concrete contextual problems and abstract non-contextual problems. Olivia and Yasmin both demonstrated a strong decline of 10% or more
from the Party Assessment to the more traditional assessment. For Olivia, who scored a 76% on the CRMP Party Assessment versus a 62% on the more traditional assessment, this decline may reference her identified learning disability in mathematics and her difficulty with number sense and abstract algebraic reasoning (see Table 1). For Yasmin, who scored a 94% on the CRMP Party Assessment versus a 60% on the more traditional assessment, this decline may reference her self-proclaimed math test anxiety. “Sometimes I'm just so nervous or something” (Student interview, May 2015). This analysis suggested that the liking mathematics may positively influence how well students do on summative assessments.

In summary, mathematical growth mindsets were developed because I provided a positive learning environment and multiple opportunities for students to exhibit mathematical understanding that encouraged learning from mistakes. Students worked on persevering through challenging mathematics tasks and it was seen through observations that they grew in their mathematical resilience through the opportunities to discuss mathematics and get support from their peers and myself. I also strived to less math anxiety in the classroom so the students were not bogged down with confusion or frustration and could focus on the mathematics tasks. This was achieved through opening my classroom in a safe and comfortable way, giving students flexibility that they needed and requested and following the school’s proficiency grading policy. My success with developing a growth mindset grew throughout the study with more consistent observations of these things in the Party Assessment then in the other two tasks. I believe that moving students from a fixed mindset to a growth mindset can improve their perception of their past mathematics performances, by being more successful through increased learning opportunities, and decreasing physiological states or anxiety in the classroom, both leading to an increase in student’s mathematics self-efficacy.
Mathematics Self-efficacy

Lara. Lara’s confidence in mathematics, or self-efficacy, grew throughout the length of the study. She was one of eight students, out of fifteen total students, that showed growth (+0.63) from the mathematics self-efficacy presurvey, with an average of 3.25, to the postsurvey, with an average of 3.88 (see Table 5 & Figures 5-9). In fact, all Bandura’s sources of self-efficacy showed increases for Lara. Her ratings related to her past mathematics performances, her belief in how successful she feels she is in mathematics, increased 0.33 (from 3.5 to 3.83) showing she felt slightly stronger in her ability to be successful in the class by the end of the study, however, her postsurvey ratings were still on average between somewhat true and somewhat false. Her ratings to the question “I do well on even the most difficult math assignments” rose from a 2 (false) on the presurvey and after the Virus Project to a 4 (somewhat true) at the end of the study. Her vicarious experiences ratings increased 0.83 (from 3.0 to 3.83) showing that her mathematics self-efficacy increased over the study through watching or learning from others, although again the ratings stayed right in the middle of the scale between somewhat true and somewhat false. Some of this increase also came from Lara’s metacognitive look at her own learning. When rating the question “I imagine myself working through challenging math problems successfully” her rating steadily increased from a 1 (definitely false) in the presurvey, to a 2 (false) after the Virus Project, to a 3 (somewhat false) at the end of the study. The source of social persuasions increased 0.5 (from 2.83-3.33), keeping her within close range of the somewhat false rating, but showing that from the presurvey to the postsurvey she seemed to have experienced more praise messaging related to her mathematics work from me, her peers, her family, or herself. Her physiological state ratings increased 0.83 (from 3.67 to 4.5) (because it is negatively scored in the survey, an increase in physiological state represents a potential increase in mathematics self-
efficacy). This growth moved her from the middle of the scale into the area between somewhat true and true. Physiological state was also her highest rated source of mathematics self-efficacy. This suggested that any anxiety that she had at the beginning of the study in regard to doing mathematics lessened somewhat by the end. Her specific responses for the question “Doing math work takes all of my energy” rose from only a 2 (true for this question because of it being negatively scored) before the study and after the Virus Project to a 5 (false) contributing to this rise in her physiological state.

Overall, Lara enjoyed the CRMP tasks and felt that she learned more when she related to the mathematics work using real life projects and hands-on learning. At times it was not obvious if she helped others to be helpful or to procrastinate doing her own work. Her highest source of mathematics self-efficacy during the surveys was her physiological state which shows that she did not have anxious tendencies or get nervous or depressed when asked to do mathematics. Overall her mathematics self-efficacy rose over the time period of the CRMP tasks, possibly because of her preference for project based learning, her teacher-like sense for helping others and receiving help, and her calm and steady emotional state while in math class. Time and details seemed to be her only obstacles with the mathematics expectations of the tasks. Her work throughout the tasks was mostly well done with a minimal amount of missing details, such as units of measurement and some weak analysis. Unfortunately, during the Buying a Car Task, time constrictions, her willingness to help others, and possibly her misunderstanding of linear systems in the context of car loans versus depreciation caused her to have her lowest score of all of the CRMP tasks. Her highest score of the CRMP tasks was the Party Assessment, where she received a perfect score.
**Olivia.** Olivia very rarely appeared confident in her mathematics abilities, however, her mathematics self-efficacy survey scores showed considerable variability with large increases and decreases throughout the study. This may be due to a lack of focus and/or understanding of the survey questions, even though they were read aloud to all students and students were allowed to ask questions if they were unsure of anything on the survey. Olivia, along with Lara, showed growth (+0.05) from the self-efficacy presurvey (3.58) to the postsurvey (3.63), however, it was minimal after a drop (3.00) after the Virus Project (see Table 5 & Figures 5-9). In regard to specific sources of self-efficacy, Olivia’s scores fell for both past mathematics performances (-0.50) and social persuasions (-2.33), but increased for both vicarious experiences (+1.17) and physiological state (+1.83). Even with a drop in her past mathematics performances average ratings (4.17 to 3.67), her responses in the presurvey related to this indicate that she may have overestimated her beliefs, with ratings of a 6 (definitely true) for “I have always been successful with math” and “Even when I study very hard, I do poorly in math” (when negatively scored) and a 5 (true) for “I do well on even the most difficult math assignments.” All three of these ratings dropped after the Virus Project, to 2 (false) for the first statement above, 2 (true, because of its negative scoring) for the second statement, and 1 (definitely false) for the last statement. At the end of the survey, the first statement continued to be rated at false, but the other two were rated back up to false for the second statement and somewhat true for the third statement. Overestimation of past mathematics performances has been shown for students with learning disabilities (Pajares & Graham, 1999). Vicarious experiences were Olivia’s highest source of self-efficacy which suggested that working in groups and modeling were important factors for her mathematics self-efficacy. In addition, her responses for the vicarious experiences statements were more consistent than the other three sources, however, two examples had considerably
larger increases. Her response to the statement “When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way” was rated a 3 (somewhat false) at the beginning of the study to a 2 (false) after the Virus Project to a 5 (true) by the end of the study. She rated the statement “I compete with myself in math” similarly, with a 3 (somewhat false) at the beginning of the study to a 5 (true) by the end of the study.

Unlike her responses to the past mathematics performances and vicarious experiences statements, Olivia’s ratings for social persuasions mostly went down throughout the study, yet her ratings for her physiological state all went up. These ratings moved her average response for statements related to social persuasions from 4.5 (between somewhat true to true) down to 2.17 (false), a large drop over a short amount of time. One example of her shift to lower ratings for social persuasion is her answers to the question “People have told me that I have a talent for math,” rated 6 (definitely true) at the beginning of the study, 2 (false) after the Virus Project, and 1 (definitely false) at the end of the study, and “I have been praised for my ability in math,” rated at 5 (true) at the beginning of the study, 4 (somewhat true) after the Virus Project, and 2 (false) at the end of the study, possibly referencing past praise that was more focused on “smartness” and less on effort. Her physiological state average response showed an opposite jump from her social persuasions ratings, moving from 2.17 (true) up to 4 (somewhat false), these survey statements were negatively scored so the scale is reversed. One example of her responses is the statement “My mind goes blank and I am unable to think clearly when doing math work.” This was rated a 3 (somewhat true) at the beginning of the study and after the Virus Project, but then increased to a 6 (definitely false) at the end of the study. Another example is her rating of the statement “My whole body becomes tense when I have to do math” from a 3 (somewhat true) to a 5 (false) to a 6 (definitely false) over the course of the study.
In summary, Olivia does not like math and does not believe she is good at math because it takes her longer to understand concepts and processes and complete assignments and tests. Her identified learning disabilities in mathematics with her working memory and processing speed contribute to this. It is hard for her to fully pay attention because of her diagnosed ADHD and her difficulty with understanding new material. When it gets difficult for her she loses focus, does not pay attention, and then is confused when she is expected to complete tasks or assessments. She likes to work in groups or with a partner and stated that this helps her feel more confident, especially when she can help someone understand something. Being able to do math problems independently is another factor that helps her feel confident in mathematics. Physiological state was the self-efficacy source that she saw the greatest increase in and social persuasions was where she had the greatest decrease. Her mathematics self-efficacy over the time of the study only increased slightly and vicarious experiences were the highest source of self-efficacy for her. The self-efficacy source that she had the highest increase from presurvey to postsurvey was physiological state, which suggested that her anxiety in math class decreased over time. She believes that to get better in mathematics she needs a lot of practice and she needs concepts and processes broke down in to small sequential steps. With her learning disabilities, she can only process a small amount of new material at a time, which was one of the reasons why the CRMP tasks were so difficult for her. She had a difficult time completing the Virus Project because she had to sift through a lot of internet research, find the important pieces for the project and analyze those. She also struggled with her understanding of scientific notation operations and volume of the virus. During the car task, Olivia struggled with graphing points on a large scaled graph, finding the solution to the system on a graph, and analyzing what the solution to the system meant in the context given. During her assessment on the party locations,
she was given some prompting and was able to complete the equations, tables, and graphs, but had misunderstandings related to what the solution was, how to write it as an ordered pair, and analyzing her data and making her final choice. She left some of the questions blank in both the car task and the Party Assessment.

**Yasmin.** Yasmin’s level of mathematics confidence, or self-efficacy, declined (-0.25) from the presurvey (3.25) to the postsurvey (3.00) (see Table 5 & Figures 5-9). She states that she “sucks at it” (Student interview, May 2015) and many negative comments of frustration from her were observed during the study, such as “This is hard” and “I don’t get this” (Student observations, March 2015). She confided that sometimes she “just gives up because it’s hard” and sometimes she gets “so nervous or something” (Student interview, May 2015). When comparing her math abilities to other students, she stated, “Some students, they’re like really smart and like some are just, I don’t know. I’m probably at the bottom” (Student interview, May 2015). Yasmin’s sources of self-efficacy scores from the pre and postsurveys were fairly consistent throughout the study, with many of her scores dropping in the middle of the study, after the Virus Project, and then rebounding at the end of the study, after the car task and the Party Assessment. Her average rating in past mathematics performances dropped 0.17 (from 3.5 to 3.33), yet still remained between the somewhat true to somewhat false range. When responding to the statement “I do well on math assignments” Yasmin rated herself a 4 (somewhat true) at the beginning of the study, then a 2 (false) after the Virus Project, and then back up to a 4 (somewhat true) at the end of the study. It is difficult to say if the complexity and openness of the Virus Project had any impact on these ratings due to other factors that could be affecting Yasmin’s beliefs, such as personal and emotional factors, and other assignments given between the CRMP tasks. Her average for vicarious experiences did not change from the
beginning of the study to the end (remaining at a 4.0), but only fluctuated slightly within each statement. Vicarious experiences were her highest rated source of mathematics self-efficacy, which suggested that group work and modeling were important aspects for building her mathematics self-efficacy.

Her ratings for social persuasions dropped 0.66 (from 2.33 to 1.67) taking her average social persuasions responses from between the somewhat false to false range to between the false and definitely false range. One example points to her perceived lack of family support. When responding to the statement “Adults in my family have told me what a good math student I am” she rated this a 3 (somewhat false) at the beginning of the study, then raised it to a 5 (true) after the Virus Project, but then dropped it to a 1 (definitely false) by the end of the study. With Yasmin’s math anxiety, her physiological state saw a slight drop overall of 0.17 (from 3.17 to 3.0), keeping her average physiological state responses around a somewhat false rating, however, three statements from the survey showed interested results, especially in regard to Virus Project. The survey statements “Doing math work takes all of my energy,” “I get depressed when I think about learning math” and “My whole body becomes tense when I have to do math” were all rated higher at the beginning of the study, dropped down to definitely true after the Virus Project, and then rebounded slightly or significantly by the end of the study (these are negatively scored, therefore a high score is false, meaning higher mathematics self-efficacy).

In summary, Yasmin did well on all CRMP tasks, even with her somewhat limited English proficiency, her test anxiety, and her low mathematics self-efficacy (her overall mathematics self-efficacy was the lowest of all four cases). According to her, she does not have strong family support when it comes to mathematics and she valued the motivating messages and extended support I gave in this class. She enjoys working in groups, but is cognizant of how easy
it can be to become off task and how sometimes she can feel dumb when she is working in a
group with students that she feels are smarter than her. Her mathematics self-efficacy ratings
stayed fairly consistent or decreased throughout the study period, dropping sharply after the
Virus Project, but rebounding some after the car task and the Party Assessment. Her highest
source of self-efficacy was vicarious experiences and her lowest was social persuasions. She had
no sources of self-efficacy increase, although her vicarious experiences ratings stayed the same
from the beginning to the end of the study. Her social persuasions ratings dropped the most from
presurvey to postsurvey. Throughout the CRMP tasks, she worked diligently, even when faced
with difficulties and frustrations, and scored 90% or above on each task. Her mathematics
procedures were good throughout with only minor mistakes or missing details, such as units or
incorrect formatting. Her understanding of mathematics concepts was good, as well, until written
analysis was required. Understanding and writing about the meaning behind the mathematics
was a difficult area for her, but her verbal skills were very good when participating in
mathematical discussions with her group members. Overall, Yasmin seemed to understand the
mathematics at a greater level when the assignments and assessments were written within a real
world context that she could make sense of. She likes to take her time to understand the context
and the mathematics processes that she is using and these CRMP tasks gave her that opportunity.

Carlos. Carlos’ mathematics self-efficacy scores went down slightly throughout the
study (-0.42), from a 3.46 on the presurvey to a 3.04 on the postsurvey (see Table 5 & Figures 5-9).
His highest sources of mathematics self-efficacy were his past mathematics performances and
vicarious experiences, both with an end of study average of 3.5. This suggest that having
continuous successes doing mathematics and opportunities to work with group and observe
models are both important for improving Carlos’ mathematics self-efficacy. His ratings in each
source of self-efficacy stayed fairly consistent from the presurvey to the postsurvey, although they did decrease over time in past mathematics performances, social persuasions and physiological state. They increased only in the area of vicarious experiences. His scores in past mathematics performances decreased 0.5 (from 4.0 to 3.5), dropping from an average response of somewhat true to between somewhat true and somewhat false. Even though there was an overall decrease over time, the ratings for each statement in the survey either stayed the same over time or only decreased one rating point. In vicarious experiences his ratings increased 0.33 through the study time period (From 3.17 to 3.5), which possibly indicated his preference for working in groups and getting one on one support from others. For example, Carlos’ response to “When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way” went from 3 (somewhat false) at the beginning of the study to 5 (true) after the Virus Project to 4 (somewhat true) by the end of the study.

His average responses to the social persuasions statements were his largest decrease, 1.0, (from 2.83 to 1.83) dropping ratings average from somewhat false to false over the course of the study. His ratings to both of these statements “I have been praised for my ability in math” and “My classmates like to work with me in math because they think I’m good at it” went from a 3 (somewhat false) at the beginning of the study to a 1 (definitely false) by the end of the study. Carlos’ physiological state also decreased, 0.5, (from 3.83 to 3.33) from presurvey to postsurvey, moving his average rating from somewhat true to closer to somewhat false. Two interesting responses from Carlos for the source of physiological state are that he rated both statements, “Doing math work takes all of my energy” and “I get depressed when I think about learning math” at a 4 (somewhat false) before the study to 6 (definitely false) after the Virus Project to 4 (somewhat false) at the end of the study. These questions had the most variability and the highest
ratings for any of the statements regarding Carlos’ physiological states showing his calm
demeanor when it comes to math anxiety.

In summary, Carlos enjoyed the math class, saying it was his favorite, and especially
enjoyed the Buying a Car Task. As a very social person, he appreciated the opportunity to work
in a group and said that working in groups and working on real world problems helped him feel
more confident in math class. His family connections were strong, especially with his Dad, who
taught him to have a strong work ethic and the importance of mathematics to life. Carlos had low
overall mathematics self-efficacy, which had the largest drop over the study of all four cases. His
highest sources of self-efficacy were his past mathematics performances and vicarious
experiences and his lowest was social persuasions. His largest increase over the time of the study
was in vicarious experiences. Carlos found it difficult to focus during whole class instruction
time and often had to ask clarifying questions that had already been addressed during the
introductory information at the beginning of the class period. At times, when he was not
interested in the lesson, for example, during the virus task, he was easily distracted, had a
difficult time staying on task and often distracted others with off task behavior and talking. Once
we began the car task, Carlos began to be more focused on the mathematics task and more
willing to participate in the activities with his group. The Virus Project seemed to be more
difficult for Carlos due to the extensive reading and summarizing of scientific data and the
misunderstandings that he showed initially on scientific notation operations. Once he revised his
project, he was able to show that many of these misunderstandings were resolved. During the car
task, he also skipped sections of the task, possibly due to his time spent searching for the
“perfect” car instead of completing the mathematics and analysis in a timely manner. He also
skipped a question on the Party Assessment, which leads me to believe that part of his reason for
skipping questions was his confusion of the mathematics and expectations of the questions. It may be that he would rather have a blank answer then be wrong, a sign of a fixed mindset. In addition, Carlos rarely asked for help, which could also explain missing answers if he was too shy or self-conscious to ask for help and would rather just get the questions wrong.

**Cross-case analysis.** Many characteristics of students’ mathematics achievement and self-efficacy were found throughout the implementation of these CRMP tasks. To summarize, Lara showed high algebra achievement, especially on assessments, and higher mathematics self-efficacy then the other cases. With her interest in real world problems and projects and her calm physiological state, she enjoyed the CRMP tasks and believed that they helped math to be easier for her. Her leadership skills helped her to lead discussions and she tried to keep her group members focused and working on the tasks, even to the detriment of her own grade. Olivia showed lower algebra achievement, especially on assessments, and higher mathematics self-efficacy than two of the other cases. Her self-efficacy responses were quite varied each time she took the survey. This suggested to me that she may have overestimated or underestimated some of her answers. Olivia’s mathematics learning disabilities in working memory and processing speed and her ADHD make learning mathematics difficult. She struggled with focusing and learning new concepts and tended to get distracted easily and give up when the mathematics seems too hard for her. Even though Olivia liked to do projects and work in groups, she strongly believed that for her to learn math she needed sufficient skills practice using worksheets and study guides. Yasmin showed higher algebra achievement (except on the non-contextual linear systems assessment) and the lowest mathematics self-efficacy of all four cases, she exhibited a negative attitude towards her own learning throughout the CRMP tasks. She enjoyed working on projects and in groups, but was self-conscious of not looking “smart” to her group members. Her
self-efficacy survey ratings all decreased, however, her observations of self-efficacy all increased through the study time. This suggested that I saw improvements in her mathematics self-efficacy that she did not see. Yasmin thrived when she understood concepts and could relate them to something in real life, therefore she did very well with all of the CRMP tasks. She participated widely in group discussions, had strong help-seeking strategies, and believed that one on one teacher or peer modeling was the best way for her to learn. Carlos showed lower algebra achievement (except on the assessments) and lower mathematics self-efficacy compared to the other cases. He believed that working in groups and doing real world projects helped him to feel more confident doing mathematics, but he did not always participate positively in his group and he had a difficult time staying on task during the CRMP tasks. He had a tendency to spend too much time on the research and creating elements of the tasks and not as much time on the mathematics of the tasks, skipping key sections. He also did not exhibit good help-seeking strategies, choosing to turn in an incomplete task then to ask his group members or myself for help understanding the questions.

Further analysis of the students’ mathematics self-efficacy ratings and observations was done through connecting the findings to the four sources of self-efficacy hypothesized by Bandura (1987): past mathematics performances, vicarious experiences, social persuasions, and physiological states. Tables 5 and 6 show the results from the student mathematical self-efficacy survey that was given to the students three times during the study, as well as the student observations done during each CRMP task. The first time the survey was given was before the study (pre), the second time was after the Virus Project (mid) and the third time was after the Party Assessment (post), but before the more traditional linear systems assessment. Table 5 shows the mathematics self-efficacy survey results for each case. Figures 5 through 9 show a
graphical representation of the changes in mathematical self-efficacy and each source at various times through the study for each case. For overall mathematics self-efficacy, all students rated themselves in the medium range, with Yasmin and Olivia dropping slightly after the Virus Project and then regaining that drop after the car task and Party Assessment (see Table 5 & Figure 5). This drop after the Virus Project was seen throughout many of the sources of self-efficacy for both Olivia and Yasmin. Lara increased slightly throughout all three surveys and Carlos decreased slightly throughout all three.

Self-efficacy source level analysis was also made of the student observation data. For overall mathematical self-efficacy, all case participants were observed in the medium to high range, except Carlos who dropped to a low-medium rating during the Party Assessment (See Table 6 & Figures 5-9). This could potentially be due to the fact that both the vicarious experiences and social persuasions were not rated during the Party Assessment because there was no modeling or praise during the assessment. Lara started and stayed in the high range, displaying a strong mathematics self-efficacy throughout the CRMP tasks. Olivia and Carlos both showed improvements during the car task, jumping from medium to medium-high, but then dropped during the Party Assessment, potentially because it was an assessment with little to no teacher or peer interaction. Yasmin showed a slight decrease in her mathematical self-efficacy from the Virus Project to the car task, but showed a large jump after the Party Assessment. This increase during the observations of the Party Assessment, was consistent across all sources of mathematics self-efficacy.

