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Student engagement and college readiness in mathematics.

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STUDENT ENGAGEMENT AND COLLEGE READINESS IN MATHEMATICS

By

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November 17, 2015

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DEDICATION

I dedicate my dissertation work to my ancestors who have encouraged me from the other side: John and Louisa Hazel, Eli and Florence Murray, Owen and Lillian Jackson, Sherman Dix, Lenora Phillips, and Tommie Dix. Thank you for your guiding presence, faith, love, and legacy that inspire me daily.

I also dedicate my work to the loving memory of mathematics' teachers Ian Welch and Steven Dillard.

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ABSTRACT

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Leah Dix White

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The purpose of this study was to determine the relationship between reform practices, student engagement in mathematics class, college readiness in mathematics for high school students, and mathematics teacher Professional Development (PD). Quasi-experimental mixed methodology addressed the research question(s) in a parallel design. Treatment teachers participated in PD where reformed teaching practices were presented, observed, discussed, and analyzed using a Cognitive Apprenticeship (CA) framework. Student's mathematics readiness was measured distantly and proximally. Student engagement in mathematics class and reform practice implementation were observed, using Reformed Teaching Observation Protocol (RTOP), and compared across groups to assess treatment effects pre and post PD.

Analysis of treatment using teacher interviews and posts from an online community blog suggested significant treatment effects. Positive changes in student engagement and teacher reform implementation were observed. Teacher beliefs and perceptions of PD impacted reform implementation as well. Implications from the study have the potential to influence policy decisions and

professional development related to reform instructional practices in secondary mathematics classrooms throughout the state.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Overview of Issues

This study addresses reform practice implementation, student engagement, and student mathematics readiness for secondary students as well as high school mathematics teacher professional development (PD). Reform implementation has been shown to increase student engagement and mathematics achievement, but research that addresses reform practice implementation in instruction at the secondary level that promotes mathematics achievement for college readiness is needed. Only one third of the states' high school students tested met college readiness benchmark scores necessary for college level mathematics (ACT Inc., 2014a). Students' mathematics readiness remains a factor in determining successful college completion, making it a crucial variable to consider for mathematics education researchers, secondary mathematics teacher leaders, and other state stakeholders engaged in mathematics education (Long, Iatoralo, & Conger, 2009). Most importantly teachers need access to PD that may assist them in implementing reform practices and providing optimum learning environments for mathematics students. Reform practices include standards-based teacher pedagogies that encourage student centeredness, discourse, and inquiry in mathematics classrooms. PD that uses an effective framework could assist teachers in implementing reform practices in classrooms of mathematics ready students.

Background Information.

Teachers have worked diligently in recent years to not only implement reform practices but align these practices with the new CCSS standards and mathematical practices (KDE, 2012; King, 2011) and NCTM's processes and guidelines for teaching mathematics (NCTM, 2000; 2012). However, these efforts have not yielded empirical evidence of increased college readiness for Kentucky's high school mathematics students. Despite the legislation of CCSS aligned curriculum taught in the majority of mathematics classrooms in Kentucky, according to Kentucky's 2013 state report, only a third of graduating seniors were considered college ready in mathematics (ACT, Inc., 2014b).

In 2010, Kentucky was among the first to adopt the CCSS standards and use them to establish common criteria for measuring student performance and school accountability. Yet, limited planning time, and class time to engage in-depth discussion were factors teachers stated that inhibit the implementation of standards-based practice (Cady, 2006). Research that considers the effects of student and classroom factors would provide insights as to whether increased attention to reform practices should expand and if so, what form they should take at the high school level.

Students' Mathematics Readiness in Kentucky. Currently, the state of Kentucky uses ACT testing instruments as a measure of college readiness beginning with ACT Explore in eighth grade, the ACT Plan in tenth grade, and lastly ACT in eleventh grade. The ACT benchmark for college readiness in Kentucky for mathematics is 19 for the ACT (ACT Inc., 2014a). Only 43% of students tested nationally and 30% of Kentucky's students reached the established ACT benchmark in mathematics in 2013 (ACT Inc., 2014a). Although 66% of high school graduates are enrolled in colleges and universities nationally, many were unprepared for college-level work (ACT Inc., 2014); where nearly 50% were required to enroll in remedial courses (Morgan & Michaelides, 2005). Roderick and colleagues (2009) suggested, "Districts and schools should combine resources and support to increase capacity within schools with the signals and incentives to reinforce both student and teacher behaviors that build college readiness" (p. 203). Most importantly, teachers need a plan that allows them to assist students with students' mathematics readiness prior to high school and continue until graduation (ACT, 2010).

Specifically, high school mathematics teachers need knowledge of the most effective reform practices to assist more students in becoming college ready (Aldeman, 2010), and knowledge of the most effective interventions for students that should take place immediately upon entering high school and continue until graduation. As students enter high school and move closer to making educational and career choices for their futures, the real world application of mathematics becomes more significant. Therefore, stakeholders must not wait until students arrive in their ninth grade classrooms, but instead plan interventions prior to them enrolling in high school. The ACT suggests "the use of longitudinal data systems that allow schools and districts to monitor student progress from elementary through high school and proactively identify students for interventions" (ACT Inc., 2014a, p. 8).