Past mathematics performances. Successful past mathematics performances, understanding and solving mathematics successfully, was seen throughout all case participants in the medium range. Olivia and Carlos did start out with slightly higher ratings for themselves, but
then dropped in to the medium range after the Virus Project and at the end of the CRMP tasks (see Table 5 & Figure 6). It is possible that some of these ratings were overestimated as has been observed in other studies with students, especially struggling learners (Pajares & Graham, 1999). Looking at Figure 6, Lara was the only case participant that did not drop in her past mathematical performances rating after the Virus Project. This may demonstrate the difficulty of that project and the frustration levels that Olivia, Yasmin and Carlos may have felt while working on it. Olivia and Yasmin did show more growth after the car task and Party Assessment, yet never getting back to their initial past mathematics performances rating, according to the survey. Carlos, again, showed slight decreases from the prestudy survey, through the midstudy, and into the final poststudy survey. Analysis of the student observations show past mathematics performances for all students were also in the medium to high range, except for Carlos, again showing a drop during the Party Assessment (see Table 6 & Figure 6). Lara and Yasmin both showed slight drops in these observations of past mathematics performances during the car task, but both showed high ratings during the Party Assessment, which is especially noted for Yasmin, who believes she suffers from math test anxiety. Even though the figure shows Olivia jumping from medium to medium-high and then staying at medium-high during the Party Assessment, the numerical data shows that her observation ratings did increase for each CRMP task, ending close to the high rating. This is also an important point for Olivia, as tests have always been an obstacle for her with her learning and attention disabilities.

**Vicarious experiences.** Vicarious experiences, gaining mathematics self-efficacy through modeling, was rated in the medium range for most of the case participants, however, the findings do show an interesting jump for both Olivia and Yasmin, the two lower performing students and the students who claim to not like math class (See Table 5 & Figure 7). Olivia rose from medium
ratings on both the pre and midsurveys to a medium-high on the postsurvey and Yasmin dropped from a medium-high rating to a medium after the Virus Project, but rose back to a medium-high rating at the end of the CRMP tasks. This may show the importance of modeling for students with low interest and self-efficacy in mathematics. Carlos showed a slight rise from the prestudy survey to the poststudy survey, even though he had a slight drop between the midstudy and poststudy. Observations of vicarious experiences were all in the medium-high to high ranges, except Carlos, who did show improvements from a low-medium rating to a medium rating (See Table 6 & Figure 7). This demonstrates Carlos’ participating more in his group during the car task than in the virus task. This could be because of Carlos’ vast knowledge on cars and him being eager to share his interest with others. Lara and Yasmin were both observed with high ratings for both the Virus Project, yet they both improved slightly in their observation ratings from the Virus Project to the car task. Olivia showed a slight drop in her vicarious experiences from high to medium-high during the car task. It is possible that Olivia’s drop could be related to the co-teacher, a special education teacher that Olivia worked closely with, being gone for most of the car task due to state-mandated standardized testing. Without the additional teacher, Olivia may have been less focused and less willing to participate in her group to work diligently on the task. Again, observations were not done for the area of vicarious experiences for the Party Assessment due to there being little to no modeling during the assessment.

Social persuasions. Social persuasions, praise from teachers, peers, and family, was rather low for all case participants. Lara was the only student who saw a rise in her ratings for social persuasions and even that was minimal. Olivia, Yasmin, and Carlos all saw drops from prestudy to poststudy, with Olivia have the largest drop from medium-high to low-medium and Yasmin having a slight increase in social persuasions after the Virus Project, but dropping at the
end of the study (see Table 5 & Figure 8). This may be an indication that praise from peers and myself is something that I may need to improve on to create a stronger classroom community focused on mathematics self-efficacy and building a growth mindset. It is interesting to note that during the observations, all students were rated as improving in the area of social persuasions (receives and responds positively to praise), yet in the student surveys, the students perceived that they received very little praise (see Table 6 & Figure 8). Perhaps this is a distinction between the teacher perception and the student perception of praise. Observations from the Virus Project to the car task showed Lara, Olivia, and Carlos all showing large increases in receiving praise from peers, teachers, or from themselves. Yasmin showed a small improvement from the Virus Project to the car task. No observations were made for the area of social persuasions for the Party Assessment since there was little to no communication between teacher and student and between peers during the assessment.

Physiological state. Physiological state, the emotional state of the students, improved for all students at one point or another, except Carlos. Higher ratings for this source of self-efficacy suggest a student who is calmer and less stressed, anxious, nervous, or depressed in the classroom. Lara’s ratings indicate that she improved slightly in her physiological state from after the Virus Project to the end of the study, with before the Virus Project showing no change (see Table 5 & Figure 9). Olivia jumped from a low-medium rating before the study, to a medium rating after the Virus Project, to a medium-high rating after all three CRMP tasks, which showed that this was an area of significant improvement for her. Yasmin initially showed a decrease in her physiological state after the Virus Project, similar to her ratings for social persuasion, but regained the loss with a medium rating after the three CRMP tasks. These drops for Yasmin may relate to difficulties that Yasmin had with the Virus Project and mathematics, or the frustrations
that she felt with the openness of the project and not having clear step by step direction. Carlos showed no change from before the study to after the Virus Project, and again showed a decline in this source of self-efficacy after the car task and Party Assessment. These declines at the study could be in relationship to the difficult time that Carlos had getting started and finishing the Party Assessment. Analysis of the student observations for this area showed that both Lara and Yasmin improved in their anxiety and stress levels ending with high ratings during the Party Assessment (see Table 6 & Figure 9). Having self-proclaimed math anxiety issues, this is a positive result for Yasmin, showing improvement among all three CRMP tasks in this area of physiological states. Olivia and Carlos had more difficulties with the assessment, showed nervous tendencies, and took considerably longer to finish the task then other students. They both showed a drop during the Party Assessment, whereas during the car task they had higher ratings. Again, this may be related to the lack of peer interaction during the task, since both of these students relied more on the help of others then on themselves or helping others during the Virus Project and the car task. When it came to the assessment, where they had to complete the task independently, they had a more difficult time getting started, but ultimately finished and passed the assessment.

In summary, some relationships between mathematics self-efficacy in relation to and the CRMP tasks and instructional strategies have been shown. Past mathematical performances were in the middle range for all students. Since research has shown that this is the most important source of self-efficacy for most students, the lower ratings are something that needs to be considered. It is possible that the ratings were lower because students had difficulties with the CRMP tasks, were not able to self-evaluate through the tasks, and ultimately, did not feel as successful as if they had completed more direct instruction skills based mathematics work. Olivia and Yasmin both suggested that they felt more confident and better at mathematics when they
are taught and practice more step by step work, therefore the openness of these tasks may have had a negative impact on their overall mathematics self-efficacy. Vicarious experiences, or modeling, was an important source of mathematics self-efficacy for these students. All students appreciated the opportunities to work in groups and felt that it helped them be more confident in their mathematics. They liked being able to get help from their peers, but more importantly, they experienced a growth in confidence when they could help others. Social persuasions were very low for most of the students, which indicated that this was an area of professional growth for me to help my students grow. Praise in the classroom, from peers, the teacher, or the students themselves, is an important piece to developing a growth mindset, one goal for these CRMP tasks. The students’ physiological state was a factor of the classroom climate, the students’ interest in the tasks, and the types of tasks and assessments that were given. The students that had higher ratings showed less frustrations and anxiety and worked more efficiently with their groups. Out of the other two students that had lower ratings, one showed much frustration and anxiety through her negative comments about her understanding of mathematics and her ability to do the task. The other student used an avoidance strategy within his group and did not engage with his group in the mathematics task. Both of these tactics could have been ways for them to deal with their perceived low ability and lower status in the class. In the next chapter, these potential relationships and influences will be discussed, as well as implications and limitations of this study, next steps in the research of mathematics self-efficacy and CRMP and concluding thoughts.
CHAPTER FIVE

DISCUSSION AND IMPLICATIONS

This study addresses the problem of low mathematics achievement by students living in poverty and the disconnections that exist between current mathematics education and students’ academic, social, and emotional learning needs. Over 20% of the population of children in the United States are growing up in homes below the poverty threshold (United States Census Bureau, 2014). Research has repeatedly shown that their achievement lags significantly behind students from higher socioeconomic families due to a multitude of factors (Brooks-Gunn, Linver, & Fauth, 2005; Cortesão, 2011; Darling-Hammond, 2010; Knapp, 1995). This study set forth to determine how I taught algebraic functions through a CRMP lens to high poverty eighth grade students and whether that teaching may have influenced change in their mathematics achievement and self-efficacy. In this chapter, I will discuss five themes, which emerged from the findings. These include: language support, CRMP task restructuring, assessment and teacher supports, achievement and self-efficacy, and connections to student status. Throughout this discussion, implications for practice will also be discussed for various stakeholders in education; such as teachers, administrators, researchers, professional development designers, curriculum developers, and policy makers. Following the discussion and implications of themes, specific recommendations for practice will be made, as well as recommendations for further research.

Language Support

Using language for learning mathematics was strongly supported in this study through the use of CRMP tasks. The use of language during these tasks was essential for researching, analyzing and justifying mathematical and contextual conclusions, as well as communicating mathematical thinking and understanding with group members. It was also an essential
requirement for teaching the CCSSM mathematical practices (NGA, 2010). Two elements of language use that I will discuss include my integration of all four language skills within the tasks (reading, writing, speaking and listening) and the high expectations I had for all students to participate in the use of these language skills.

**Integration of language skills.** The CRMP tasks I developed made use of all four language skills (reading, writing, speaking, and listening). The Virus Project and Buying a Car Task included elements where students had to read research using internet webpages. These two tasks also included expectations of speaking and listening as students were encouraged to work together towards a shared understanding of the mathematics and contexts. All three tasks, including the Party Assessment had written components where students had to analyze their mathematics to justify their decisions and come to a conclusion. Findings indicated that students enjoyed using their speaking and listening skills to learn mathematics within a whole group setting, a small group setting or individually with a teacher. Most students were able to express their mathematics understanding in a coherent way and make sense of others’ understandings.

Difficulties did ensue for some students when the task required them to read technical websites for information related to their task or write about their understanding and analyses. All students in the study had some difficulties with the scientific reading required in the Virus Project and in the summary and analysis writing needed in all three tasks, but students with identified mathematics learning disabilities and ELL students struggled the most. Specifically, Carlos had great challenges with this task because of his lower ability to read and comprehend the articles, the scientific vocabulary, and even the task instructions. As an exited ELL student, he did not receive any additional time or support during these tasks unless he came in on his own.
time. This did seem to play a factor in his ability to understand the mathematics and complete the
tasks proficiently.

With these tasks being conducted in the second semester of a full year mathematics
course, the findings seem to suggest that more opportunities to practice using these language
skills for learning mathematics would have been beneficial. The continued use of language in
mathematics benefits students’ conceptual understanding and their ability to transfer their
mathematics knowledge to various contexts, such as in these three CRMP tasks (Moschkovich &
Nelson-Barber, 2009). For future use of this task, for students who struggle with reading and
writing in mathematics, I would also suggest three task modifications. First, I would consider
simplifying the task language, making the language of the task expectations clear and concise. I
would also offer choices in the resources, by identifying websites that are easier to read, but still
having appropriate content for the task. Moschkovich (2013) suggests that using sentence starters
in mathematics can facilitate students, especially ELLs, in practicing and producing language of
their mathematical understanding. Therefore, I would create sentence starters that students,
especially those with identified reading and writing needs, could use for writing their analysis
pieces.

**Expectations of language usage.** As in accordance with CRMP tenets, I worked to have
high expectations for all of my students throughout these tasks and this included the use of
language. Students were expected to participate in all areas of language use, which included
whole class “instructional conversations” and small group math discussions (Kersaint et al.,
2013). These discussions promoted a positive learning community and encouraged all students to
speak, listen and participate in the mathematics learning. Speaking and writing for mathematics
learning can also build perseverance or mathematical resilience (Johnston-Wilder & Lee, 2010).
As referenced previously, many students had difficulties with the complexity of the reading in the Virus Project and the writing necessary throughout all three tasks. Due to this, many students raised their hands for help with comprehending the reading or clarifying what my expectations were for the writing. Some students simply quit working on the task when it became too difficult or would skip questions that required reading or writing. Students that did try to produce their written analyses most often showed a weak ability to express their mathematical understanding in writing and make the necessary connections between the mathematics and the context. Moschkovich and Nelson-Barber (2009) suggest that using language to express mathematical thinking, explain ideas, and justify conclusions is a practice that should be incorporated throughout mathematics classes.

Olivia had problems throughout these tasks with her ability to make connections between the context and the mathematics. As a student with identified learning disabilities in mathematics and reading, she also struggled with writing conventions and her comprehension of reading the contextual information. However, Olivia did have an additional tutorial class period built in to her day to provide her with extra time and support, with her special education teacher. In addition, I regularly communicated with her special education teacher with the difficulties she was having so we could both support her needs with the CRMP tasks.

These findings suggest some implications for teachers using CRMP tasks with diverse student populations. First, it is important for teachers to know which students have special learning or language needs so they can offer additional feedback and support for the language needs of the students. All students should have clear goals with high expectations for their learning of mathematics and the use of language for learning mathematics, but some scaffolding may be necessary to accommodate students with special needs. With further relationship
building between the teacher and the student and continual teacher feedback, this scaffolding may be lessened gradually to a point where it may not be needed (Hmelo-Silver et al., 2007). Additional support may also include supplementary vocabulary instruction and engagement with using vocabulary, as well as opportunities for time with the teacher before school, after school, or at lunch.

**Exited ELL students.** Throughout the study, it became apparent that some of my students that struggled the most with the CRMP tasks were students who had been previously exited from the school’s ELL program. Students are exited from the ELL program when they receive a five on the English Language Proficiency Assessment (ELPA), which is considered advanced proficient, and have recommendations from teachers to support their exiting (Townsend, 2013). What I found in this study was that students that were exited from the ELL program may have showed advanced proficiency in their English literacy skills according to the ELPA, but may still struggle with understanding mathematics concepts, especially within contextual CRMP tasks. They may also struggle with status in the classroom, low mathematics self-efficacy and fixed mindsets. To counteract this, I found that building caring relationships through listening, questioning, and offering frequent check-ins were effective ways to build their self-efficacy and motivate them to engage in the mathematics tasks. I also found that praising students’ work, effort, participation, and strategies, especially for the purpose of assigning competence, was an important part of their mathematics learning development. Studies have shown that Spanish dominant students’ mathematics achievement and self-efficacy can rise when teachers demonstrate care in their instruction and attitudes (Lewis et al., 2012; Riconscente, 2014).
Schools are required to monitor their exited ELL students for two years after their exit to ensure adequate progress in their core academic subjects (Townsend, 2013). However, in this school, teachers were unaware of who the exited ELL students were and these students were not given extra time within their school day to gain additional support, like current ELL students get. Besides offering additional supports as will be discussed later in this chapter, this study suggests that schools may want to consider offering an additional support class for exited ELL students to continue to support their language needs in mathematics, as well as their other courses. Schools can further support exited ELL students’ mathematics growth by setting up additional opportunities for help and support outside of class time, after school, before school, or at lunch. Teachers can further encourage these students’ participation in these additional opportunities by working with them to make a plan and hold them accountable for attending. With the average time to acquire the advanced proficient level of a five on the ELPA as four to seven years, students who come in to early elementary with very little to no English will likely be exiting from the ELL program during their middle school years (Townsend, 2013). This makes this an important issue and consideration for administrators and teachers at the secondary level.

**CRMP Task Restructuring**

The CRMP tasks I developed for this action research study were modified throughout to create the best mathematics tasks for my students’ learning of algebraic functions. During and after the time I taught each task, I reflected on the successes and the difficulties that the students and I encountered with the task. These reflections, along with my own observations and my students’ opinions expressed in questionnaires and interviews, supported a need for further thoughts and discussion on restructuring the CRMP tasks to best benefit the mathematics achievement and self-efficacy of students living in poverty. These included the use of
technology, keeping the focus on the mathematics, students becoming experts, and considerations for special student populations.

**Technology.** Technology played a necessary role in two of the three CRMP tasks as students used technology for research, gathering data, and creating mathematical representations. I specifically designed these tasks to use technology because of the importance I placed on using real world data and relevance. Not only was the context and real world data relevant to the students’ lives within society as a whole and within their own individual lives, but also the vast importance and relevance of technology to today’s student. Atweh & Brady (2009, p. 272) suggest mathematics education be socially responsible by incorporating modeling, relevance, and not only “reading the world” through mathematics, but “transforming the world.” Technology is an avenue to achieve this. Building technology into these CRMP tasks, especially with tasks that made use of online data, added dimensionality, choice, and highly important skills for students’ futures in college and careers (Borba et al., 2016).

With the use of technology came challenges, difficulties, and frustrations. At times during the study it was very difficult for some students to find all of the information they needed for the tasks, specifically virus reproduction numbers. The amount of information on the internet was overwhelming and difficult for students to filter through to find the most important data, especially ELL students and students with reading disabilities, like Carlos and Olivia. The reading level of some websites, especially medical websites, were at high levels which caused barriers for some students’ learning and the completion of their tasks. These challenges could have led to decreases in mathematics self-efficacy and a lowering of student status, but overall this was not seen. I believe this was partially due to the extensive support that students received through peer help-seeking, teacher scaffolding, and feedback. In addition, many of these
challenges caused students to work together, make mistakes and learn from them, offer praise to each other, and persevere through frustrating times, which may have helped lead them towards a growth mindset (Boaler, 2016; Dweck, 2006).

In this study, I also found that using technology increased some students’ classroom status among their peers by building on their strengths and increasing their mathematics self-efficacy through observations of and praise from others. Other findings suggested that relevant technology use increased students’ engagement and motivation to complete the task and potentially influenced their mathematics self-efficacy through decreasing their stress or anxiety. Teachers and curriculum developers who decide to incorporate technology, specifically from online data sources, may want to keep the following things in mind as they design CRMP tasks. First, keep tasks relevant to students’ past, present and future lives. Second, ensure opportunities for students to work together on their understanding of mathematics and use of technology. Third, allow students to struggle, yet build in accessibility options and student choice in topics to motivate and encourage productive struggle (NCTM, 2014). Last, work to praise low status students’ technology usage, effort, and group participation.

**Focus on mathematics.** The internet can be highly engaging and this study showed that this caused a loss of productivity for some students when they spent more time then needed browsing and talking to their neighbors about their topic versus doing the mathematics. This study suggested that teaching algebraic functions using CRMP tasks can increase interest, engagement and motivation leading to increased mathematics achievement, but it can be difficult to find the balance between the context and the math. As this was a mathematics class with an emphasis on understanding algebraic functions, the primary objective was to focus on the mathematics. All three CRMP tasks had a math priority with the real world context being the
secondary focus. Even though the task seemed to have the right balance, the students many times did not have the same primary focus on the mathematics. For example, Carlos had a difficult time staying focused when he was researching his virus seemingly because of the amount of information he had to read and comprehend. He was fascinated by the new and used cars for sale and he used up a good portion of his time on one day of the project choosing which car he wanted to buy. Many students had the same issues as Carlos, getting sidetracked by their interest in their virus or being excited by the variety of cars to choose from.

To help keep their focus on the mathematics, short and directed time limits at appropriate times was helpful. These were best used during times when students were researching and it was easy for them to become distracted by the amount of information in front of them. This also gave me time to check-in with the students with the most needs because students had a defined time to work independently. In this study, this seemed to be one of the times where students with high needs got behind in the task.

Another issue that I encountered during these CRMP tasks was a lack of appropriate participation among some students. This included students who were disengaged and talking about off-topic subjects, in turn getting other students off-task. Some students showed signs of anxiety during the Buying a Car Task, as they wanted to pick the “perfect” car, but were challenged to find the exact car they wanted among the thousands of choices and within their stated budget. This also included some higher achieving students who were not interested in being part of a group and focused on their own task, trying to complete it independently. I worked to remedy this through frequent teacher check-ins and reminders to follow the group norms and expectations, but the busyness of the classroom and the constant need for my help kept me from adequately addressing these students.
One way that participation in the task and in the groups could be encouraged more would be stricter adherence to the group norms. This could make students more accountable for each other’s learning, leaving me more freedom to address the students not following the expectations. Even though these CRMP tasks were not *groupworthy* tasks as defined by Cohen and Lotan (1997), Horn (2012) or Boaler (2016), teachers can still utilize group norms and roles with CRMP tasks with some adjustments. Requiring students to play roles within the group may have helped with student accountability, however, roles of “facilitator,” “resource manager,” “recorder/reporter,” and “team captain,” as often seen in current research, may not have been completely appropriate for these CRMP tasks due to their independent accountability (Cohen & Lotan, 1997 & Horn, 2012). For example, the role of recorder/reporter would need to change because each student was accountable for their own task. Instead, they might be responsible for writing a daily summary of what each member of their team learned and completed each day and reporting this out to the class. This may encourage all members of the group to come together and share what they have been working on, allowing all students participation in the learning and connecting of their mathematics to the context and potentially helping students be less fearful to work together (Boaler, 2016; Horn, 2012). The team captain could still work to keep all team members on task by encouraging participation, enforcing the group norms, and keeping time. The facilitator could still make sure that everyone is understanding the questions and clarify students’ understandings by asking good questions to their team members. The resource monitor could still collect and return supplies, however, it may not prove effective for them to be the sole point person for team to teacher communication because of the independent accountability in the tasks (Cohen & Lotan, 1997 & Horn, 2012).
Whole class and small group discussions were an important way for students to share their mathematical understanding and their knowledge of their context, however, the focus on the mathematics was varied. Some groups were able to stay on topic and discuss their mathematics in relation to the context, fulfilling my intent for the tasks. Unfortunately, some groups became so engaged in the context that the mathematics came second. To remedy this in the future, I would consider restructuring the tasks to include specific discussion points. This would be both about keeping the focus on the mathematics and helping students see the connections between the mathematics and the context. Being explicit about the conversations we want students to have, by including discussion points, may help them make better connections between the mathematics and the context (Hmelo-Silver et al., 2007; Kirschner et al., 2006). This could be done by including group discussion prompts and encouraging groups to stay together in the task as they work through the questions and activities. These discussion prompts could be written in to the task assignment with places for students to summarize their discussion or write their own thoughts on a question. These could help keep the task more focused on the mathematics goals and encourage deeper mathematical thinking, while working to keep the cognitive load low for all students to experience success (Kirschner et al., 2006). This could also foster the sharing of ideas and opinions about the real world context (Hmelo-Silver et al., 2007). With high populations of students in poverty, I had hoped to include more connections to poverty locally and globally, but time constraints lessened the quantity and quality of these conversations in both groups and as a whole class.

**Special populations.** For lower-status students, the structure of the task seemed to make a difference in their willingness to participate, persevere, and be open to learning the mathematics. When the tasks were more scaffolded with clearer directions, less resources and
more built in structure, students were able to be more successful with the task and their learning about algebraic functions in real life (Kirschner et al., 2006). Using technology also gave students the opportunity to shine amongst their classmates and gain status within their group. In this study, this occurred when lower-status students, specifically students with identified learning disabilities, were able to help their group members with researching data, formatting representations and understanding unfamiliar vocabulary. As these students helped each other, they received social persuasions, which added to their own beliefs about themselves and their abilities to do mathematics.

It was a concern of mine that the use of additional scaffolding may have constricted some students’ ability to think more deeply about the mathematics and contextual connections. One prospect for improving the mathematics instruction for all students in a diverse heterogeneous class is to create two similar CRMP tasks, one left open and one with more built-in scaffolding. These tasks may both be used within the same group, but the scaffolded task could be given to only one student in the group. This student could be the one student in the group that needs the most support, possibly a student with special academic or language needs or a student with low self-efficacy or status. This scaffolded task could include highlighted vocabulary, tips for using the technology, and worked examples, lowering the cognitive load of the tasks (Kirschner et al., 2006). The second set of tasks would be given to all other group members and include all of the same instructions and content except, instead of the scaffolds, there would be increased spaces for note taking and student work. This approach may encourage cooperative learning, as students would need to work together to get additional scaffolding and help. This may also empower the student given the scaffolded task and engage them more in the tasks, aiding them in understanding the content better so they can give assistance to others. My goal for this design
would be to improve the status of the selected student, increase their mathematical understanding by lowering the cognitive load on their working memory, and help them feel like a successful doer of mathematics (Hmelo-Silver et al., 2007; Kirschner et al., 2006).

Implications for restructuring of CRMP tasks to support all levels of students may be of interest to not only teachers, but mathematics coaches, professional development designers and curriculum developers. It is important that we analyze the strengths and weaknesses of students that will be working on these tasks and offer choices and alternative opportunities that will strengthen not only their mathematics, but also their self-efficacy and status in the classroom. When designing CRMP modeling tasks for diverse students living in poverty, I would suggest utilizing technology for research and data gathering, setting short and focused time limits during independent research periods, and including set discussion prompts into the task. In addition, high expectations can be expressed for following group norms and roles and leveled tasks may be considered for students with special academic and language needs.

Assessment and Teacher Support

Throughout the study, there were interesting findings that arose in regard to assessments and teacher support. In this section I will outline these findings, along with connections to literature and implications for teachers, researchers, curriculum developers, and other stakeholders. Specific topics include summative assessments tied to CRMP tenets, using CRMP tasks and assessments as preparation for CCSSM assessments, finding a balance with productive struggle, and using teacher supports, such as scaffolding, feedback, questioning, and praise (NCTM, 2014).

CRMP assessments. One concern that I pondered throughout this study was the number of assessments I gave to my students. Regularly, before the study, my students were given
weekly quizzes and a summative assessment at the end of each unit. Cleary and Zimmerman’s (2004) research on self-regulated learning promotes the use of many assessments to improve student self-efficacy by increasing students’ opportunities to show mastery. In my classroom, unit tests could be retaken multiple times, resulting in a potential of twelve assessments within a nine-week quarter. Students did not seem to look forward to these opportunities and their confidence seemed to be lacking each time they did not perform as well as they would have liked. I wondered if too many summative assessments were working against the improvement of their mathematics self-efficacy and student status. Boaler (2016) suggests that summative assessments, such as chapter quizzes and tests, should be limited, saying that students can perform well on state required standardized testing, even with little experience on similar assessments, if they have developed a growth mindset.

After the Virus Project, I did not give weekly quizzes and one of the tasks, the Party Assessment, was a summative assessment with CRMP influenced elements. For example, it used local places, interesting contexts, multiple representations, and justification of choices and conclusions using mathematics and writing. I also gave a non-contextual summative assessment on linear systems after the use of the Party Assessment to compare the two. My findings indicated that students did overwhelmingly better on the contextualized CRMP assessment. As the teacher, I was able to see more of their understandings of the mathematics and their ability to analyze, evaluate, and justify decisions using mathematics, not just their ability to perform skills and procedures. I was also able to assess their real world problem solving abilities and their understanding of the context and its mathematical connections.

This assessment also included opportunities for students to make a choice and justify it based on mathematical evidence. This gave students an invested interest in the context of the
assessment, which may have led to more engagement and motivation to understand the mathematics and fully complete the assessment. Students also had to explain their thinking regarding their mathematics calculations which helped give me more insight into their mathematical thinking then a traditional non-contextual assessment could. Many students also did better on the non-contextual assessment than they had done on similar assessments earlier in the year. This finding led me to consider the use of contextual CRMP assessments prior to non-contextual assessments and ensuring that summative assessments have a balance of both contextual and non-contextual elements.

Staples (2014) suggests using group quizzes, or participation or explanation quizzes. These quizzes are an opportunity for students to practice assessment-like questions when they can still use each other as a resource and while they are still learning the mathematics content. Groups are assessed together by assessing one randomly selected student’s ability to answer and explain the problem to the teacher. This encourages students to work together and reinforces the norms of the classroom, everyone can learn mathematics and each student is expected to help one another (Staples, 2014).

For future summative assessments, I would like to make them more balanced by including tenets of CRMP, like the Party Assessment, but also including non-contextual elements that focus on mathematical process, conceptual understanding, and skills. These balanced assessments would have a focus on procedures and skills, mathematical modeling, multiple representations, and justification, all within a real world context (Van Den Heuval-Panhuizen, 2005). In this study, students were more successful showing their understanding of algebraic functions on assessments if the problems were relatable and used multiple representations for analysis and explanation. For example, three of the four case studies presented had higher scores
on the Party Assessment than on the non-contextual linear systems assessment. Yasmin, in particular, showed the highest difference with a 94% on the Party Assessment, yet only a 60% on the non-contextual assessment. With the context of a party, she was better able to show her understanding of linear systems. The inclusion of CRMP elements in assessments could provide many benefits to students. These assessments may decrease students’ physiological state, like seen in Yasmin, by lessening test anxiety. This combined with an increase in students’ mathematics performance may increase their overall mathematics self-efficacy leading to higher mathematics achievement, as well as possibly be a better indicator of students’ mathematical understanding and knowledge.

**CCSSM assessment preparation.** The importance of state required standardized assessments at grades 3-12, cannot be understated. Low school ratings have reduced federal funds and resulted in school takeovers, teacher job loss, and mathematics curricular overhauls towards direct, scripted curriculum with a high focus on skills and procedures (Crocco & Costigan, 2007; Young, 2010). With new national focus on the CCSSM content standards and mathematical practices, it is worthwhile to discuss ways in which teachers can prepare students for these assessments. Improving student performance on these assessments may raise teachers’ confidence in their ability to teach and students’ confidence in their ability to learn and understand mathematics. It may also improve the communities’ confidence in the school and district and the learning that is occurring there. The assessments tied to the CCSSM have many question-types that did not previously exist on standardized assessments, explaining questions, technology enhanced questions, and performance tasks, just to name a few (NGA, 2010). CRMP tasks and instructional strategies may be advantageous to the goal of improving student performance on these assessments.
In order to design CRMP tasks and assessments to better prepare students for CCSSM assessments, teachers and curriculum developers first need to have a strong understanding of the CCSSM standards and mathematical practices and choose the standards carefully that best promote the mathematical goals of the task (NGA, 2010). The CCSSM standards can be difficult to decipher and it is essential that designers know and understand the underlying expectations for each standard. In addition, the complexity, connectedness, and problem solving required of these assessments signal for a heavy push for teachers to work on increasing student perseverance. In this study, student perseverance, or mathematical resilience, improved when the tasks were more engaging and students believed they could be successful, but this took time. Student perseverance also grew in this study through the continued practice of using challenging and multi-dimensional CRMP tasks, as well as encouraging mistakes, and using groups with explicitly taught norms. Students working in groups encouraged each other to keep trying when they may have stopped or to work together and ask for help if they had been working independently. Balanced local assessments, as discussed previously, with real life contexts, may also be beneficial for preparation for CCSSM assessments. They can assess students’ conceptual understanding, skills and procedures, and transfer abilities with multiple representations, data analysis, evaluation, and justification, all of which are important parts of the CCSSM. All of these recommendations are also important for school administrator consideration. If administrators are not aware of the complexity, connectedness and problem solving required of the CCSSM assessments, they may continue to promote skill and procedure based curriculum and instruction when other forms are necessary.

**Student struggle.** The curriculum and instructional strategies used with cooperative learning were important pieces of the CRMP tasks in this study. They promoted high levels of
engagement and algebraic understanding, they allowed each student a voice to express their thoughts on the mathematics and the context, and they supported the growth of students’ mathematics self-efficacy through all four hypothesized sources. One thing that I found difficult for me, that other teachers may also struggle with, was allowing my groups the opportunity to struggle with the mathematics. At times, I had a tendency to offer too much support and guidance when it came to students asking for help. As a teacher, I frequently felt the need to explain and make clear the concepts and procedures we were learning about, but research has demonstrated that students can learn mathematics deeply and accurately when given adequate time and an effective structure to work together on mathematical tasks (Boaler, 2016; Horn, 2012). One way I could have promoted this more was by choosing only one person in each group to respond to questions, as suggested by proponents of Complex Instruction (Boaler, 2016; Cohen & Lotan, 1997; Horn, 2012). However, with these tasks, each student researched a different topic and that was not always possible.

By giving too much support and guidance and not allowing students to struggle with the mathematics, I realized I was taking away my students opportunity to experience the freedom and power that comes from working through problems and figuring them out without my help. As I reflected on this study, I also realized the opportunity to learn that I was taking away from some of my students when I jumped in to help each time a hand was raised. When students were given the structure, time, and place to struggle with complex mathematical problems, they were able to make sense of the mathematics in their own way, with their own understanding. Research has indicated that when students make sense of the mathematics through productive struggle they retain this conceptual understanding more readily, as well as build growth mindsets about mathematics (Boaler, 2016; Dweck, 2006; Hiebert & Grouws, 2007; NCTM, 2014). They also
work together with their peers to solve problems, developing social skills and minimizing status differences when they begin to realize that all students can learn and understand algebra. Working within cooperative groups with set group norms can help all group members see that each student has strengths and weaknesses and that each student struggles with mathematics in their own way, which is a crucial part of learning (Boaler, 2016; Dweck, 2006).

One constant that I saw throughout the implementation of these CRMP tasks was that many students were afraid to make their own choices and go their own way with the tasks. They did not trust themselves and their mathematics abilities. This was especially true with my current and exited ELL students and students with identified learning disabilities. Researchers have demonstrated that these student groups traditionally are given more skills and procedures based mathematics instruction and less conceptual development and problem solving (McKinney et al., 2009; Watson, 2006). Because of this they may have had less opportunities in their math classes to experience productive struggle and the benefits one gets from successfully solving complex problems together with a group of their peers (Lubienski, 2000). Having low mathematical self-confidence, low status, and a fixed mindset about mathematics may also be a reason for this hesitant and unsure behavior (Cohen & Lotan, 1997; Dweck, 2006).

A balance for all students was difficult to find. I did not want to give too much guidance and support, but I also wanted to build their beliefs in their ability to do high level mathematics. If the tasks were too complex or too frustrating, students experienced a rising of stress or anxiety which decreased their mathematics self-efficacy, lowered their individual or group status, and pushed them towards a fixed mindset. Kirschner, Sweller, and Clark (2006) suggest that more guidance is needed during problem-based instruction, especially for novice students, because of the increased cognitive load on students’ working memory. For example, during the study, the
one student that had the largest drop in her past mathematics performances rating was a student that complained of the difficulty of the Virus Project. She desperately wanted to know if she was right throughout all of the tasks and not knowing where she stood caused her anxiety and made her second guess her answers.

There is a balance for this productive struggle for each student, somewhere between giving students direct questions and answers and students experiencing continual frustration while learning mathematics, yet it is difficult to find (NCTM, 2014). It is possible that more opportunities throughout the year to practice problem solving through struggle, with a gradual release along the spectrum, may help students like this feel more comfortable with these types of tasks (Warshauer, 2015; Wilburne et al., 2014). Instructional strategies supported by CRMP research did alleviate some of this and students showed a better ability to deal with frustrations and academic struggles as the study progressed. These strategies included scaffolding the task, offering frequent feedback and connecting with each student to build strong relationships of care. In addition, I also worked to build their status through the use of cooperative learning structures and group norms which included teaching all students help-seeking strategies. These teacher supports are seen in Table 7 with reference to students with low or high mathematics self-efficacy and low or high mathematics achievement. Each section identifies the target, with highlighted special populations, and overriding goals that teachers may want to address with these groups of students. Additional suggestions are listed for scaffolding, praise, questioning, and status for each section. These suggestions will be discussed throughout the next sections.

**Scaffolding.** In terms of scaffolding, the Virus Project was a more open task with less scaffolding than the Buying a Car Task. This led students to experience high frustration and confusion levels at times. With the limited structure of the project, there were concerns raised in
the findings that there needed to be more focused discussions in the groups and with the whole class on the mathematical thinking and contexts, including issues of social justice. Therefore, more structure was built in to the Buying a Car Task, which facilitated more understanding of the math involved and the task expectations, but somewhat constrained the students’ ideas and their opportunities to develop their own mathematical thinking about linear functions and systems. Through this limitation, I may have also inadvertently limited potential status minimization and growth mindset developments in my students. Elizabeth Cohen (1994) discussed her dilemma regarding the amount of structure to include in tasks utilizing Complex Instruction. If there is no structure, then students’ thinking will be mostly concrete, yet if there is too much structure students may be confined in their thinking to what is written in the task and not develop their own understanding. Kirschner et al. (2006) suggest that by using worked examples and process worksheets teachers can alleviate some of the cognitive load on students’ working memory during problem-based instruction. Hmelo-Silver, Duncan and Chinn (2007, p. 100) suggest modeling, coaching, questioning, “just-in-time instruction,” and structuring the task to decrease cognitive load.

My recommendation for future CRMP tasks, in regard to scaffolding, is to provide balance in the openness of the task with appropriately timed discussion and analysis prompts and teacher check-ins. A teacher check-in would be when students reach a specified point in the task, the students call the teacher over to their group and the teacher questions their understanding of the math, the context, or the task expectations. This task structure would leave room for student exploration of the mathematics, be explicit to the discussion expectations, and provide scheduled feedback opportunities throughout the task.
Findings from this study suggest the recommendations laid out in Table 7. In Table 7, scaffolding of the tasks was recommended for students with traditionally low mathematics achievement and either low or high mathematics self-efficacy. Students with low mathematics self-efficacy and achievement need additional supports to not only provide them with equitable opportunities to access the mathematics, since many of these students have learning disabilities or low English proficiency, but also to increase their mathematics performance. Students with traditionally low mathematics achievement and higher mathematics self-efficacy also need scaffolding supports to access the mathematics and contexts within CRMP tasks, however, some of these students tend to overestimate their mathematics ability, believing they are more proficient than they truly are (Pajares & Graham, 1999). These students require frequent check-ins with the teacher to ensure they understand the mathematics and can rectify any misconceptions. This will be further discussed in the next section on questioning.

**Questioning.** With CRMP tasks taught using a cooperative learning structure, teacher questioning was an important mode of assessing and pressing student mathematical learning. Through data analysis, I noted some questioning that I used that did assess student learning and push students’ understanding, however, there were many times that my questions could have been answered with a simple yes or no or with numerical answers. Staples (2014) suggests through her analysis of the instruction at Railside high school, that teacher questions should probe students for their understanding, help them to clarify their confusions, and focus their attention on incomplete logic. Restructuring of the tasks, as explained earlier, with specific teacher check-in points could help facilitate this process and make sure that each group was supported with effective questioning.
Findings from this study recommend different types of questioning dependent on students’ levels of mathematics achievement and self-efficacy (see Table 7). For students identified as having traditionally low mathematics achievement and either low or high mathematics self-efficacy, I suggest a need for questioning that probes for understanding, clarifies misconceptions and remedies incomplete logic (Boaler & Brodie, 2004; Boaler & Humphreys, 2005; Staples, 2014). For students with traditionally higher mathematics achievement and either low or high mathematics self-efficacy, I suggest a need for questions which probe for understanding and extend and connect the mathematics to other math concepts and contexts.

A tool that may be helpful for teachers working to question students more frequently and effectively can be seen in Table 8. It consists of a comprehensive list of questions for different points within a CRMP task (Boaler & Brodie, 2004; Boaler & Humphreys, 2005; Staples, 2014). Questions at the beginning of the lesson focus on identifying difficulties before students lose too much time on the task; such as what information they already know, what they are trying to find, and a review of math concepts they have learned that may be helpful. Questions offered for the middle of the task focus more heavily on strategies, explaining processes, and clarifying misunderstandings. This section is also separated by questions asked from the teacher to an individual, from the teacher to a group, and from a peer to a peer within a group. For the end of the task, questions focus on explaining answers, final representations, analysis, justification, and the relevance of the context. Before utilizing this tool, teachers can first follow the suggestions in the shaded timeline: (1) listen to students, (2) watch their interactions, (3) connect to students personally through kindness, (4) connect to students through praise, and (5) connect to students through questioning. The next section will discuss the praise aspect for this tool.
**Praise.** Examples of teacher to student praise used in this study were primarily for celebrating successes, an important part of developing self-efficacy through social persuasions as described by Bandura (1987). I used this praise to identify to students when they had been successful at a part of the task in hopes that those experiences of success would motivate them to try harder and potentially build their mathematics self-efficacy and perseverance. However, Dweck’s (2006) research on growth mindset and Boaler’s (2016) research on mathematical mindsets suggest that teachers praise should be focused more heavily on students’ effort, strategies and group participation. Throughout this study, I came to the conclusion that, at first, my students wanted to feel validated that they were doing the mathematics correct. I believe this is due to their experiences in past mathematics classes where a majority of the instructional time was spent on getting the right answer to a set of problems. These bits of praise were necessary for some students during the CRMP tasks to reconcile students’ concerns and anxiety by confirming that they were on the right track with their mathematical thinking. The problem I encountered during these CRMP tasks was that I praised mostly on success and accuracy, and less on effort, strategies, and group participation.

In future CRMP tasks, I would suggest a heavier weight on meaningful praise in these three areas and a gradual lessening of praise on accuracy. One thing that may be helpful for teachers working on increasing meaningful praise to their students is a list of praise statements focused on different points throughout the task (see Table 8). The praise listed in Table 8 is also separated by praise teachers could give to individual or groups versus praise that teachers could give to assign competence to lower-status students (Boaler, 2016). For example, at the beginning of a CRMP task, teachers may praise individuals and groups for being prepared and getting started on the task. Teachers may also specifically praise lower-status students for the same
things except saying it publicly as a way to assign competence to the student and encourage other students to follow suit (Boaler, 2015; Cohen & Lotan, 1997). During the middle of the task, teachers may praise and or assign competence for students’ efforts, the strategies they used, or their participation within their group. To finish up the task, praise may be more concentrated on students’ analysis, representations, and their problem solving processes.

In regard to praise, I was surprised and concerned by the findings of the social persuasion source of self-efficacy during my surveys. My own observations of my praise towards students showed a slight increase from the Virus Project to the Buying a Car Task as I purposely tried to increase praise in my instruction. However, from prestudy to poststudy, the social persuasions source of self-efficacy was the only source that showed an overall average decrease among the class on the student self-efficacy surveys. Three out of the four cases in this report also showed overall decreases, with Lara, the higher achieving student, having the only increase in social persuasions over the course of the study. Olivia showed the largest drop with Carlos and Yasmin having smaller decreases in this category. Studies have shown that for some student groups, specifically African Americans and females, social persuasions can be an integral part of their self-efficacy development (Usher & Pajares, 2006). More focused attention on this self-efficacy source from a teacher’s perspective could be vital to increasing the mathematics achievement of students living in poverty.

My recommendations in Table 7 suggest that students with traditionally lower mathematics achievement with either high or low mathematics self-efficacy may be better served by praise related to their participation in the task and in their group, asking for help and helping others, giving good effort, and utilizing correct and efficient strategies. Students with traditionally higher mathematics achievement and either low or high mathematics self-efficacy
may respond best to praise on unique strategies, their ability to solve problems in multiple ways, positive attributes of their analysis writing, their mathematical processes being thorough, and their willingness to help others.

**Feedback.** These CRMP tasks provided students and myself with knowledge of their understanding of the mathematics and the real world context. There were multiple opportunities for formative feedback throughout each class day (see Figure 3). The warmup questions at the beginning of the class and the reflection questions at the end of the class allowed students an opportunity to express their understanding and me the opportunity to assess their understanding in a casual, non-threatening way. During the task, questioning and modeling were used to offer feedback when students needed help. Due to the heterogeneity of the classes, this feedback needed to be differentiated in order to be effective.

Recommendations for feedback types based on students’ mathematics achievement and self-efficacy can be seen in Table 7. Students with historically higher mathematics achievement in school and higher mathematics self-efficacy may need less overall feedback during the task, but still may need teacher check-ins with probing questions to get them to extend their mathematical thinking. Students with higher mathematics achievement, but lower mathematics self-efficacy, also may need probing questions, but additional reassurance that they are headed in the right direction with their mathematics understanding. Studies have also shown that higher ability students have the highest gains when taught mathematics using strategies such as in Complex Instruction (Boaler, 2016). In addition, studies have shown that many students with the highest mathematics achievement, as assessed through procedure and skill-based tests, tend to have more of a fixed mindset. Continued questioning and teacher check-ins may help these students form their mathematical mindset to being one focused on growth.
Students with historically lower mathematics achievement in school and lower mathematics self-efficacy may need more frequent feedback related to their misconceptions and the context in general, as well as additional reassurance and motivation to keep persevering on the task at hand (See Table 7). Students with lower mathematics achievement and higher mathematics self-efficacy may also need frequent feedback related to their misconceptions and the context in general, but may also need feedback related to accuracy, checking their work, slowing down, and continued motivation to complete the task. Studies have shown that students with identified learning disabilities in mathematics tend to report higher mathematics self-efficacy due to overestimating their past mathematical performance, such as on assessments (Zimmerman, 2000). In addition, I suggest that teachers offer ways to build students’ confidence during the tasks, such as building in teacher check-ins throughout the class period and also offering feedback on students’ progress each day. This feedback could help motivate students by helping them to experience incremental successes on longer projects or tasks before the final due date, counteracting the difficulties some students have with project-based tasks (Kirschner et al., 2006).

After analyzing the data, I found that I needed to refine and improve my ability to give social persuasions to my students and use them to build the status of lower-status students. I did work on this throughout the three CRMP tasks, but found that I was still lacking in giving consistent and appropriate praise, as defined by Dweck (2006) and Boaler (2016). I did, however, try to focus my praise on students of lower-status, pointing out their strategies and solutions to them and their peers to raise their status in the classroom. This strategy worked well. These students felt pride that I used their strategy or were happy that they were publicly being commended for being right in math. I believe that this strategy could have been expanded even
further to include more students and more instances of building status. The difficulties in this strategy included the busy nature of the classroom, the overriding confusion at times of the students, and the overwhelming belief I had to help everyone. By holding strong to the group norm expectations and improved teaching of student roles, the classroom may have been less chaotic and my ability to focus on giving specific praise to lower-status students could have occurred more often.

Implications for these areas are numerous. By building these instructional skills in their practice, teachers may increase student engagement, motivation and achievement, which may also lead to increases in students’ self-efficacy. It may also help teachers connect socially, emotionally, and academically with their students. Professional development designers and teacher leaders can promote learning opportunities for teachers to grow in these areas. In addition, administration can encourage teachers to visit other teachers’ classrooms that are more experienced in these levels of teacher support, to gain ideas and confidence in their abilities. Curriculum developers would do well to build such ideas into their resources to guide teachers towards utilizing these multiple levels of offering feedback and support to their students. Guidance in scaffolding, praise, and questioning would allow teachers to utilize their curricular resources more instead of searching for other resources to learn from.

**Achievement and Self-efficacy**

As has been previously discussed, mathematics achievement has been shown to be greatly influenced by students’ mathematics self-efficacy (Marat, 2005; Meece et al., 2003; Multon et al., 1991; Pajares & Graham, 1999; Pajares & Miller, 1994). Certain aspects of the CRMP tasks and instruction may have influenced this in positive and negative ways. In this
section, I will discuss some of those aspects that may have contributed to changes in my students’ mathematics self-efficacy and subsequent achievement.

**Achievement.** Students’ mathematics achievement during these three CRMP tasks increased in multiple ways during this study. This included their ability to understand and create multiple representations of both linear and exponential functions, their ability to find volume and use scientific notation operations, and their ability to analyze mathematics within real world contexts. By teaching mathematics through a culturally relevant context, the evidence in this study suggested that students were more engaged, interested, and motivated to understand the mathematics with contextual assignments versus non-contextual assignments. Observations also confirmed that students continued working on the tasks even through their frustrations, confusions, and questions, seemingly because they were invested in the topic and had opportunities to become experts. ELL students and students with special needs had increased difficulties making connections between the context and the mathematics and had lower overall scores, but still showed growth in their understanding of the mathematics and procedures due to the additional supports they had from teachers and peers. In this section I will discuss four main factors that my findings suggest influenced student achievement during these three CRMP tasks: high expectations, opportunity to learn, teacher support, and peer support.

**High expectations.** One factor that may have contributed to students’ mathematics self-efficacy was the high cognitive demands and language demands required in the CRMP tasks. These demands gave students access to high level mathematics and practice using language skills to learn the mathematics, but seemed to have mixed results for students’ mathematics self-efficacy. Bandura (1987) hypothesized that past mathematics performances, also called mastery experiences, are the most influential source of self-efficacy. This indicates that if students have
not experienced continued successful performances in mathematics their mathematics self-efficacy may decrease, potentially leading to lower mathematics achievement. With the structure of these CRMP tasks being longer, more complex, and with little opportunities for self-evaluation, it concerned me that the students’ past performances rating may decline, contributing to a lower mathematics self-efficacy through the three tasks. As Pajares (2006b) noted, “academic work should be hard enough that it energizes, not so hard that it paralyzes” (p. 344). In fact, all five students who experienced a decline in their mathematics self-efficacy also showed decreases in their past performance rating. This suggested that the task structures, the high cognitive and language demands, and the lack of continuous successful experiences for these students may have influenced their mathematics self-efficacy negatively, particularly for ELL and exited ELL students.

School policies and classroom routines also influenced students’ achievement. The school proficiency grading policy required students to score a 70% or higher on summative assessments. Therefore, students who did not score at a 70% or higher on the Party Assessment or the non-contextual linear systems assessment were required to get additional remediation and retake opportunities until they scored at or above 70%. This policy forced me to offer the support and guidance that students needed to better understand these assessments on linear systems. (Black et al., 2003; Posner, 2011) Due the additional review time, all students were able to pass the Party Assessment at the proficient level. Students also showed higher than average achievement on the non-contextual summative assessment partly due to their achievement on the Party Assessment and the focus it had on multiple representations of linear systems. This proficiency grading policy also seemed to encourage the development of a growth mindset as students developed an understanding that assessments are also for learning and that it takes time
to acquire new mathematics skills and knowledge. I did have concerns that this policy led to me teaching to the test and focused my students’ attention on getting the right answers versus learning. However, my realization was that if the summative assessments have a balanced approach with conceptual understanding, procedures, and problem solving interwoven, then teaching to the test was reinforcing all of the CCSSM and mathematical practices that I would like them to be proficient in. There are many considerations when reflecting on proficiency grading policies, but these findings show that a proficiency grading policy can be utilized with CRMP tasks and assessments and promote growth in student achievement (Black et al., 2003; Posner, 2011).

**Opportunity to learn.** Many students were not comfortable with the CRMP tasks and at first seemed frustrated by the complexity of the expectations. They had not had much experience with tasks like these in past courses and they struggled to make the necessary connections among mathematics strands and the context. Yasmin, an exited ELL student with high math anxiety, and Olivia, a student with an identified learning disability in mathematics and confirmed ADHD, both seemed to struggle at times with the mathematics, the context, and their own self-confidence. I suggest that they both may have been hindered by difficulties related to their opportunities to learn (OTL) (Tate, 2008). Research on OTL has primarily focused on students’ success and their availability to high quality curriculum and instruction in relation to standardized test scores, but has shifted to include an equity link, including factors related to geographic regions. Reeves (2012) found that math achievement was related to geographic factors including family socioeconomic status and the influence of students’ friends. Other researchers have found that ELL students have less of an OTL due to factors of parent education, poverty, challenges of learning a second language, and the complexity of the language demands
of the tasks (Abedi & Herman, 2010). In this study I would suggest that other factors also limited the OTL for Yasmin, Olivia, and other students with special needs. These include their difficulty in understanding the language of the task and the mathematics vocabulary, their difficulty making connections between the mathematics and the contexts, and their math anxiety and low mathematics self-efficacy. Their math anxiety and low mathematics self-efficacy, I believe, stemmed from continuous low achievement in past mathematics courses with a heavy focus on skills and procedures. To provide equitable education for all students, teachers need to be aware of these limitations and work to overcome them with additional scaffolding, feedback, relationship building, and instruction that values a balance of conceptual understanding, procedures, and problem solving.

**Teacher and peer support.** During questionnaires, interviews, and surveys, student participants cited my support, motivation, and our relationships as reasons why they felt more comfortable and less anxious about doing mathematics in my classroom. They expressed that I was always there to help them understand the mathematics and support them through challenging problems. These supports influenced their achievement by motivating them to continue working, to ask for help, and to ultimately complete these longer tasks. The growth seen in some students’ perseverance influenced their positive achievement on the Party Assessment and on the non-contextual linear systems assessment.

Students also expressed, through qualitative data sources, that working in cooperative groups and using group norms positively influenced their mathematics achievement by helping them feel more confident and helping them see how similar they were to their peers in understanding algebraic functions. Cooperative groups gave all students more opportunities to learn than working individually and resulted in less negative talk and more experiences of
mathematical success. Observations of Yasmin and Olivia during all three tasks showed a decreased use of negative self-talk about mathematics and the tasks, such as “This is hard,” “I suck at math,” and “This is pissing me off” (Student observations, March 2015). These aspects of less negative talk and increased mathematical resilience may also have important influences standardized assessment performance.

Besides teachers, these findings can also be critical for administrators, curriculum developers and professional development designers as they work to provide equitable schools, classrooms, and curriculum for students in need. It is important for them to realize that supports and scaffolds are necessary for tasks with high cognitive and language demands. Proficiency grading may have positive intentions, but can promote teaching to the test and skills based instruction. Balanced assessments may support more positive gains when using proficiency grading policies. All stakeholders need to be aware of how to best address students’ opportunities to learn and ensure that all students have adequate time, appropriate supports, and equal access to the curriculum. Finally, creating a positive classroom climate is a culmination of multiple factors influenced by school climate, curriculum, and instructional strategies (Averill, 2012; Gay, 2010). Therefore, all stakeholders need to understand the importance of teachers and peers knowing how to support increases in student motivation, perseverance, mathematics achievement and self-efficacy.

Mathematics self-efficacy. Self-efficacy has been shown to be the best and most consistent predictor of academic outcomes when compared with other motivational constructs (Graham & Weiner, 1996; Multon, Brown, & Lent, 1991). Self-efficacy has also been shown to have a direct effect on mathematics problem solving and engagement in the classroom (Pajares, 1996b; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pintrich & DeGroot, 1990).
Therefore, by focusing our attention on improving mathematics self-efficacy within our efforts to provide equitable mathematics education using CRMP we may create more positive change in mathematics achievement for students of poverty than by only focusing on student performance.

Throughout this study, findings about self-efficacy were mixed. Eight out of the seventeen students in the study had increases in their mathematics self-efficacy over the course of the three CRMP tasks, whereas five had small to large decreases. The other four students had either the same scores from pre to post or did not complete the post test. Out of the students that decreased in their self-efficacy, all but one were current ELL students or exited ELL students (including Yasmin and Carlos), which suggested that these tasks may have had a negative effect on their mathematics self-efficacy. Interestingly, all four of the students with identified learning disabilities in mathematics, with documented IEPs, improved in their overall mathematics self-efficacy or stayed steady. The fact that the special education teacher was a co-teacher in this classroom and these students had additional time with her may have shielded them from potential similar decreases in self-efficacy as seen in the ELL and exited ELL students.

**Self-efficacy sources.** Student surveys and observations were used in this study to rate students on their sources of mathematics self-efficacy. These sources influence the mathematics self-efficacy of students, however, different students’ value different sources of self-efficacy (Arslan, 2013; Hampton & Mason, 2013; Usher & Pajares, 2008). Therefore, it is imperative that teachers design their pedagogy with all four sources in mind: past mathematics performances, vicarious experiences, social persuasions, and physiological state. Findings suggest that many of the tenets of CRMP that were utilized in this study may have influenced students’ mathematics self-efficacy.
Decreasing physiological state. Both student surveys and observations of students’ physiological state indicated increases in this self-efficacy source throughout the study. This is reflected within the positive classroom climate, which I created, with defined routines, help-seeking opportunities, the valuing of students’ interests and opinions, and strong teacher-student relationships built through support and care (Benard, 2004; Lee & Johnston-Wilder, 2013; McKinney et al., 2009). Building relationships through teacher care has been shown to improve students’ mathematics self-efficacy, especially for Latina/os and Spanish dominant ELL students (Lewis et al., 2012; Riconscente, 2014). I worked to build relationships throughout this study by having respect for each student and expressing this through my positive interactions with students, my enthusiasm for the tasks, and my interest in their personal and mathematical thoughts. In exchange, students expressed that I was patient, motivating, and supportive and that these things helped them learn about algebraic functions. In Figure 4, I showcase the most important factors which were suggested by my student participants as important facets of me, as a teacher, that helped them learn math and be more confident in math class during the CRMP tasks. These included offering support and patience, showing interest and enthusiasm, and being positive and motivating, with a priority of respect for the whole student. I also showed respect for the whole student, such as I learned about their culture, showed interest in their mathematical and personal ideas, and treated them with kindness.

Besides building relationships, teachers can lower students’ physiological stress by creating learning environments where students feel safe to participate in mathematics activities (Benard, 2004; Lee & Johnston-Wilder, 2013; McKinney et al., 2009). In this study, this included being flexible with assessment options, giving students choices, and teaching all students how to work together respectfully. Teacher support added to this when I prioritized
frequent feedback, gave appropriate praise, and had high expectations for students helping each other (Middleton & Spanias, 1999; Usher, 2009). These safe and supportive structures provided students with confidence and reassurance that they have others by their side at all times should they need help. Many students come to eighth grade math with anxiety due to previous negative school experiences and family negativity towards math and the word “algebra” (Ashcraft et al., 2007; Usher, 2009). These recommendations may ease this anxiety and promote a comfortable environment for mathematics learning, improving mathematics self-efficacy, and improving mathematics achievement.

Students’ interest and engagement in tasks has been shown to be related to mathematics self-efficacy (Multon, Brown, & Lent, 1991). By relating curriculum and content to students’ funds of knowledge, I found that it may have lessened my students’ math anxiety and improved their physiological state in the classroom. Improving a student’s physiological state can lead to an improvement in their overall mathematics self-efficacy (Bandura, 1987; Schunk & Meece, 2006). In this study, interest in the mathematics was increased through the use of CRMP tasks, cooperative learning, and the sharing of interests, mathematical ideas, and funds of knowledge. In addition, students’ math anxiety seemed to decrease during the Party Assessment in comparison to the non-contextual linear systems assessment possibly due to the relevant local context and the accessibility of the problem with multiple representations and explanatory analysis questions. Observations of Yasmin during the Party Assessment confirmed this with a focus and determination on an assessment like I had not observed from her prior to this task. Overall, both average ratings on the student surveys and the student observations, in the area of physiological states, increased over the time of the study. In addition, the average percentage score on the party assessment was approximately 10% higher than on the non-contextual linear
systems assessment. These findings suggested that students physiological state did decrease over time possibly in part to the CRMP task interest and the CRMP assessments, with higher relevance and more accessibility for all learners.

**Improving social persuasions.** Social persuasions decreased according to the student surveys, yet increased according to my observations. This indicated a difference between the student perceptions of praise directed at them and my perceptions of the praise I gave. Students did not seem to experience or internalize the praise statements that I gave and did not experience praise from peers or parents much at all. For some students, social persuasions, or praise, can be their most important source of self-efficacy. This has been shown to be especially true for girls and for African American students (Usher & Pajares, 2006). By prioritizing praise, mathematics teachers can impart confidence and motivation in students that can lead to increased mathematics achievement (Boaler, 2016; Dweck, 2006). Social persuasions to students occurs from four primary sources according to Bandura (1986): from teachers, parents, peers, or a students’ own thoughts about their abilities. Teachers can support this in many ways, first and foremost, with their own positive praise for students with a focus on students’ effort, participation, and strategies (Boaler, 2016; Dweck, 2006; Usher, 2009). Many times peers do not know how to praise others genuinely or what to praise specifically, teachers can include praise expectations in their group norms and teach students how to praise one another appropriately. Teachers may be able to help build social persuasions from parents by regularly sharing their child’s progress and successes. Finally, some students with low self-efficacy use a high amount of negative self-talk. “If negative self-messages are not properly redirected, they may chip away at the potential beneficial effects of even the smallest academic victory” (Usher, 2009, p. 298). By modeling and encouraging students to praise themselves through explanatory metacognitive pieces and student
reflections, students’ mathematics self-efficacy and achievement can grow. Consistent positive praise needs to be infused throughout the curriculum to further improve the mathematics self-efficacy and achievement of impoverished students’ mathematics.

*Importance of vicarious experiences.* Surveys indicate that the average vicarious experiences increased among students in this study, but decreased according to observations. This suggested that students did observe teachers, peers, and themselves as models to learn and grow in their beliefs about themselves doing mathematics. I believe this was primarily due to the cooperative group structures I utilized. Vicarious experiences, or observations of modeling, have been shown to be the most important source of self-efficacy for many students, including Latina/os and students with low mathematics proficiency (Arslan, 2013; Hampton & Mason, 2003; Stevens et al., 2006). Working in cooperative learning groups gave my students opportunities to observe other students modeling mathematics and were an important factor in their mathematics achievement and self-efficacy, especially for many of my lower-status students, including Yasmin and Olivia. Observing others do mathematics, including the teacher and technology, can lead students to believe they can be successful doing mathematics too (Bandura, 1987; Schunk & Meece, 2006; Usher, 2009). This is especially true if the observer believes the model to be more similar to them. Through these observations, students began to feel stronger in their ability to do mathematics, leading to a higher mathematics self-efficacy.

Teachers can improve students’ vicarious experiences by modeling and explaining mathematics clearly with effective questioning (Meece et al., 2003; Riconscente, 2014). Curriculum choices can also affect opportunities for vicarious experiences (Middleton & Spanias, 1999). For example, in this study with CRMP tasks, students had to analyze and solve tasks together using specified and taught group norms and roles. When groups are designed,
teachers may further facilitate this important source of self-efficacy by placing students with low self-efficacy in the same group as a student similar to them in ethnicity, gender and general mathematics ability. Finally, teachers can also utilize technology within CRMP tasks, which may incorporate more opportunities for student modeling and collaboration. Increasing opportunities and providing effective structures for students’ vicarious experiences can lead to increased mathematics self-efficacy and achievement (Meece et al., 2003; Middleton & Spanias, 1999; Riconscente, 2014).

Increasing past mathematics performances. Average past mathematics performances rose in both the students’ surveys and observations. This indicated that students did have successful mathematics experiences throughout the CRMP study, potentially related to the scaffolded organization of the tasks, frequent feedback, accessible assessments, and relevant contexts. Throughout the self-efficacy research on mathematics education the most important source of self-efficacy has reliably been past mathematics performances. This has been shown to be especially true for boys (Usher & Pajares, 2006). Students must have consistent opportunities to experience success in mathematics for them to develop high mathematics self-efficacy, however, there are multiple ways for students to experience this. Using CRMP curriculum and instructional practices, I used tasks that allowed students choice to delve deep into a topic and become an expert on that topic. This led to increased power and status in the classroom and more positive beliefs about their ability to do math. I also used curricular pieces that supported group work and individual accountability, which allowed my students opportunities to experience both success while working and learning with others and as individuals doing math independently. In addition, I provided students with frequent feedback and appropriate scaffolding throughout the
CRMP tasks which provided the structure and confirmation that many of my students needed to build up their overall mathematics self-efficacy and improve their mathematics achievement.

**Teacher support.** Scaffolding, feedback, and building relationships seemed to also influence my students’ mathematics self-efficacy by influencing all four hypothesized sources of Bandura’s self-efficacy theory: past mathematics performances, vicarious experiences, social persuasions, and physiological state. Making the content more accessible by scaffolding seemed to decrease my students’ frustrations and math anxiety, therefore decreasing their physiological state and increasing their overall mathematics self-efficacy, as was seen with Olivia. However, too much scaffolding may have inhibited my students from experiencing independently successful learning, which could have decreased their successful mathematics performances leading to a lowering of their self-efficacy, as was seen with Carlos.

A similar balance was determined with feedback, in that offering frequent, specific feedback with good modeling and explaining improved students’ mathematics self-efficacy through the increase of their vicarious experiences, as seen in Lara, Olivia and Yasmin. However, too much feedback may have inhibited their own growth mindset and opportunities for them to learn how to think mathematically, persevere, and be a help-seeker. This may have decreased their past mathematics performances rating as seen in Carlos and Olivia after the Virus Project. Additionally, the problem of too many questions being asked of the teacher and not enough help-seeking and help-giving within the groups seemed to have added frustration and potential decreases in both Carlos and Olivia’s past mathematics performances rating. This was because they could not get the help they needed to consistently and successfully solve their math questions independently. Feedback as praise is one factor of improving self-efficacy, but if the praise is solely focused on completion and success of right answers it can undermine the
development of a growth mindset (Boaler, 2016; Dweck, 2006). Social persuasions were lower for both Olivia and Carlos which suggested that they rarely received praise from me or their peers, which ultimately may have decreased their mathematics self-efficacy. Finally, the relationships that I built with students also influenced their mathematics self-efficacy in the area of physiological states, which grew for Lara, Olivia and Yasmin, yet decreased for Carlos, which suggested some discomfort for him in some aspects of the math class.

**Cooperative learning.** During this study, cooperative learning strategies were utilized not only as a way to improve mathematics achievement among students, but also to improve their self-efficacy about mathematics. All four sources of self-efficacy hypothesized by Bandura (1987) came in to play when students worked in cooperative groups on CRMP tasks. Vicarious experiences have been shown to be a highly important source of self-efficacy for marginalized students, specifically African American, Latina/o students and students with special needs (Arslan, 2013; Hampton & Mason, 2003; Stevens et al., 2006; Usher & Pajares, 2006). This was observed when the highest source of self-efficacy for Yasmin and Olivia was vicarious experiences, which suggested that this was an important piece of their self-efficacy development. In addition, vicarious experiences were the only self-efficacy source for Carlos that showed growth throughout the study. The power of vicarious experiences in cooperative learning was seen when students modeled and explained their thinking to others. The observers related to the student modeling and began to see themselves as being able to solve math problems successfully too. These observations reassured the observer that they were not alone, promoted additional perseverance in the observer, and moved them from a fixed mindset towards a growth mindset.

The cooperative learning structure also influenced students’ self-efficacy through their positive peer to peer social persuasions or praise, however, this was not seen consistently through
the study. It was observed that peer to peer praise was infrequent and I believe this was because I did not facilitate it through high expectations for following group norms, nor did I explicitly teach or model what appropriate peer to peer praise should look like in the math classroom. The kinds of praise needed from peers can be similar to those from a teacher (see Table 8). In particular, this may include students praising other students’ efforts, their willingness to participate in helping others, and their specific strategies for solving problems. Findings indicated that there was some peer-to-peer praise, but again most of it was praise based on successful completion of a question or problem, not as described above. By incorporating strong group norms based in mutual respect and care, by teaching students how to follow the norms and by consistently modeling what kinds of praise students should be using, social persuasions could become much more powerful in the math classroom and move students towards a growth mindset and higher mathematics self-efficacies (Boaler, 2016; Dweck, 2006). Sample group norms used in this study included, “You have the right to ask anyone in your group for help,” “You have the duty to assist anyone who asks for help,” and “No one is as smart as all of us together” (Cohen & Lotan, 1997; Horn, 2012).

Lastly, cooperative learning promoted a positive classroom climate where students’ thoughts were valued and respected. Students’ discussions about their interests were encouraged and tied to the mathematics to provide relevancy to the curriculum. Mathematics anxiety was limited by lessening the focus on memorization and rules and opening up mathematics using modeling to understand algebraic functions using multiple representations. Almost all students rated their physiological state as being positive, which suggested that the class did not cause them undo stress or anxiety. Carlos expressed that he enjoyed math class more because of the cooperative learning opportunities, in fact, saying that it was his favorite subject. The
physiological state was the highest rated source of self-efficacy recorded throughout the student surveys and Olivia’s ratings improved the most among the student participants. This suggested that she may have grown more comfortable in the class through the work on the CRMP tasks. The cooperative learning structure, although not perfectly implemented, did facilitate the learning of algebraic functions with findings that showed that students did have successful mathematics performances, some social persuasions, and many vicarious experiences. This combined with the low stress, positive climate, all helped to develop my students’ mathematics self-efficacy and feel more confident tackling algebra.

Due to the strong connections identified between mathematics self-efficacy and achievement, improving mathematics self-efficacy should be important to all stakeholders in secondary mathematics education. Understanding the four sources of self-efficacy and how they can be developed in the classroom has vital implications to what priorities they hold when it comes to improving mathematics education for all students. To address mathematics self-efficacy in secondary mathematics, curriculum can be designed and differentiated to best provide successful math performances for each student. This may include connections to students’ interests, local places, and other relevant funds of knowledge. Professional development designers can prepare learning opportunities for teachers in using groups to improve vicarious experiences and increase appropriate social persuasions or praise. Administrators and teachers need to be knowledgeable of the importance of mathematics self-efficacy to students’ achievement and support these changes. They need to be open to trying new ideas to reach their students and improve self-efficacy, including cooperative learning and various techniques of supporting students learning of mathematics.

**Status Connections**
Status positions in the math classroom can hinder collaboration and full participation from all group members (Cohen & Lotan, 1997; Horn, 2012). Findings in this study suggest that status positions can also influence students’ mathematics self-efficacy and achievement. Status is a perception of ability held by peers, teachers and the student in question (Cohen & Lotan, 1997). Minimizing differences in status among students, especially in groups, can support greater mathematics learning and understanding by lessening student anxiety and promoting student confidence. This is primarily done by raising the status of lower-status students (Boaler, 2016; Cohen & Lotan, 1997). To improve the status of lower-status students within groups, these students must feel successful at mathematics and appear successful to their peers. They need to be participants, actively engaged in the mathematics, fulfilling their role in the group and productively completing the task. For students with low status, and most likely low self-efficacy, teachers can support raising status with strong group norms and explicit teaching of the expectations within those norms. Expressing high standards for all group members to work together, help each other and participate fully in the mathematical and contextual discussions will also support this process. CRMP tasks, structured in open ways, can also improve low students’ status by opening up opportunities for them to participate and feel validated in their own mathematical ideas (Alexander et al., 2009; Boaler, 2016; Cohen & Lotan, 1997). This can include the use of students’ funds of knowledge, their lived experiences, beliefs, and interests (Moll et al., 1992). All of the above may lead to improved status through stronger peer to peer relationships, deeper mathematics understanding, and the opportunity for all students to feel like valuable members of their group.

Assigning competence is a strategy that teachers can use to improve students’ status in the classroom (Cohen & Lotan, 1999; Cohen et al., 1999). Examples of this strategy in a
mathematics classroom include praising lower-status students’ mathematical ideas or strategies in front of their group or the whole class (Boaler, 2016). This practice gives lower-status students credibility within the group or class, changing other students’ perceptions of that student’s mathematics ability and changing the particular student’s perception of themselves. For the best effectiveness of this strategy, teachers need to spend the necessary time and energy learning about their students through observations and conversation. Once a teacher knows which students have low status in the classroom, they need to show interest in their mathematics work by listening, questioning, and praising their strategies. The teacher would then publicly share and present ideas or strategies that the lower-status student did. Assigning competence to lower-status students and students with low self-efficacy increased students’ engagement and interest in the CRMP tasks in this study, which led to further mathematical understanding and a stronger sense of status in the classroom.

These recommendations were also stated in Table 7 for students of varying degrees of mathematics self-efficacy and mathematics achievement. For example, to improve low status for students with traditionally low mathematics achievement and low self-efficacy, teachers can assign competence by publicly and privately praising students’ effort, participation, and strategies. Students who have traditionally higher mathematics achievement, yet low self-efficacy, may also improve their status when teachers assign them competence through public and private praise, but praise may be more for their strategies, processing, and deep thinking. These students also can participate in groups with strong norms and roles to better see themselves as successful doers of mathematics. Students with traditionally lower mathematics achievement, yet higher self-efficacy, tend to be students who overestimate their mathematics abilities (Pajares & Graham, 1999). These students also need strong group norms and roles to
help form a more realistic vision of their mathematics abilities so they can continue to increase their mathematics achievement. Students with traditionally higher mathematics achievement and high self-efficacy also may need strong group norms and roles in order to better understand the strengths and abilities of others and work towards trusting others mathematically.

Minimization of status differences. One of the most interesting findings during this study was that many students reported feeling like they were the same ability in mathematics, that they all learn together at the same pace and that they are all capable and smart (Cohen & Lotan, 1997; Horn, 2012). These findings verify that status minimization did occur in this classroom and I believe it was due to three main factors: cooperative learning, group norms, and opportunities to become experts.

Cooperative learning. Findings suggested that these CRMP tasks, taught using a cooperative group structure, minimized student status differences to the point that many students stated that they felt they were all the same “smartness” and that everyone was capable. Working in groups allowed lower-status students the opportunity to see other students struggle when they struggled and have moments of individual success when they worked together with others. They saw themselves in comparison to others and began to believe that they were not much different in ability. For example, one student said in an interview, “We are all pretty smart, I think, and we are always on the same level” (Student interview, May 2015). Another student mentioned that “It is hard to tell who the smart ones are because all students work together” (Student questionnaire, March 2015).

As the teacher, it also became clearer what strengths students had that I was not aware of before. For example, I learned that some students had strengths in understanding context, working with computers, or explaining their thinking in concrete ways to their group members.
This ties in with Bandura’s source of self-efficacy, vicarious experiences (Bandura, 1986). Frustration levels on these challenging tasks seemed to decrease as they saw that everyone was challenged and experienced the same feelings. Findings suggested that differences lessened and students’ status in the classroom rose as they were able to observe each other, learn from each other, and become more confident in their understanding of algebraic functions.

**Group norms.** The second thing that I believe contributed to this was explicitly teaching group norms for help-seeking. These expectations, that they must help each other and they must not be afraid to ask for help, promoted status minimization and a growth mindset in some students. Students grew in their willingness to ask for help and give help throughout. When students helped each other, they saw that they were all capable of helping others at different times dependent on their own strengths and understandings. They were also able to believe that they can learn algebra well. They began to believe that algebra was not out of their reach, but that it takes perseverance, effort and working together. Findings showed that students also used the groups to offer support when a student seemed off track and to check in with their group members to make sure they were progressing on their mathematics activities. With Complex Instruction as a framework for group norms, students supported each other leading to an understanding that “we all help each other and learn together” (Cohen & Lotan, 1997; Horn, 2012).

**Becoming an expert.** I designed the CRMP tasks so each student focused on one topic and became an expert on that topic. Findings suggested that this design led to status improvements for lower-status students. Students learned about their topic through researching, analyzing and writing, and ultimately knew more about their topic than anyone else in the classroom, even me. I had a sense of pride when my students taught me about the size, shape, or
reproduction rate of the Ebola virus or their knowledge about the gas mileage and loan payments for a Ford Mustang. It is not often that the students know more than their teacher about something taught in a math class. This feeling also made them proud and excited to share what they had learned. They were interested in the mathematics because they were invested in their topic. The cooperative group structure also promoted the sharing and building of academic knowledge and becoming an expert. The findings demonstrated productive mathematical conversations between peers about both algebraic functions and the real world contexts.

Findings from this study implied that improving status in a heterogeneous high poverty mathematics classroom is possible and can influence students’ self-efficacy and achievement. Stakeholders from administrators to teachers to curriculum developers may not be aware of the concept of student status or may believe there is little they can do about low student status. It is imperative that they know and understand that status can be improved and status differences can be minimized through the recommendations outlined above. It is also essential that they have general knowledge of the research and how improving status in the mathematics classroom can influence students’ achievement, motivation, perseverance, and mathematics performance. Curriculum developers can include resources to support group tasks, as well as instructional materials for teachers on how to set up group norms and roles in their classrooms. Professional developers can create opportunities for teachers to gain additional knowledge and resources on how to improve their students’ status. Finally, it is important for administrators to trust their teachers as they venture into cooperative learning, group norms, and roles, especially if they are novices. It is equally important that teachers have support from teacher leaders and administrators who will encourage them to trust in themselves and in their students, that these
strategies to improve status in their classrooms will pay dividends in their students’ mathematics self-efficacy and achievement.

**Further Implications for Special Populations**

It can be challenging teaching a diverse group of learners in a heterogeneous classroom. In this study, the school setting had high poverty with a majority-minority population. It had a high population of ELL students and students with identified learning disabilities. Teachers using CRMP tasks and instructional practices with an eye towards improving mathematics self-efficacy need a plan set in place to support these special populations of students with diverse needs. Without support, these students may struggle to learn the mathematics being taught, but may also experience frustration with the tasks and within their groups, which could decrease their mathematics self-efficacy and potentially lead to lower mathematics achievement.

Even though ELL and special needs students have very different specific needs tied to their learning challenges, the accommodations that can be made in the mathematics classroom with CRMP tasks can be very similar. Most importantly, teachers need to be aware of each ELL students’ English language proficiency level and each special needs students IEP requirements. By knowing this information, teachers can scaffold the lessons appropriately for each student. Scaffolding for both groups of students may consist of a tiered task with simpler language, translated text or vocabulary words for ELLs, and a limited choice of internet resources and formats.

Teachers can also carefully consider the student groups that these students are placed in. ELL students, depending on their English language proficiency, may need to be placed with a bilingual student who can assist them with directions and vocabulary. They will then be able to have deeper, more meaningful mathematical discussions about the tasks. Special needs students,
depending on their mathematical proficiency, may need to be placed with a student who has a
good ability in mathematics, but is kind, patient, and willing to give additional help to their
group member. In addition, teachers may decide to place these students with other students who
are similar in ethnicity, gender, or mathematics abilities to increase their vicarious experiences
and mathematics self-efficacy.

Finally, with students in special populations, teachers should also communicate regularly
with their ELL or special education teacher to ensure that they are offering the right kind of
supports for each student. The ELL and special education teacher may also be able to offer
additional support on the CRMP tasks if the student has an additional class period with them.

These implications are not only geared towards teachers. Administrators also need to be
aware of the challenges teachers face when working with special populations of students and
support them in their ventures with time, resources, and professional development opportunities.
Professional development designers can also have a special focus on these issues as they create
opportunities for teachers to grow in their knowledge of equitable teaching practices. Curriculum
developers can incorporate these ideas into their resources with an eye towards providing
additional teacher supports and scaffolding opportunities. Finally, policy makers may also find
value in understanding these challenges. Perhaps realizing that equity does not mean the same
curriculum and instruction for all, but that schools need additional time and resources to support
true equity of opportunity and accessibility for all. This can be better achieved through adequate
funding for students with special academic and language needs, their teachers, and their schools.

**Recommendations**

This study provided many opportunities to promote equitable practices in mathematics
classrooms for students living in poverty. By utilizing CRMP curriculum and instructional
practices, teachers can influence students’ mathematics achievement, their self-efficacy in mathematics and their status within the classroom, potentially leading to positive mathematics learning experiences for all students. Findings in this study indicated that I taught algebraic functions using CRMP tenets with a few key pieces that ended up being highly important to the success of my students in understanding algebraic functions and growing their mathematics self-efficacy. The following is a list of these key pieces as recommendations for developing similar CRMP tasks and instructional practices for diverse mathematics classroom.

1. Topics for CRMP tasks connect to students’ funds of knowledge, their experiences, beliefs, interests, and future responsibilities.

2. CRMP tasks utilize group work with individual accountability so students can experience becoming an expert on a topic.

3. CRMP tasks include opportunities to analyze real world data, evaluate findings, and justify conclusions using multiple representations.

4. Students receive praise from their teacher on participation, effort, and strategies, which includes the teacher assigning competence to lower-status students.

5. Strong teacher-student relationship built through support, care and kindness develop a positive classroom climate that is a safe place to discuss mathematical ideas and make mistakes.

6. Assessments are balanced and include contextual elements that utilize CCSSM mathematical practices and non-contextual elements that assess CCSSM procedures, skills, and conceptual understanding.
7. CRMP tasks offer multiple ways for students to practice the four language skills, reading, writing, speaking and listening, with a priority focus on speaking and listening through group discussions on mathematics and context.

8. CRMP tasks are challenging with productive struggle expected and planned for with scaffolds built in and accommodations identified for ELL students and students with identified learning disabilities (NCTM, 2014).

9. Students are placed in heterogeneous cooperative learning groups and are expected to follow group norms and roles, including, but not limited to asking for help and helping when asked.

10. Feedback and questioning through frequent teacher check-ins is used continuously to probe for understanding, clarify misconceptions, and fill in incomplete logic, as well as to support student motivation and engagement.

Future Research Needed

This study suggested potential relationships between CRMP, mathematics self-efficacy, and mathematics achievement, but there is still much research needed to add to these findings. This section will focus on the need for research in the areas of CRMP task demands and self-efficacy, tools to promote student support, diverse learners and CRMP tasks, group norms and roles in homogeneous classrooms, contextual assessments, links between status and self-efficacy, links between family support and self-efficacy, and technology use with CRMP tasks.

CRMP Task Demands and Self-efficacy

The cognitive and language demands of the CRMP tasks in this study were high according to findings. Concern was addressed that these high demands may have had negative influences on some students’ mathematics self-efficacy if supportive structures were not put in to
place with the curriculum and classroom instruction. Further research is needed on these
influences with direct relation to the four sources of self-efficacy: past mathematics performance,
vicarious experiences, social persuasions, and physiological state. For example, research could
investigate the cognitive load of CRMP algebra tasks on students’ working memory and how that
may or may not affect their self-efficacy sources. It is also necessary to understand how the
language expectations and demands of these tasks may influence the self-efficacy of students
with special academic and language needs. Finally, the aspects of offering students choice and
the individual accountability built in to these CRMP tasks allows students opportunities to
become experts. Research can examine these aspects and how they may also influence students’
sources of self-efficacy and subsequent mathematics achievement in algebra.

**Student Support Tools**

As mentioned above, because of the high demands and openness of these tasks, supports
were needed to support, monitor and extend the mathematics learning for all students, especially
in the heterogeneous classroom. Further research is needed on how to best scaffold CRMP tasks
for diverse learners. Specifically, research would be worthwhile to study the two-tiered design
suggested in this study, with worked examples, discussion prompts, and vocabulary built in to
the task for students with special academic and language needs. Feedback tools designed for
teacher use need to be tested for effectiveness and usefulness, then refined for further teacher
use. This includes the feedback tool identifying supports for students with varying levels of
mathematics achievement and self-efficacy, as well as the tool with specified praise and
questioning ideas (see Tables 7 and 8).

**CRMP Tasks and Diverse Learners**
Every student comes in to a classroom with different mathematics backgrounds, experiences, and identities. In addition, they each come with diverse cultural backgrounds, lived experiences, and identities as learners. It would be interesting to research how these different aspects influence students’ beliefs and performances on CRMP tasks. Are there components of the curriculum or instruction that resonate strongly for different students and what facets of their histories influence these beliefs and their performance? For example, what aspects of CRMP tasks trigger students’ anxiety versus experiencing productive struggle and why (NCTM, 2014). Are there varying ways that student perseverance can be positively influenced during CRMP tasks and are these strategies influenced by students’ cultural backgrounds and experiences?

**Group Norms and Roles in Homogeneous Classrooms**

High school mathematics classes rarely are detracked, therefore there is a need to research CRMP and accountable group work, such as Complex Instruction, for classes that have more homogeneous student populations (Boaler & Staples, 2008; Reeves, 2012). Specific research questions may include whether group norms, roles, and assigning competence show the same promise for raising student status as has been shown in heterogeneous math classes. Are there additional structures or supports that can be developed or utilized to ensure greater improvements of status during these tasks in homogenous classrooms? How might group roles be utilized most effectively when using CRMP tasks with independent accountability?

**Contextual Assessments**

Contextual assessments, like the Party Assessment, have the potential to lessen students’ test anxiety, giving students more opportunities to show their understanding of algebraic concepts. Research is needed to develop, design, and refine contextual algebra assessments and determine their influences on students’ mathematics self-efficacy, specifically influences on their
mathematics performances and physiological state. Additionally, research is needed in the
development of balanced assessments, as recommended, which include both contextual and non-
contextual elements; balancing conceptual understanding, procedures and skills, and real world
application within one assessment. Research is needed to determine the quantity of each element
and the influence each has on student motivation, algebra achievement, and mathematics self-
efficacy. Research would also be worthwhile on the influences these assessments may further
have on students’ preparation and performance on state-required standardized tests.

**Status and Self-efficacy**

This study supported the idea that student status and mathematics self-efficacy may be
related. Further research is necessary to determine the relationship between these two constructs
and the connection between the two and students’ mathematics achievement. Quantitative studies
may be able to determine if student status and self-efficacy can predict students’ mathematics
achievement. Qualitative studies may be able to determine influences that student status and self-
efficacy beliefs have on students’ mathematics achievement. These relationships could
strengthen the need for other research into the development of more equitable curriculum and
instruction that considers both student status and self-efficacy, such as CRMP tasks, projects, and
assessments.

**Family Support and Self-efficacy**

Findings in this study supported a potential link between family support and mathematics
self-efficacy. Research is needed to explore this relationship and determine if the strength of
family support in mathematics is related to students’ mathematics self-efficacy and subsequent
achievement in algebra. This research could factor in family attributes, such as socioeconomic
status, ethnicities, and whether the student lives with only one parent, two parents, or their
extended family. Further research could also investigate ways that families could support positive mathematics self-efficacy and develop strategies to make families aware of these methods.

**CRMP Tasks and Technology**

Lastly, these CRMP tasks utilized technological resources for students to research contexts, analyze data, and present their final products. More research is needed in exploring the influences of technology use on students’ mathematics self-efficacy and status. Does the use of technology for gathering data and knowledge for CRMP tasks influence students’ status and mathematics self-efficacy in positive or negative ways or both? In what ways can technology be utilized during CRMP tasks most effectively for learning about algebraic functions, yet positively influence student status and self-efficacy? What teacher supports or curriculum structures are needed for students with special academic and language needs using technology for problem-based or project-based CRMP tasks? Further research in all of these areas could better secure our understanding of the influences of CRMP tasks on students’ achievement in algebra, their mathematics self-efficacy, and how to provide the most equitable mathematics education for each student.

**Conclusions**

This study set forth to better understand how I teach algebraic functions to eighth grade students living in poverty using tenets of CRMP in both the curriculum and in my instruction. Further, I wanted to determine if my use of these CRMP tenets influenced my students’ mathematics achievement and self-efficacy. Mathematics self-efficacy has been shown to be tied to mathematics achievement and, in some cases, socioeconomic status (Arslan, 2013; Multon et al., 1991; Pajares & Graham, 1999). However, there is still much to learn about how teachers can
implement instruction to improve students’ mathematics self-efficacy and whether influences on mathematics self-efficacy will translate to mathematics achievement and vice versa. CRMP has been shown to encourage student engagement, high expectations, cultural awareness, and seeing the world through mathematics (Gay, 2010; Ladson-Billings, 1995; Gutstein et al., 1997). These qualities along with using accountable group work, multi-dimensional tasks, and building a positive classroom community can increase mathematics achievement, especially for marginalized students. The main findings of this study are summarized below.

**Cognitive Demand**

All tasks had high cognitive demand and depth of knowledge because they exhibited complex mathematical thinking, used multiple representations, and made connections between mathematical concepts and real-life contexts. This high demand challenged all students with varying levels of productive struggle, but did cause some students (primarily ELL, exited ELL and special needs students) high frustration levels due to the complexity of the data, internet resources, and context (NCTM, 2014).

**Language Demand**

All three CRMP tasks exhibited high language demands and utilized all four language skills (reading, writing, speaking and listening). This promoted the CCSSM mathematical practices, but was challenging again for students with special needs, such as ELL students and students with identified learning disabilities, because of their lower proficiencies in reading and writing and the high expectations for these skills within the task. Language support was given for all three tasks, however, it could have been stronger throughout, by better scaffolding of discussions and offering additional support for exited ELL students.

**Funds of Knowledge**
All three CRMP tasks were designed to make use of students’ funds of knowledge, give students choice in topics and provide connections to students’ futures. This also included using technology as a resource, as a way to create representations, and as a tool to present their final product. Using students’ funds of knowledge also provided a space for students to see social issues through a mathematics lens, however, that aspect was weaker throughout. It was also seen that these tasks may have changed students’ views about mathematics because many of them expressed these tasks as their favorite activities in our class.

**Cooperative Groups**

Throughout this study, specifically during these CRMP tasks, students worked in cooperative groups, yet their tasks were individually assessed and each student had their own topic. It was seen throughout that this task structure helped students build relationships with each other, develop a collective understanding of algebraic functions, and become an expert on the mathematics of their specific topic. This gave students power in the classroom, as they had more knowledge than me on their topic. It also gave them the opportunity to observe others and come to realize that they were all similar in their mathematics abilities when it came to CRMP tasks. Minimization of status differences was observed among the groups which helped lower-status students engage more in the tasks and feel more successful doing the mathematics.

**Teacher Support**

Multiple levels of teacher support were used to engage students, support them in the learning process, and help them make connections between the mathematics and the context. Scaffolding was used to create more structure in the task for clarity of the mathematical expectations, however, this added structure limited the group work because there was less challenge, struggle, and discussion. Frequent feedback was used throughout each day, built in to
the class routine. I used a predictable pattern of feedback procedures, including checking in with groups and previously identified students with additional language, academic and behavioral needs, using multiple levels of questions, modeling of mathematics procedures and skills, and explaining algebraic concepts.

**Group Norms**

Group norms were an important part of the class structure seen throughout the study. These norms had high expectations for all students to seek help when needed and give help when needed. Students were receptive to this and utilized each other as resources throughout the two group work tasks. These norms not only assisted students in developing collective mathematical understandings and improving their mathematics achievement, but they also improved student status and mathematics self-efficacy when lower-status students were able to help others. There were still instances of higher-status students who wanted to work independently of their group and lower-status students who did not want to ask for help for fear of looking “not smart.”

**Teacher-Student Relationships**

Building strong teacher-student relationships was a key CRMP tenet that I utilized. Findings indicated that students saw this in my patience, motivating support, and clear and straightforward feedback. Part of building relationships included my efforts to praise their participation and mathematics success, as well as efforts to try and assign competence to my lower-status students, but student ratings of received praise were generally low. In addition, my praise for students did not include as many instances of praising students’ effort and specific strategies as praising accuracy. I also built relationships by having high expectations of my students mathematically, socially, and behaviorally. However, at times, it was difficult to express
these high expectations to all students because of the high student needs and questions they had throughout the class time.

**Mathematical Growth Mindsets**

Throughout the study, it was observed that many students with fixed mindsets about mathematics did move towards mathematical growth mindsets. This was seen through their willingness to work on challenging problems, their negative self-talk becoming more positive, their acceptance that mistakes were a part of learning, and their growth in perseverance, especially seen during the last task, the Party Assessment. It was suggested that the challenging multi-dimensional nature of the tasks, the opportunity to work in groups with specified norms on helping, and the strong teacher support assisted in their growth mindset progress. Additionally, the use of proficiency grading gave students multiple opportunities to learn, review, and retake assignments and assessments.

**Mathematics Self-efficacy**

Findings and analysis of this study suggest that students’ mathematics self-efficacy was influenced by the use of CRMP tasks and instruction.

**Case studies.** Lara, and other higher-status students with strong help-seeking and helping skills, grew in their mathematics self-efficacy and mathematics achievement. Over the course of the study, she showed increases in all four self-efficacy sources, with a large increase in feeling confident on difficult problems and a large decrease in having anxiety when doing math. Olivia, and other students with lower-status and negative feelings towards math, showed slight increases in overall mathematics self-efficacy or stayed relatively the same over the study time. She showed decreases in successful mathematics performances and social persuasions and increases in vicarious experiences and physiological state. Her ratings suggest she overestimated
her mathematics abilities, which is common among special needs students (Pajares & Graham, 1999).

Yasmin and Carlos, both exited ELL students, exhibited low status and low self-efficacy. Yasmin had high help-seeking and help-giving skills and a strong desire to learn mathematics for understanding. She showed slight decreases in all four sources of self-efficacy, with large decreases after the first task, the Virus Project, with a rebound after the second, the Buying a Car Task. This suggested that more time and experience with CRMP tasks may be valuable in continued mathematics self-efficacy growth. In addition, the first task had less scaffolding and more complexity, which may have influenced this initial drop, however, even with this decrease in mathematics self-efficacy, Yasmin showed growth in her perseverance, growth mindset, and status. Carlos showed high interest in the context of the CRMP tasks, but not in the mathematics. His mathematics self-efficacy decreased over the study in all four sources except vicarious experiences, which suggested the importance of observations and modeling to him. His biggest decrease was in social persuasions which correlated with him not receiving much praise due to his high distraction level, his lack of participation with his group, and his low interest in learning the mathematics.

All participants. When I analyzed the findings for all students there was a slight average increase in mathematics self-efficacy with average increases in all sources of self-efficacy except social persuasions, which suggested that less praise was experienced by students overall through the study. The largest increase was in the source physiological state, which suggested that students felt less stress and anxiety by the end of the CRMP tasks than they did at the beginning. All but one of the exited ELL students showed increases or stayed the same for vicarious experiences. This suggested that observations within groups or with the teacher were an
important source for their mathematics self-efficacy growth. For the other three sources of self-efficacy only about half of the exited ELL students showed increases. Student participants with identified learning disabilities also all showed increases in vicarious experiences and in physiological state, meaning their stress or anxiety doing math decreased over the study time. In comparison, only about half of these students showed increases in their past mathematics performances and all of these students showed decreases or stayed the same for their social persuasions.

**Final Thoughts**

Studies have demonstrated that students living in poverty have lower overall achievement in mathematics due to a multitude of factors, one of which is called an “opportunity gap” (Milner, 2012). Milner suggests that there is less of an achievement gap among students of diverse ethnicities and socioeconomic status and more of a gap in the opportunities that students experience. Students living in poverty, whether rural or urban, can have much different experiences in schools from scripted curriculum, to a strict adherence to specific behaviors, to a mathematical focus on procedures and skills. Students who experience school in this way may feel that mathematics is irrelevant to their futures and they may not see the value in upper level mathematics classes or having perseverance when solving challenging problems. Secondary mathematics teachers must face this problem through engaging and equitable high quality curriculum that supports all students in learning mathematics wherever they are. CRMP is an option for teachers who are looking for a teaching and learning philosophy which promotes equity. Students in poverty depend on school staff, especially teacher relationships, for social, emotional, behavioral, and cognitive support, as well as to have more positive attitudes and effort in school (Milner, 2013). By prioritizing students’ funds of knowledge, teacher supports, and
cooperative learning with real-life tasks, all students can learn mathematics at high levels and be prepared for standardized assessments.

It has been shown within this study that facets of CRMP curriculum and instruction can influence impoverished students’ mathematics achievement in their understanding of algebraic functions and can influence their overall mathematics self-efficacy through a sustained focus on successful math performances, vicarious experiences, social persuasions, and physiological states. The eighth grade is a critical time for student growth in academics and self-discovery. Gaining mathematics self-efficacy can help students transition more successfully to high school mathematics and promote students in continuing to take more advanced mathematics courses in their future. Equitable mathematics teaching practices can provide the support, relevance, and rigor for all students to advance in mathematics.

Moving secondary mathematics towards equitable practices will take a concerted effort from all stakeholders, including teachers, administrators, professional development designers, curriculum developers, and policy makers. Teacher leaders can begin this transition by sharing their knowledge of equitable practices with these stakeholders in various venues, schools, conferences, research avenues, and online. They can make these stakeholders aware of both curricular and instructional components of mathematics teaching and learning that supports high mathematics achievement and high mathematics self-efficacy, but that stay true to students’ cultural and personal learning preferences and self-efficacy needs. They can encourage strategies that minimize status differences in the classroom, which can allow all students to feel “smart” and valued in their mathematical thoughts and strategies. They can demonstrate how small steps in offering support, frequent feedback, the utilization of group norms, and teaching students through care and respect can go a long way in supporting impoverished students’ mathematical
growth and their mathematical resilience. Most importantly, they can stress the notion that equitable mathematics teaching does not promote the same instruction for all students. That to provide all students with an equitable opportunity to access and learn mathematics, we need to treat each student as an individual with specific learning needs, tied to their past experiences with mathematics, their cultural backgrounds, and their personal identities as doers of mathematics. Combining these facets of curriculum and instruction can create powerful environments for mathematics learning, shaping the future of mathematics education and the future of our neediest students.

This research bridges the sociocultural with the social cognitive (see Figure 1), however, the question remains. How much of a students’ mathematics achievement is delegated by psychological constructs such as self-efficacy and how much does poverty influence this relationship? Furthermore, are secondary schools aware of this relationship and moving their curriculum and instructional practices towards equity? There is still much work to be done in mathematics classrooms around the country and this research provides some answers to how teachers and other stakeholders can provide equitable, high quality mathematics experiences for diverse students living in poverty.
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### TABLES

#### Table 1

*Student Grades for CRMP Tasks, Assessments, and Quarter Grades for each Case Study*

<table>
<thead>
<tr>
<th></th>
<th>Lara</th>
<th>Olivia</th>
<th>Yasmin</th>
<th>Carlos</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Virus Project</strong></td>
<td>92%</td>
<td>72%, 88% after revisions</td>
<td>90%</td>
<td>58%, 90% after revisions</td>
</tr>
<tr>
<td><strong>Car Task</strong></td>
<td>78%</td>
<td>85%</td>
<td>98%</td>
<td>70%</td>
</tr>
<tr>
<td><strong>Party Assessment</strong></td>
<td>100%</td>
<td>76%</td>
<td>94%</td>
<td>80% after retake</td>
</tr>
<tr>
<td><strong>More Traditional Linear Systems Assessment</strong></td>
<td>98%</td>
<td>62%</td>
<td>60%</td>
<td>88%</td>
</tr>
<tr>
<td><strong>End of 3rd Quarter</strong></td>
<td>81%</td>
<td>70%</td>
<td>72%</td>
<td>80%</td>
</tr>
<tr>
<td><strong>End of 4th Quarter</strong></td>
<td>97%</td>
<td>75%</td>
<td>73%</td>
<td>82%</td>
</tr>
</tbody>
</table>
### Table 2

*Results from the CRMP Lesson Analysis Tool for CRMP Tasks*

<table>
<thead>
<tr>
<th></th>
<th>Virus Project</th>
<th>Car Task</th>
<th>Party Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive demand</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Depth of knowledge and student understanding</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Mathematical discourse and communication</td>
<td>Med.-High</td>
<td>Med.-High</td>
<td>High</td>
</tr>
<tr>
<td>Power and participation</td>
<td>Med.-High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Academic language support for ELLs</td>
<td>Med.-High</td>
<td>Med.-High</td>
<td>Med.-High</td>
</tr>
<tr>
<td>Funds of knowledge/culture/community</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Use of critical knowledge/social justice support</td>
<td>Med.-High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

*Note.* Ratings correspond to the 1-5 scale on the tool; 1=low, 2=low-medium, 3=medium, 4=medium-high and 5=high. Qualifiers were used for easier comparison with other tools.
Table 3

*Results from the Teacher Observation Scales for CRMP Tasks*

<table>
<thead>
<tr>
<th></th>
<th>Virus Project</th>
<th>Car Task</th>
<th>Party Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Curriculum Resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connects to students’ culture, experiences, beliefs, or community values</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Offers students choices</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Promotes interesting real-life mathematical contexts</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Utilizes multiple resources</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Ties to other mathematics and past student work.</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Incorporates high level tasks (Smith &amp; Stein, 1998).</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Instructional Strategies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher anticipates and monitors students’ understanding</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Teacher models expectations and understandings</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Lessons are scaffolded or adapted, as needed</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Cooperative learning is used</td>
<td>Medium</td>
<td>Medium</td>
<td>N/A</td>
</tr>
<tr>
<td>Peer models are used within small groups</td>
<td>High</td>
<td>Medium</td>
<td>N/A</td>
</tr>
<tr>
<td>Feedback is frequent, focused, and meaningful</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Teacher Care</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher shows high expectations for every student</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Teacher has specific and consistent routines and rituals</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Teacher works to build relationships with each student</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Teacher celebrates small and big successes</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Teacher explains content clearly and checks in with students</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Classroom is a positive environment for learning</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td><strong>Cultural communication</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher addresses social inequities</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Teacher takes time to discuss personal interests</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Classroom has norms, which promote a growth mindset</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Students engage in productive mathematical discussions</td>
<td>Medium</td>
<td>High</td>
<td>N/A</td>
</tr>
<tr>
<td>Teacher makes students aware of individual differences</td>
<td>High</td>
<td>High</td>
<td>N/A</td>
</tr>
<tr>
<td>Teacher encourages self-monitoring strategies</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td><strong>Sociopolitical consciousness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allows students to see the world through mathematics</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Lesson includes opportunities for critical dialogue</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Lesson develops an awareness of social inequities</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Lesson allows students to develop social agency</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Lesson may change students' views on mathematics</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Lesson honors students’ voices</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

*Note.* Ratings correspond to the 1-5 scale on the tool; 1=low, 2=low-medium, 3=medium, 4=medium-high and 5=high. Qualifiers were used for easier comparison with other tools.
Table 4

Average Mathematics Self-efficacy Ratings from Student Participants

<table>
<thead>
<tr>
<th>Average Ratings</th>
<th>Student Surveys</th>
<th>Student Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prestudy</td>
<td>Midstudy</td>
</tr>
<tr>
<td>Overall Mathematics Self-Efficacy</td>
<td>3.44</td>
<td>3.42</td>
</tr>
<tr>
<td>Past Mathematics Performances</td>
<td>3.54</td>
<td>3.62</td>
</tr>
<tr>
<td>Vicarious Experiences</td>
<td>3.13</td>
<td>3.20</td>
</tr>
<tr>
<td>Social Persuasions</td>
<td>2.88</td>
<td>2.60</td>
</tr>
<tr>
<td>Physiological State</td>
<td>4.22</td>
<td>4.27</td>
</tr>
</tbody>
</table>

*Note.* All data was rated between 1 and 6. Observation data was not collected for vicarious experiences and social persuasions, therefore there is only change calculated from the virus project to the car task.
Table 5

*Student Survey on Mathematical Self-efficacy*

<table>
<thead>
<tr>
<th></th>
<th>Lara</th>
<th></th>
<th></th>
<th>Olivia</th>
<th></th>
<th></th>
<th>Yasmin</th>
<th></th>
<th></th>
<th>Carlos</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
<td>Pre</td>
<td>Mid</td>
<td>Post</td>
</tr>
<tr>
<td>Overall Mathematical Self-efficacy</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>L-M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Past Mathematics Performances</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M-H</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M-H</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Vicarious Experiences</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M-H</td>
<td>M</td>
<td>M</td>
<td>M-H</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Social Persuasions</td>
<td>L-M</td>
<td>M</td>
<td>M</td>
<td>M-H</td>
<td>L-M</td>
<td>M</td>
<td>L-M</td>
<td>L</td>
<td>L</td>
<td>L-M</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Physiological States</td>
<td>L-M</td>
<td>M</td>
<td>M-H</td>
<td>L-M</td>
<td>M</td>
<td>M-H</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

*Note. Results taken before CRMP tasks (pre), after the virus project (mid) and after all three CRMP tasks (post). Ratings are between 1 (definitely false) to 6 (definitely true); Low (L) is a rating of 1.0-1.9, Low-Medium (L-M) is a rating of 2.0-2.9, Medium (M) is a rating of 3.0-3.9, Medium-High (M-H) is a rating of 4.0-4.9, and High (H) is a rating of 5.0-6.0. Qualifiers were used for easier comparison with other tools in the study.*
Table 6

*Student Observations on Mathematical Self-efficacy*

<table>
<thead>
<tr>
<th></th>
<th>Lara</th>
<th>Olivia</th>
<th>Yasmin</th>
<th>Carlos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VP</td>
<td>CT</td>
<td>PA</td>
<td>VP</td>
</tr>
<tr>
<td>Mathematical Self-efficacy</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Past Mathematics Performances</td>
<td>M-H</td>
<td>H</td>
<td>M</td>
<td>M-H</td>
</tr>
<tr>
<td>Vicarious Experiences</td>
<td>H</td>
<td>H</td>
<td>N/A</td>
<td>H</td>
</tr>
<tr>
<td>Social Persuasions</td>
<td>M-H</td>
<td>H</td>
<td>N/A</td>
<td>M</td>
</tr>
<tr>
<td>Physiological States</td>
<td>M-H</td>
<td>M-H</td>
<td>H</td>
<td>M</td>
</tr>
</tbody>
</table>

*Note.* Results taken during the Virus Project (VP), the Buying a Car Task (CT), and the Party Assessment (PA). Ratings are between 1 (definitely false) to 6 (definitely true); Low (L) is a rating of 1.0-1.9, Low-Medium (L-M) is a rating of 2.0-2.9, Medium (M) is a rating of 3.0-3.9, Medium-High (M-H) is a rating of 4.0-4.9, and High (H) is a rating of 5.0-6.0. Qualifiers were used for easier comparison with other tools in the study.
Table 7

*Teacher Support and Feedback Tool*

<table>
<thead>
<tr>
<th>Low Mathematics Self-efficacy</th>
<th>High Mathematics Self-efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Low MSE)</td>
<td>(High MSE)</td>
</tr>
<tr>
<td><strong>Traditionally Low Mathematics Achievement (Low MA)</strong></td>
<td><strong>Traditionally High Mathematics Achievement (High MA)</strong></td>
</tr>
<tr>
<td>Target: Low MSE/Low MA (Many special needs and ELL)</td>
<td>Target: Low MSE/High MA (Many girls)</td>
</tr>
<tr>
<td>Goals: Build mathematics understanding through increased performance and confidence in doing math.</td>
<td>Goals: Provide challenge; Encourage slower, deeper thinking and analysis; Promote awareness of others’ strengths; Work on explaining and justifying.</td>
</tr>
<tr>
<td><strong>Scaffolding:</strong> Simplified task and resource language, worked examples, vocabulary and frequent check ins</td>
<td><strong>Scaffolding:</strong> None needed</td>
</tr>
<tr>
<td><strong>Praise:</strong> Participation in task and in group; asking for help and helping others; good effort; correct strategies</td>
<td><strong>Praise:</strong> Unique strategies and the ability to solve problems in multiple ways; positive analysis attributes; thorough mathematical processes; helping others</td>
</tr>
<tr>
<td><strong>Questioning:</strong> Probing for understanding; Clarifying misconceptions; Intentional questions on incomplete logic</td>
<td><strong>Questioning:</strong> Probing for understanding; Extensions and connections to other math concepts and contexts.</td>
</tr>
<tr>
<td><strong>Status:</strong> Assign competence by public and private praise for good effort, participation and strategies.</td>
<td><strong>Status:</strong> Promote group norms and roles to require cooperative learning and forming a realistic vision of own mathematics abilities and improving them.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target: High MSE/Low MA (Some special needs)</th>
<th>Target: High MSE/High MA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goals:</strong> Build mathematics understanding through increased performance, awareness of current mathematics abilities and self-regulation strategies.</td>
<td><strong>Goals:</strong> Provide challenge; Encourage slower, deeper thinking and analysis; Promote awareness of others’ strengths; Work on explaining and justifying.</td>
</tr>
<tr>
<td><strong>Scaffolding:</strong> Simplified task and resource language, worked examples, vocabulary and frequent check-ins</td>
<td><strong>Scaffolding:</strong> None needed</td>
</tr>
<tr>
<td><strong>Praise:</strong> Participation in task and in group; asking for help and helping others; good effort; correct strategies</td>
<td><strong>Praise:</strong> Unique strategies and the ability to solve problems in multiple ways; positive analysis attributes; thorough mathematical processes; helping others</td>
</tr>
<tr>
<td><strong>Questioning:</strong> Probing for understanding; Clarifying misconceptions; Intentional questions on incomplete logic</td>
<td><strong>Questioning:</strong> Probing for understanding; Extensions and connections to other math concepts and contexts.</td>
</tr>
<tr>
<td><strong>Status:</strong> Promote group norms and roles to require cooperative learning and forming an understanding of ones’ own math abilities. Assign competence by public and private praise for strategies, processing and deep thinking.</td>
<td><strong>Status:</strong> Promote group norms and roles to require cooperative learning and forming an understanding and trust in other students’ math abilities.</td>
</tr>
</tbody>
</table>
Table 8

*Feedback Tool: Praise with Questioning*

Use this tool during each part of a CRMP task to appropriately praise students and extend their mathematical thinking through questioning.

<table>
<thead>
<tr>
<th>Listen to students</th>
<th>Watch their interactions</th>
<th>Connect to students personally through kindness</th>
<th>Connect to students through praise</th>
<th>Connect to math through questioning</th>
</tr>
</thead>
</table>

### Praise Ideas

#### Individual and Group Praise
- **___**, I appreciate how you have gotten started on your task.
- Team **___** is ready to go with each member having their paper, pencil and computer open to the correct webpage. Nice work team!

#### Status Influencing Praise
- I appreciate how **___** has gotten started on their task. They have their paper and pencil out and their computer open to the correct webpage. Thank you **___**.
- Thank you **___** for helping your group members get started today. I really appreciate your help getting your team focused on the task.

### Questioning Ideas

<table>
<thead>
<tr>
<th>Beginning of CRMP task</th>
</tr>
</thead>
<tbody>
<tr>
<td>What difficulties are you having understanding the problem?</td>
</tr>
<tr>
<td>What difficulties are you having understanding the project expectations?</td>
</tr>
<tr>
<td>What difficulties are you having understanding the mathematics you are using?</td>
</tr>
<tr>
<td>What information have you found?</td>
</tr>
<tr>
<td>What do you notice about …?</td>
</tr>
<tr>
<td>What have you learned about your topic so far?</td>
</tr>
<tr>
<td>What do you think about that?</td>
</tr>
<tr>
<td>What are you trying to find?</td>
</tr>
<tr>
<td>Will you explain what <strong>___________</strong> means?</td>
</tr>
<tr>
<td>What math ideas have we learned that will help you answer this question?</td>
</tr>
<tr>
<td>What patterns do you see?</td>
</tr>
<tr>
<td>What would be the next numbers in this pattern? How do you know?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Middle of CRMP task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can you think of another way to think about …?</td>
</tr>
<tr>
<td>How else could you…?</td>
</tr>
<tr>
<td>Why did you do that step?</td>
</tr>
<tr>
<td>How did you know where to draw your line?</td>
</tr>
<tr>
<td>How does your representation match your thinking?</td>
</tr>
<tr>
<td>I’m confused about this part. Can you tell me more?</td>
</tr>
<tr>
<td>Can you explain your solution steps to me?</td>
</tr>
<tr>
<td>I see you wrote this, can you explain that more to me?</td>
</tr>
<tr>
<td>What were you thinking?</td>
</tr>
<tr>
<td>What happens if the question/problem changes to…?</td>
</tr>
<tr>
<td>How is this similar to the <strong>___________</strong> problem?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual and Group Praise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>___</strong>, you have found some really interesting information.</td>
</tr>
<tr>
<td><strong>___</strong>, you have really stepped up today. You are putting out a lot of effort and learning a lot today.</td>
</tr>
<tr>
<td><strong>___</strong>, I can tell you are trying really hard today. Good job!</td>
</tr>
<tr>
<td>What a great strategy <strong>___</strong>. Make sure you share that with your team.</td>
</tr>
<tr>
<td><strong>___</strong>, you really helped <strong>___</strong> understand his problem today.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual questioning from teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can you think of another way to think about …?</td>
</tr>
<tr>
<td>How else could you…?</td>
</tr>
<tr>
<td>Why did you do that step?</td>
</tr>
<tr>
<td>How did you know where to draw your line?</td>
</tr>
<tr>
<td>How does your representation match your thinking?</td>
</tr>
<tr>
<td>I’m confused about this part. Can you tell me more?</td>
</tr>
<tr>
<td>Can you explain your solution steps to me?</td>
</tr>
<tr>
<td>I see you wrote this, can you explain that more to me?</td>
</tr>
<tr>
<td>What were you thinking?</td>
</tr>
<tr>
<td>What happens if the question/problem changes to…?</td>
</tr>
<tr>
<td>How is this similar to the <strong>___________</strong> problem?</td>
</tr>
</tbody>
</table>
Nice work in your group today _____. I really appreciate how you worked together to help each other understand the math.

Great job team! It was so nice to everyone participating in the task.

**Status Influencing Praise**
- Class, ____ found some interesting information about ____. Share interesting finds with your group.
- ____ found a really cool strategy for ____. Want to see?
- I really appreciate the effort that ____ is showing today. Hard work always pays off.
- ____ was having a tough time with figuring out the questions on ____, but she worked hard and figured them out. If you are having trouble, ask for help.
- It is great to see everyone helping each other and asking for help. ____ and ____ showed this just now as they were working on _____. Nice work!
- Team ____ is working really well together. Everyone is helping each other and learning lots of math. Great job!

**Group questioning from teacher**
Your group member showed their steps in a different way. Can you discuss your solutions together and how you reached them?
Can you add to what ____________ said? What do you think?
Do you agree or disagree? Why?
You and ____ have different takes on this issue. Can you share your thoughts with each other?
Why do you think ___________ did that?

**Group questioning between peers**
Tell me about your topic. What have you found out?
How did you find your answer?
Can you explain to me how you did that?
Mine is much different than that. I wonder why? What do you think?
Ours are very similar. I wonder why? What do you think?
Can you check my work and tell me what you think?
Can you read my analysis and see if it makes sense?
How do you think I can make my answer better?
How can you convince me that your answer is reasonable?

**End of CRMP task**

**Individual and Group Praise**
Nice work on your analysis. I really liked the part about _________. _____, your representations are neat and well done. Good job!
____, your work is shown clearly and accurately. Great work!

**Status Influencing Praise**
____ had a really great thought come up in his analysis. Would you mind sharing?
_____ did a nice job on her graph. Would you mind showing us?
____’s steps were very clear and accurate. Would you mind explaining what you did?
**Figure 1.** Theoretical framework for proposed study on CRMP and self-efficacy. This figure demonstrates the main beliefs in each theoretical view and how they are connected through resilience theory.
Figure 2. Research design for proposed study on CRMP and self-efficacy using a convergent multiphase mixed methods design through a critical action research paradigm.
Figure 3: Feedback opportunities throughout CRMP tasks.
Figure 4: Teacher aspects needed for building relationships within CRMP based on participant comments within study findings.
Figure 5: This figure shows the overall mathematical self-efficacy change in the student survey from before the CRMP tasks (pre) to after the virus project (mid) and from mid to after the CRMP tasks (post). This figure also shows the overall mathematical self-efficacy change seen in the student observations from the virus project to the car task and from the car task to the party assessment.
Figure 6: This figure shows the change in student perspectives of past mathematical performances in the student survey from before the CRMP tasks (pre) to after the virus project (mid) and from mid to after the CRMP tasks (post). This figure also shows the overall mathematical self-efficacy change seen in the student observations from the virus project to the car task and from the car task to the party assessment.
**Figure 7:** This figure shows the change in student perspectives of vicarious experiences in the student survey from before the CRMP tasks (pre) to after the virus project (mid) and from mid to after the CRMP tasks (post). This figure also shows the overall mathematical self-efficacy change seen in the student observations from the virus project to the car task. Observation change from the car task to the party assessment is not shown because vicarious experiences were not recorded during the party assessment.
Figure 8: This figure shows the change in student perspectives of social persuasions in the student survey from before the CRMP tasks (pre) to after the virus project (mid) and from mid to after the CRMP tasks (post). This figure also shows the overall mathematical self-efficacy change seen in the student observations from the virus project to the car task. Observation change from the car task to the party assessment is not shown because social persuasions were not recorded during the party assessment.
Figure 9: This figure shows the change in student perspectives of physiological states in the student survey from before the CRMP tasks (pre) to after the virus project (mid) and from mid to after the CRMP tasks (post). This figure also shows the overall mathematical self-efficacy change seen in the student observations from the virus project to the car task and from the car task to the party assessment.
Appendix A: Visual Model of Proposed Data Collection and Analysis, including Timeline
(Critical Action Research with a Convergent Multiphase Mixed Methods design)

<table>
<thead>
<tr>
<th>Date</th>
<th>Phase</th>
<th>Data collection &amp; Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 2015</td>
<td>Phase 1: quan &amp; QUAL Data</td>
<td>• Teacher reflection journal (phase 1-3) – qual. data - coding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Convenience sampling – all participants for weekly self-efficacy ratings and assessments and general mathematics self-efficacy survey – quan. data – calibration accuracy</td>
</tr>
<tr>
<td></td>
<td>Quantitative Data Analysis</td>
<td>• Data screening, statistical analysis, describing trends, comparing differences through descriptive statistics, summed scores, percentile rankings, and differences.</td>
</tr>
<tr>
<td></td>
<td>Selection of 4 participants</td>
<td>• Analysis used to determine selection of Phase 2 participants.</td>
</tr>
<tr>
<td>February 2015</td>
<td>Phase 2: QUAL &amp; quan Data Collection</td>
<td>• Purposeful selection of participants (N=4) for case studies, 1 from each determined category</td>
</tr>
<tr>
<td></td>
<td>Data Analysis</td>
<td>• Video-taped observations of students and teacher with scales and field notes, and artifact analysis of student work, – qual. data – reflection interview transcripts, artifact rubrics, observation descriptions, field notes – analysis through coding and thematic analysis within and between cases using similar and different themes and visual data displays; matrices.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Weekly self-efficacy ratings and assessments – quan. data – calibration accuracy</td>
</tr>
<tr>
<td>February-April 2015</td>
<td>Phase 3: QUAL &amp; quan Data Collection</td>
<td>• Convenience sampling – all participants for general mathematics self-efficacy survey – quan. data – analysis through descriptive statistics, summed scores, percentile rankings, differences, and t-tests.</td>
</tr>
<tr>
<td></td>
<td>Separate Qualitative &amp; Quantitative Data</td>
<td>• Semistructured interviews with 4 cases – qual. data – analysis through coding, themes, similar and different themes, and visual data displays; matrices.</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
<td>• All quantitative data analysis through data screening: statistical analysis, describing trends, comparing differences</td>
</tr>
<tr>
<td></td>
<td>Integration Analysis</td>
<td>• All qualitative data analysis through coding and thematic analysis within and between cases, and visual displays.</td>
</tr>
<tr>
<td></td>
<td>Determine Inferences</td>
<td>• Integrate quan. and qual. through qualitizing quantitative data, correlation and consolidation of all data, visual displays, comparison, integration, and interferences.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Discussion and recommendations for future studies.</td>
</tr>
</tbody>
</table>

July-August 2015
Appendix B: Potential Teacher Reflection Prompts to be used in Reflection Journal

- What recent curricular and instructional implementation decisions regarding CRMP have you had to make recently?
- Describe specific instances of relationship building through mathematics teaching and learning that you have experiences recently with your students.
- Name some examples of student self-efficacy beliefs that you have heard students express recently.
- What are some ways that student and/or teacher cultural competence has been developed during mathematics teaching and learning recently?
- What difficulties have students had recently with the mathematics, particularly with specific instructional methods, assignments, or curricular contexts related to CRMP?
- How have you shown students that you have high expectations for them within their learning of mathematics? Do you consistently express this to every student?
- How have you exhibited high expectations for yourself as a teacher of mathematics?
- How have you been an advocate for students’ mathematics learning?
- What decisions have you made where you have determined cultural relevancy of curricular or pedagogical decisions?
- Express how you believe you can bring about positive change for students.
- Describe any conflicting thoughts you have about using the culturally relevant curriculum that you are using.
- Describe any difficulties that you have developing caring relationships with students.
- What did you find in analyzing your curriculum for relevance for your students? Have you had to make any adaptations recently? If so, why?
- How do the instructional strategies that you are using to teach mathematics also develop students’ social and cultural identities?
- How do the instructional strategies that you are using to teach mathematics also work to minimize status and assign competence to low status students?
- How are you developing cultural competence about your students?
- Have you had any experiences that caused you to rethink past assumptions about students?
- Have you had any experiences that caused you to rethink past assumptions about mathematics teaching and learning?
- Using examples of recent student work, reflect on the student’s mathematical understanding, their ability to express their understanding, and their ability to connect to the real world context.
### Appendix C: General Mathematics Self-efficacy Scale

**Sources of Middle School Mathematics Self-efficacy Scale**

This questionnaire is designed to help me understand what you believe about your abilities to do math. Please rate how confident you are about each statement by circling a number between 1 (*definitely false*) to 6 (*definitely true*). Your answers will be kept strictly confidential and will not be identified by name.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I make excellent grades on math tests.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>Seeing adults do well in math pushes me to do better.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>My math teachers have told me that I am good at learning math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>Just being in math class makes me feel stressed and nervous.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>I have always been successful with math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>People have told me that I have a talent for math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>Doing math work takes all of my energy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>Even when I study very hard, I do poorly in math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>Seeing kids do better than me in math pushes me to do better.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>Adults in my family have told me what a good math student I am.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>I start to feel stressed-out as soon as I begin my math work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>I got good grades in math on my last report card.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>When I see how another student solves a math problem, I can see myself solving the problem in the same way.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15.</td>
<td>I have been praised for my ability in math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16.</td>
<td>My mind goes blank and I am unable to think clearly when doing math work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>I do well on math assignments.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18.</td>
<td>I imagine myself working through challenging math problems successfully.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>19.</td>
<td>Other students have told me that I’m good at learning math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20.</td>
<td>I get depressed when I think about learning math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>21.</td>
<td>I do well on even the most difficult math assignments.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>22.</td>
<td>I compete with myself in math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>23.</td>
<td>My classmates like to work with me in math because they think I’m good at it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>24.</td>
<td>My whole body becomes tense when I have to do math.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Adapted from (Ivankova & Stick, 2007)
Appendix D: Example of a Weekly Quiz with Built in Self-efficacy Rating, Student Data Recording Table, and Graph Template

Homework Quiz

a.) Review the problems below.

b.) Write a number on the line below that answers this question:
   How confident are you that you will have the correct answers for these problems? Please be honest, this number will not be entered into your grade.
   Math Confidence Rating __________

   c.) Take the quiz and do not change your math confidence rating.

1. Some bacteria multiply once every 20 minutes. If you get one bacteria into your body, how long will it take before there at least 1000 bacteria in your body? Create a table and a graph to show how you determined your answer.

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

   2000  1900  1800  1700  1600  1500  1400  1300  1200  1100  1000  900  800  700  600  500  400  300  200  100  0
   0  20  40  60  80  100  120  140  160  180  200  220  240  260  280  300

   Time (seconds)

2. Is this a linear function? Explain your thoughts.
Appendix E: CRMP Lesson Analysis Tool

Culturally Responsive Mathematics Teaching – Lesson Analysis Tool


PURPOSE: CRMT-TM Lesson Analysis Tool is designed to promote intentional teaching discussions and critical reflection on mathematics lessons with a combined focus on children’s mathematical thinking and equity. It is not designed to be an evaluation tool of teachers, but a self-reflective professional tool that can support lesson/unit design and implementation.

TOOL DESCRIPTION: The CRMT-TM Lesson Analysis Tool consists of six important categories of mathematics teaching. Each category connects to a rubric rating scale 1-5 that provides descriptors of classroom practice including task design, implementation, and interaction. In addition, there are corresponding reflection prompts to help with lesson analysis. The table below provides a brief description of each category and accompanying reflection prompt.

<table>
<thead>
<tr>
<th>Category</th>
<th>Reflection Prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cognitive Demand</td>
<td>How does my lesson enable students to closely explore and analyze math concepts(s), procedure(s), and reasoning strategies?</td>
</tr>
<tr>
<td>2 Depth of Knowledge &amp; Student Understanding</td>
<td>How does my lesson make student thinking/understanding visible and deep?</td>
</tr>
<tr>
<td>3 Mathematical Discourse</td>
<td>How does my lesson create opportunities to discuss mathematics in meaningful and rigorous ways (e.g. debate math ideas/solution strategies, use math terminology, develop explanations, communicate reasoning, and/or make generalizations)?</td>
</tr>
<tr>
<td>4 Power and Participation</td>
<td>How does my lesson distribute math knowledge authority, value student math contributions, and address status differences among students?</td>
</tr>
<tr>
<td>5 Academic Language Support for ELL</td>
<td>How does my lesson provide academic language support for English Language Learners?</td>
</tr>
<tr>
<td>6 Cultural/Community-based funds of knowledge</td>
<td>How does my lesson help students connect mathematics with relevant/authentic situations in their lives? How does my lesson support students’ use of mathematics to understand, critique, and change an important equity or social justice issue in their lives?</td>
</tr>
<tr>
<td>Category</td>
<td>Rating</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>1) Cognitive Demand</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td></td>
<td>3</td>
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<td></td>
<td>4</td>
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<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Rating</td>
<td>1</td>
</tr>
<tr>
<td>--------</td>
<td>---</td>
</tr>
<tr>
<td><strong>Category</strong></td>
<td><strong>Guiding Question: how does my lesson make student thinking/understanding visible and deep?</strong></td>
</tr>
<tr>
<td>Category</td>
<td>Rating</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>3) Mathematical Discourse &amp; Communication</td>
<td></td>
</tr>
<tr>
<td>Rating</td>
<td>1</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Category</td>
<td>4) Power and Participation</td>
</tr>
<tr>
<td>Rating</td>
<td>1</td>
</tr>
<tr>
<td>--------</td>
<td>---</td>
</tr>
<tr>
<td><strong>Category</strong></td>
<td><strong>Guiding Question:</strong> How does my lesson provide academic language support for English Language Learners?</td>
</tr>
<tr>
<td>5) Academic Language Support for ELLs</td>
<td>No evidence of a language scaffolding strategy for ELLs. Students who are not yet fully proficient in English are ignored and/or seated apart from their classmates.</td>
</tr>
<tr>
<td>Rating</td>
<td>1</td>
</tr>
<tr>
<td>--------</td>
<td>---</td>
</tr>
<tr>
<td>Category</td>
<td>Guiding Question: How does my lesson help students connect mathematics with relevant/authentic situations in their lives?</td>
</tr>
<tr>
<td>6a) USE of critical knowledge/social justice Support</td>
<td>Guiding Question: How does my lesson help students connect mathematics with relevant/authentic situations in their lives?</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>No evidence of connection to critical knowledge (sociopolitical contexts, issues that concern students)</td>
<td>Opportunity to critically mathematize a situation went unacknowledged or unaddressed when present.</td>
</tr>
<tr>
<td>There is at least one instance of connecting mathematics to analyze a sociopolitical/cultural context.</td>
<td>There is at least one major activity in which students collectively engage in mathematical analysis within a sociopolitical/authentic or problem-posing context. Mathematical arguments are provided to solve the problems. Pathways to change/transform the situation are briefly addressed.</td>
</tr>
<tr>
<td>Deliberate and continuous use of mathematics as an analytical tool to understand an issue/context, formulate mathematically-based arguments to address the issues and provide substantive pathways to change/transform the issue.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: Teacher Observation Scale

Teacher Observation Scale for Culturally Relevant Mathematics Pedagogy

Date:_____________ Task:_________________________________________________

*During this observation*, mark 1 if there are no observations of that component, 2 if there are some observations of that component, or 3 if there are consistent observations of that component.

<table>
<thead>
<tr>
<th>Teacher CRMP components</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics curriculum connects to student culture, experiences, beliefs, or community values.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Curriculum offers students choices in their mathematics activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Curriculum promotes interesting real-life mathematical contexts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Multiple resources are utilized to “create” culturally relevant mathematics curriculum.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher explicitly ties mathematics activity to other mathematics concepts, procedures, and past student work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mathematics curriculum incorporates high level tasks (Smith &amp; Stein, 1998).</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Instructional strategies:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher anticipates and monitors students’ mathematical understanding.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher models mathematical expectations and understandings through the selection, sequencing, and connections of student work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Lessons are scaffolded or adapted, as needed, to assist all students in their own mathematical meaning making.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cooperative learning is used with a model that encourages participation of all group members, including group decision making, in the mathematics activity.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Peer models are used within small groups to facilitate autonomous mathematics teaching and learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Feedback on mathematics understanding is frequent, focused, and meaningful.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher care:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher shows high expectations for every student.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher has specific and consistent routines and rituals.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher works to build relationships with each student.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher celebrates small and big successes in mathematics learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Teacher explains content clearly and checks in with individual students to clarify.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Math anxiety is reduced by the classroom being a positive environment for mathematics learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
### Cultural communication:

<table>
<thead>
<tr>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher addresses social inequities within classroom discourse</td>
<td>1</td>
</tr>
<tr>
<td>Teacher takes time to discuss personal interests with students.</td>
<td>2</td>
</tr>
<tr>
<td>Classroom has norms for having a safe and supportive learning environment, which encourages learning from your mistakes</td>
<td>3</td>
</tr>
<tr>
<td>Students engage in productive mathematical discussions as if they partake in this type of activity regularly</td>
<td>1</td>
</tr>
<tr>
<td>Teacher makes students aware of individual differences in the classroom and insists on respectful collaboration</td>
<td>2</td>
</tr>
<tr>
<td>Teacher explicitly teaches and encourages self-monitoring strategies, such as help-seeking behaviors, metacognition, and reflection</td>
<td>3</td>
</tr>
</tbody>
</table>

### Sociopolitical consciousness:

<table>
<thead>
<tr>
<th>Description</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson allows students to see the world through mathematics</td>
<td>1</td>
</tr>
<tr>
<td>Lesson includes opportunities for critical dialogue, including developing arguments, justifying answers, and validating ones’ own perspective</td>
<td>2</td>
</tr>
<tr>
<td>Lesson develops an awareness of social inequities</td>
<td>3</td>
</tr>
<tr>
<td>Lesson allows students to develop social agency, the belief that they can make a difference</td>
<td>1</td>
</tr>
<tr>
<td>Lesson may change students’ views on mathematics, encouraging future mathematics learning</td>
<td>2</td>
</tr>
<tr>
<td>Lesson honors students’ voices through their mathematical thoughts, beliefs, and opinions</td>
<td>3</td>
</tr>
</tbody>
</table>

Notes on above ratings:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________

________________________________________________________________________
Appendix G: Student CRMP Task – Virus Project

Virus Project

In this project you will investigate a disease and the virus that causes it. You will create a flyer to teach other students about your virus. This project has three parts. Create Part A and B in a Google Doc and send it to our Google Classroom when you finish. Complete part C on the last page of this assignment and turn it in when finished.

Part A: Research your chosen virus and create a flyer to teach others about the virus and the disease it causes.

Using the following websites and any other that is useful, research your virus and answer the following questions.

- Scientific name of the virus (genus)
- How does someone get this virus? Be specific.
- Where around the world is this virus commonly seen?
- How many people on average got this virus last year? (Or whatever year you can find that is recent).
- Has this virus had an epidemic or an outbreak? If so, explain what happened, when it happened, and how scientists think the epidemic or outbreak started or what caused it?
- What are the symptoms of this disease? How do you know if someone has it? Is it deadly?
- Are their vaccines available for people to take to keep people from getting this virus?
- What should someone do if they believe they have this virus or disease? Is there a cure? What medications are available to help?
- Include a photo of a person showing signs of the disease. (http://images.google.com/). Make sure it is school appropriate.
- Include a photo of the actual virus (computer generated or from an electron microscope.)

Part B: research the reproduction of the virus.

1. Find the estimated $R_0$ (basic reproduction number) of the virus or disease. This is the number of people infected by a sick person on average during their infectious period. If there is a range (such as 14-17) find the average. $R_0 =$

2. Create a table in Google Sheets to show how many people can become infected if each infected person infects the number of people indicated from the $R_0$ for 10 cycles.

<table>
<thead>
<tr>
<th>Cycle</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of infected people</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Create a graph using Google Sheets of your table data. Paste both the table and graph in to your Google Doc from Part A.
4. Write a paragraph about your results. Include the answers to the following questions:
   a. What type of function does your data represent?
   b. Is your virus slow-spreading ($R_0$ less than or equal to 2), average-spreading ($R_0$ between 2 and 10) or fast-spreading ($R_0$ greater than 10)?
   c. Why do you think it is important to know how fast a virus spreads?
   d. Would you consider your virus and disease to be a big problem in the United States? Why or why not? Be sure to use the evidence of your research.
   e. Would you consider your virus and the disease to be a big problem in another place in the world? Why or why not? Be sure to use the evidence of your research.

Part C: Virus size and volume

Answer the following questions to complete part C of this project.

1. Is your virus closer to a sphere, cylinder, or cone shape?

   What are the ranges of the dimensions of this virus in nanometers (nm)? (Length, Width, and Diameter)
   
   Remember: the virus may have only 1 or 2 of these, depending on their shape.

   What the average of each of the ranges in nanometers (nm)? (Length, Width, and Diameter)

   What is the radius of your virus in nanometers (nm)?

   Convert the nanometer (nm) dimensions into meters (m). Show your work. Write your answer in standard notation and scientific notation. *1 nanometer = 1 \times 10^{-9} meter

<table>
<thead>
<tr>
<th>Notation standard (in meters)</th>
<th>Scientific notation (in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td></td>
</tr>
<tr>
<td>Radius</td>
<td></td>
</tr>
</tbody>
</table>

2. Find the virus’ volume (in m$^3$) using the appropriate formula. Write it in standard notation and scientific notation (round the scientific notation to the nearest hundredth).

<table>
<thead>
<tr>
<th>Standard notation (in meters)</th>
<th>Scientific notation (in meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td></td>
</tr>
</tbody>
</table>

3. The video we watched said that one virus that enters a cell can leave with 1 million of exact copies of itself. Using the volume of your virus, what would be the volume of approximately 1,000,000 of your viruses? Show your work.

4. A type of immune cell called a lymphocyte has a spherical volume of about $1.15 \times 10^{-14}$ m$^3$. Using the volume of your virus, approximately how many of your viruses could fit inside of a lymphocyte? Show your work.

5. A newly discovered virus, Pithovirus, is the largest virus known to date. It is a cylindrical virus with a volume of $2.94 \times 10^{-19}$ m$^3$. How many times larger is Pithovirus virus than your virus? Show your work.
Appendix H: Student CRMP Task – Buying a Car Task

Personal Finance Algebra – Task 4 – Buying a Car

Cars are an expensive purchase and, unlike houses, they lose their value over time. In this activity, you will investigate buying a used car and a new car using linear systems. A linear system is two situations that are modeled together with algebra. They can be represented in three different ways.

**Equations**

\[ y = 1x + 2 \]
\[ y = -1x + 4 \]

To solve – Set the equations equal to each other and solve for x, then y

\[ 1x + 2 = -1x + 4 \]

**Table**

<table>
<thead>
<tr>
<th>X</th>
<th>Y₁</th>
<th>Y₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>-1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

The solution is (1, 3), where the y’s are the same and where the lines cross.

**Buying a Used Car**

We can create a linear system to better understand the value of a car we buy and its depreciation.

1.) You are allowed to get a used car loan that is equal to or less than 25% of your net yearly salary. How much can your used car loan be? (Round to the nearest hundred)

2.) Go to cars.com and find a used car (no 2014 or 2015 models) that is not more than your car loan. Keep it below $40,000 so it will fit on the graph. Write down this information about your car.

   Year:  
   Model:  
   Make:  
   Price:  
   Miles:  
   Transmission:  

3.) Click on “Calculate Payment”. What is your monthly payment? (Round to the nearest dollar).

4.) What is the yearly amount you will pay for your car loan?

5.) Complete the table for the amount you pay over the 6 years of the loan. Then, graph your data.
6.) Write an equation that could be used to determine the amount of money paid on your car loan if \( x \) is the number of years and \( y \) is the total money paid. \( y = \)

7.) What kind of function is the table, graph, and equation above? (Linear or Exponential). How do you know?

8.) Cars lose value each year. This is called depreciation. How much money will your car be worth each year if we include depreciation? For used cars, we are going to use a depreciation rate of 5%. This means that your car will decrease in value 5% each year. What is 5% of your car’s price?

9.) Complete the table for the value of your car after each year that you own it by subtracting the 5% depreciation amount each year. Then, graph your data on the same graph above.

Start at Year 0 with the amount of money you paid for the car. Then subtract the 5% each year.

<table>
<thead>
<tr>
<th>Years</th>
<th>Value of your Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

10.) Write an equation that could be used to determine the value of your car if \( x \) is the number of years and \( y \) is the total value of your car.
\( y = \)

11.) The graph above is a linear system. Where two lines meet. What is the solution of this system? (Approximately, at what \( x \) and \( y \) do the lines meet?)

12.) What does this point mean about your car?

**Buying a New Car**

1.) You are allowed to get a new car loan that is equal to or less than 50% of your net yearly salary. How much can your new car loan be? (Round to the nearest hundred)

2.) Go to cars.com and find a new car (2015 models only) that is not more than your car loan. Keep it below $80,000 so it will fit on the graph. Write down this information about your car.

Year: Model: Make:
Price: Miles: Transmission:

3.) Click on “Calculate Payment”. What is your monthly payment? (Round to the nearest dollar).

4.) What is the yearly amount you will pay for your car loan?
5.) Complete the table for the amount you pay over the 6 years of the loan. Then, graph your data.

6.) Write an equation that could be used to determine the amount of money paid on your car loan if \(x\) is the number of years and \(y\) is the total money paid. 

\[ y = \]

7.) What kind of function is the table, graph, and equation above? (Linear or Exponential)

How do you know?

8.) New cars lose value much faster than used cars. Remember, this is called depreciation. How much money will your car be worth each year if we include depreciation? For new cars, we are going to use a depreciation rate of 10%. This means that your car will decrease in value 10% each year. What is 10% of your car’s price?

9.) Complete the table for the value of your car after each year that you own it by subtracting the 10% depreciation amount each year. Then, graph your data on the same graph above.

Start at Year 0 with the amount of money you paid for the car. Then subtract the 10% each year.

<table>
<thead>
<tr>
<th>Years</th>
<th>Value of your Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

10.) Write an equation that could be used to determine the value of your car if \(x\) is the number of years and \(y\) is the total value of your car.

\[ y = \]

11.) The graph above is a linear system. Where two lines meet. What is the solution of this system? (Approximately, at what \(x\) and \(y\) do the lines meet?)

12.) What does this point mean about your car?
Appendix I: Student CRMP Task – Party Assessment

Performance Task - Planning a Birthday Party

You are trying to decide where to have your birthday party at. Here are the choices:

<table>
<thead>
<tr>
<th>George’s Skate Center</th>
<th>Desert Lanes Bowling Alley</th>
</tr>
</thead>
<tbody>
<tr>
<td>$80 for the party plus $10 per person</td>
<td>$50 for the party plus $15 per person</td>
</tr>
<tr>
<td>Includes skate rentals, skating for two hours, pizza, soda, and free passes for another skate night.</td>
<td>Includes shoe rentals, bowling for one hour, an arcade card, pizza, and soda.</td>
</tr>
</tbody>
</table>

1.) Using the information above, write an equation for each party plan in $y = mx + b$ format.

**George’s Skate Center:**

2.) Using the equations that you made, complete a table showing the cost of the first 8 people to each party. Start each at 0 people.

<table>
<thead>
<tr>
<th>George’s Skate Center</th>
<th>Desert Lanes Bowling Alley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of People (x)</td>
<td>Number of People (x)</td>
</tr>
<tr>
<td>Total Cost (y)</td>
<td>Total Cost (y)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.) Using the tables above for each party, graph the cost for each person for both parties.

**Comparing Birthday Parties**

4.) About what number of people coming to the party do both places charge the same amount? Explain.

5.) What is the solution to this system? Write in \((x, y)\) format. If no solution, explain how you know.

6.) If you only wanted to invite 4 people (for a total of 5, including you), which party would be the cheapest? Explain.

7.) If you wanted to invite 9 people (for a total of 10, including you), which party would be the cheapest? Explain.

8.) Knowing what you know now about cost and what each party offers, which party would you choose and why? (Use complete sentences)
Appendix J: Student Observation Scale

Student Observation Scale for Mathematics Self-Efficacy
(Researcher developed using Bandura (1986), Middleton and Spanias (1999), Schunk and Meece (2006))

Student name:_____________________________________ Gender:_____ Grade:_____
Date:_____________ Task:_______________________________

During this task, mark 1 if there were no observations of that behavior, 2 if there were some observations of that behavior, or 3 if there consistent observations of that behavior.

<table>
<thead>
<tr>
<th>Student mathematical self-efficacy behaviors</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Past mathematics performances:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Volunteers problem answers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2. Shows perseverance in problem solving</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3. Participates in all aspects of mathematics task</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4. Has success completing mathematics task accurately</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

| Vicarious observations (using models):      |   |   |   |       |
| 1. Observes and listens to other students’ mathematical reasoning | 1 | 2 | 3 |       |
| 2. Seeks help from other students or teachers on their mathematics understanding | 1 | 2 | 3 |       |
| 3. Contributes own mathematical reasoning to group discussions | 1 | 2 | 3 |       |
| 4. Uses self-regulation techniques, such as metacognition and reflection | 1 | 2 | 3 |       |

| Social persuasion:                         |   |   |   |       |
| 1. Receives teacher praise for mathematics learning behaviors and/or understanding | 1 | 2 | 3 |       |
| 2. Responds positively to teacher praise   | 1 | 2 | 3 |       |
| 3. Receives peer praise for mathematics learning behaviors and/or understanding | 1 | 2 | 3 |       |
| 4. Responds positively to peer praise     | 1 | 2 | 3 |       |

| Physiological state:                       |   |   |   |       |
| 1. Appears confident in mathematics abilities | 1 | 2 | 3 |       |
| 2. Is committed to completing and understanding mathematics task | 1 | 2 | 3 |       |
| 3. Seems genuinely interested in mathematics task | 1 | 2 | 3 |       |
| 4. Appears calm throughout the mathematics task | 1 | 2 | 3 |       |

Notes on above ratings:______________________________________________________________________________
### Appendix K: Artifact Analysis Rubrics (to be used with Appendices G, H and I)

**Rubrics for Artifact Analysis of Mathematical Practices and Content**  
(Researcher designed using Common Core State Standards for Mathematical Practices (NGA, 2010)).

<table>
<thead>
<tr>
<th>Mathematical Practice</th>
<th>Needs Improvement (1)</th>
<th>Proficient (2)</th>
<th>Beyond Proficient (3)</th>
<th>Advanced Proficient (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasons abstractly and quantitatively.</td>
<td>Does not use mathematics correctly to solve problems.</td>
<td>Uses mathematics mostly correctly to solve problems, may use simple methods.</td>
<td>Uses mathematics correctly to solve problems.</td>
<td>Uses mathematics correctly, with advanced methods, to solve problems.</td>
</tr>
<tr>
<td>Construct viable arguments and critique the reasoning of others.</td>
<td>Does not communicate argument clearly.</td>
<td>Communicates arguments clearly, may not justify claim with evidence.</td>
<td>Communicates arguments clearly with some evidence to justify claim.</td>
<td>Communicates arguments clearly with enough evidence to justify claim.</td>
</tr>
<tr>
<td>Uses appropriate tools strategically.</td>
<td>Uses tools, such as technology, graphs, tables, etc… incorrectly.</td>
<td>Uses tools, such as technology, graphs, tables, etc… in simple, yet correct, ways.</td>
<td>Uses tools, such as technology, graphs, tables, etc… correctly and strategically.</td>
<td>Uses tools, such as technology, graphs, tables, etc… in advanced ways.</td>
</tr>
<tr>
<td>Attends to precision.</td>
<td>Most or all of answers are inaccurate.</td>
<td>Small procedural mistake may have caused some inaccuracy.</td>
<td>All answers are accurate, but may be missing labels.</td>
<td>All answers are accurate with correct labels.</td>
</tr>
<tr>
<td>Looks for and makes use of structure.</td>
<td>Does not use correct methods to solve problems.</td>
<td>Uses mathematical methods to solve problems that work, but may not be efficient.</td>
<td>Uses efficient mathematical methods to solve problems.</td>
<td>Uses highly efficient mathematical methods to solve problems.</td>
</tr>
<tr>
<td>Looks for and expresses regularity in repeated reasoning.</td>
<td>Does not show an understanding of prior mathematics knowledge.</td>
<td>Shows some understanding of prior mathematics knowledge and uses that knowledge to solve problems.</td>
<td>Shows an understanding of prior mathematics knowledge and uses that knowledge to solve problems.</td>
<td>Shows advanced understanding of prior mathematics knowledge and uses that knowledge to solve problems.</td>
</tr>
</tbody>
</table>
### Rubric for Viruses Project (Individual project with group participation)

**CCSSM Content standards assessed by this task:**
8.EE.A.3 and 8.EE.A.4 (scientific notation), 8.F.A.3 (linear vs. non-linear functions), and 8.G.C.9 (volume of spheres and cylinders)
Mathematical practices will be assessed using that rubric.

<table>
<thead>
<tr>
<th>Points (0, 1/2, and 1 point are possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. 1-3) Correct information about the virus: Family, Genus, Species, hosts, transmission</td>
</tr>
<tr>
<td>B. 4) Where is the virus located? Include a map.</td>
</tr>
<tr>
<td>B. 5-7) Prevention and protection, symptoms, treatment</td>
</tr>
<tr>
<td>C. 1-2) Find accurate information (within the past 10 years) on outbreaks and thoughtfully answer question C2.</td>
</tr>
<tr>
<td>C. 3-4) Make a scatterplot using technology or by hand of outbreaks, with good scales and labels. Thoughtfully answer question C4.</td>
</tr>
<tr>
<td>D. 1-3) Describe the shape and size (diameter) of the virus by using two pictures as evidence. Convert nanometers into meters. Use correct scientific notation for meters and label answers correctly.</td>
</tr>
<tr>
<td>D. 4) Correctly determine the volume using the formula correctly for both nanometers$^3$ and meters$^3$. Use correct scientific notation for meters$^3$ and label answers correctly.</td>
</tr>
<tr>
<td>D. 5) Correctly answer question D5 and thoughtfully explain what the answer means.</td>
</tr>
<tr>
<td>E. 1) Create a table of the possible multiplication rate of the virus having accurate answers and including all column titles.</td>
</tr>
<tr>
<td>E. 2-4) Create an accurate scatterplot, correctly identify the type of graph, with thoughtful explanations of its characteristics and thoughtfully answer question D4.</td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
</tr>
</tbody>
</table>
Appendix L: Semistructured Interview Protocol

Student Interview Protocol
(adapted from Usher, 2009)

Background
1. Tell me a little bit about yourself.
   a. What sorts of things do you enjoy doing outside of school?
   b. Tell me about your friends.
   c. Tell me about your family.
2. Describe yourself as a student.
   a. What would you say is your best subject in school? Why?
   b. What would you say is your favorite subject in school? Why?
   c. What subject do you feel is your weakest? Why?
   d. Which subject is your least favorite? Why?
   e. Tell me about the grades you typically make in school.
   f. Do you agree with the grades you are given? Why or why not?

Mathematics experiences and self-efficacy
3. Tell me a story that explains to me something about the type of student you are in math. In other words, share with me something that happened to you that involves this subject and perhaps your parents, teachers, or friends.
   a. How do you feel about your ability to solve math problems? Why do you think that?
   b. If you were asked to rate your ability in math on a scale of 1 (lowest) to 10 (highest), where would you be? Why?
   c. Do you do other things outside of school that you use math for?
   d. Tell me about a time you experienced a setback in math. How did you deal with it?

Mathematics learning environment
4. Tell me about our math class.
   a. How would you say you compare to the rest of your classmates in your math abilities?
   b. How does this math class compare with other math classes you have had in the past?
   c. What have been your favorite activities in math this year? Why are they your favorites?
   d. What have been your least favorite activities in math this year? Why are they your least favorite?
   e. How do the things we have learned in math this year relate to your life?
   f. What activities do we do that you think help you learn math best? Why?
   g. Which types of activities have made it difficult for you to learn math this year? Why?
h. In what ways do you think you are better at math now than when the year began?
   Do you feel you are worse in some areas of math?

i. Have your grades in math improved this year, gone down, or stayed the same?
   Why do you think that happened?

j. What parts of our class help you to feel more confident doing math?

Mathematics and others

5. If you were going to be the teacher for this class next year, how would you make it a
   better class for students like you?

6. What do your family members tell you about math and math class?

7. What do your friends tell you about math and math class?

Affective and physiological response to mathematics

8. I want to ask you to think about how math makes you feel. You probably haven’t been
   asked to think about that before. When you are given a math test, how does that make
   you feel? How do you feel when you are given a math assignment?
Appendix M: Non-contextual linear systems assessment (non-CRMP)

linear Systems Unit Test

<table>
<thead>
<tr>
<th>Common Core Mathematics Standard</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.EE.8 – Understand and solve linear systems graphically and algebraically.</td>
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</tbody>
</table>

1.) A linear system is two equations that relate to the same two variables in the same situation. When the two equations are graphed and they intersect, what is the intersection point called?

2.) Is \((5, 0)\) a solution to the system? \[
\begin{align*}
y &= 2x - 8 \\
y &= -2x + 10
\end{align*}
\]
Show your work.

3.) Write the solution to this system as an \((x, y)\) coordinate. If there is no solution, then write “no solution”.

4.) Write the solution to this system as an \((x, y)\) coordinate. If there is no solution, then write “no solution”.

5.) Write the solution to this system as an \((x, y)\) coordinate. If there is no solution, then write “no solution”.

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6.) Solve the linear system below by graphing on the graph to the right. Write your answer as an (x, y) coordinate.
\[
\begin{align*}
  y &= -\frac{2}{3}x + 4 \\
  y &= x - 1
\end{align*}
\]

7.) Solve the linear system below algebraically by setting the two equations equal to each other. Make sure to find both x and y to be able to write your answer as an (x, y) coordinate. Show your work.
\[
\begin{align*}
  y &= 5x - 6 \\
  y &= 2x + 3
\end{align*}
\]

8.) Solve one of the linear systems below using either substitution or combinations/eliminations. Make sure to find both x and y to be able to write you answer as an (x, y) coordinate. Show your work.
\[
\begin{align*}
  y &= x - 5 \\
  2x + 5y &= -11
\end{align*}
\]

OR
\[
\begin{align*}
  2x + 4y &= -3 \\
  -2x - 8y &= 15
\end{align*}
\]
### Appendix N: Predetermined Codes for Qualitative Analysis

<table>
<thead>
<tr>
<th>CRMP codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASS</td>
<td>Assessment is situated within student culture, experiences, beliefs, or values</td>
</tr>
<tr>
<td>CARE</td>
<td>Teacher care is seen through relationship building with students and families</td>
</tr>
<tr>
<td>CELE</td>
<td>Small and big successes are celebrated</td>
</tr>
<tr>
<td>CG</td>
<td>Cognitive demand of mathematics</td>
</tr>
<tr>
<td>COMM</td>
<td>Teacher creates safe and supportive community of learners</td>
</tr>
<tr>
<td>CURR</td>
<td>Mathematics curriculum situated within student culture, experiences, beliefs, or values</td>
</tr>
<tr>
<td>DIA</td>
<td>Classroom dialogue and discussion on mathematical ideas</td>
</tr>
<tr>
<td>DOK</td>
<td>Depth of knowledge of mathematics</td>
</tr>
<tr>
<td>FEED</td>
<td>Teacher giving feedback</td>
</tr>
<tr>
<td>HE</td>
<td>Teacher demonstrates high expectations for mathematics learning</td>
</tr>
<tr>
<td>ID</td>
<td>Student developing a positive cultural identity; cultural competence</td>
</tr>
<tr>
<td>INST</td>
<td>Instructional strategies support development of social identity; cooperative</td>
</tr>
<tr>
<td>LANG</td>
<td>Language support during tasks</td>
</tr>
<tr>
<td>MR</td>
<td>Multiple resources are used to make learning meaningful</td>
</tr>
<tr>
<td>POWER</td>
<td>Power and authority during tasks</td>
</tr>
<tr>
<td>ROU</td>
<td>Routines are seen within the classroom</td>
</tr>
<tr>
<td>S-AG</td>
<td>Student developing agency; sense that they can change society</td>
</tr>
<tr>
<td>SCAF</td>
<td>Scaffolding instruction so all students can access high level mathematics</td>
</tr>
<tr>
<td>SPC</td>
<td>Student developing sociopolitical consciousness</td>
</tr>
<tr>
<td>T-AG</td>
<td>Teacher developing agency; sense that they can bring about positive change for students</td>
</tr>
<tr>
<td>T-EQ</td>
<td>Teacher works to resolve inequities in classroom and school</td>
</tr>
<tr>
<td>T-REF</td>
<td>Teacher reflects on personal biases and assumptions</td>
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<table>
<thead>
<tr>
<th>Mathematics Self-efficacy Codes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOAL</td>
<td>Use of goal setting</td>
</tr>
<tr>
<td>HELP</td>
<td>Use of help-seeking</td>
</tr>
<tr>
<td>MAS</td>
<td>Students experiencing mastery of mathematics content</td>
</tr>
<tr>
<td>META</td>
<td>Use of metacognition</td>
</tr>
<tr>
<td>PHY</td>
<td>Student experiencing positive state of mind; seems happy, interested, engaged</td>
</tr>
<tr>
<td>SE</td>
<td>Use of self-evaluation strategies</td>
</tr>
<tr>
<td>SOC</td>
<td>Students experiences social persuasions or verbal praise</td>
</tr>
<tr>
<td>VIC-S</td>
<td>Student experiencing student model</td>
</tr>
<tr>
<td>VIC-T</td>
<td>Student experiencing teacher model</td>
</tr>
<tr>
<td>VOI</td>
<td>Teacher honoring student voices</td>
</tr>
<tr>
<td>GOAL</td>
<td>Goal setting</td>
</tr>
<tr>
<td>MSE</td>
<td>Mathematics self-efficacy</td>
</tr>
<tr>
<td>SM</td>
<td>Self-monitoring</td>
</tr>
<tr>
<td>SE</td>
<td>Self-evaluation</td>
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