In Professional Learning Communities (PLCs) (DuFour & Fullan, 2013), which are employed throughout the district in this study, secondary teachers analyze student performance on summative assessments over time but additional discourse is needed between all stakeholders across the district in determining which student and classroom factors have the most positive effect on student performance in mathematics. "Only a few states have linked high school student indicators to actual college performance" (Roderick et al., 2009, p. 186). "The dilemma lies in defining ways in which reform teaching is realized and implemented, particularly in urban settings" (Manouchehri, 2004, p. 502) and with underrepresented or disadvantaged students.

Students' Mathematics Readiness Disparities. Perhaps most alarming is that student performance on most indicators of students' mathematics readiness show significant racial and ethnic disparities (Roderick et al., 2009). Although 52% of Caucasians and 68% of Asian students scored at benchmark or higher than benchmark when compared to the national average on ACT mathematics tests, other minority students did not perform as well. Only 13% of African-American students and 27% of Hispanic students reached the benchmark or above in mathematics (ACT Inc., 2014). More recently, of all college-ready Kentuckians in 2013 only 10% were African American (ACT Inc., 2014). Because mathematics performance on standardized assessments is related to mathematics and science related career attainment (Birman, Desimone, Porter, &

Garet., 2000; Roderick et al., 2009) and college readiness, further research is needed that investigates ways to attract more urban students of a variety of races and ethnicities toward mathematics career trajectories (Conley, 2007; Thompson & Lewis, 2005).

Reform for Disparities. Given the priority to reaching high levels of mathematics achievement for America's students, stakeholders from various perspectives have discussed ways to address the issue of widespread low performance through various reforms (King, 2011; NCTM, 2000). The reform movement of the 1980's led many professional educational organizations to create standards to support positive changes in mathematics education. Today, standards, assessment, and accountability in terms of college readiness are frequently the focus of conversations involving constituents of mathematics achievement or reforms. Initiatives include the legislation of the CCSS including the eight Standards of Mathematical Practice, Race to the Top Initiatives, the Elementary and Secondary Education Act (ESEA) Flexibility Waiver, and several state-level reforms. All of these initiatives acknowledge college and career readiness as the goal for post-secondary mathematics students (ACT Inc., 2014a). Currently, CCSSO leads 14 State Collaboratives on Assessments and Student Standards (SCASS), which include leaders from state education agencies with mutual interest in mathematics assessments and the challenges in meeting standards (CCSSO, 2014). Also, NCTM supports reform based mathematics teaching consistent with the CCSS content standards and eight mathematics practices that promote college and career readiness for their students through their recent document *Principles to Actions* (NCTM, 2014).

Considering the urgency expressed through these conversations and initiatives, research that explores reforms practices would inform educators and stakeholders of ways to sufficiently prepare high school students for college mathematics and life beyond secondary education. Then, teachers would have empirical evidence of reform practices that work best in preparing their students for college and beyond. Most importantly more students would enter college prepared to enroll in mathematics courses rather than demonstrating a need for intense intervention.

> *"Improved academic preparation in high schools is expected to contribute to increasing college completion. For these outcomes to occur, states need a careful and thoughtful plan for implementing the CCSS, including the development of integrated and aligned K–12 and postsecondary policies and practices" (King, 2011, p. 4)*

Given the increasing pressure on schools to be accountable for high levels of mathematics achievement and the emerging calls for a reform teaching approach (Lubienski, 2002; Martin, 2006), this study addressed reform practices in high school mathematics classrooms, teachers' implementation of these reforms, student engagement in mathematics classes, and mathematics achievement in terms of college readiness in order to better understand the relationship between student engagement, all in an effort to increase positive student outcomes in mathematics.

This Study

Problem Statement

Presently, education policy does not reflect empirically validated studies in mathematics education that connect reform practices, student engagement, and college readiness on the secondary level (Desimone, et al., 2002). Far too many students complete high school unprepared for college level mathematics or other post-secondary career and educational options (Long, Iatarola, & Conger, 2009). Reform practices are inconsistently implemented and secondary teachers lack the appropriate professional development (PD) to assist them in effective implementation of these practices (Desimone, Smith, & Phillips, 2007). Also, first year college students are not being prepared for college level mathematics, and there is low student enrollment in mathematics related career trajectories, especially for disadvantaged students (Morgan & Michaelides, 2005).

Purpose

Education research that considers reform practices, mathematics teacher PD, student engagement, and college readiness in mathematics for all high school students regardless of background, ethnicity, or socioeconomic status is needed. According to Kentucky Department of Education, a majority of students who were administered ACT Explore and Plan tests in one of the state's largest districts did not meet benchmark scores for college readiness in mathematics (KDE.gov, 2015). The numbers meeting benchmark scores are even smaller for students who have been identified as "gap status" (KDE.gov, 2015). Gap status is a labeling of students who belong to groups that historically have had achievement gaps, which include: African American Hispanic, Native American, special education, poverty (free-reduced meals), gender, and limited English proficiency (KDE, 2013, p. 3). KDE's Closing the Gap Delivery Plan (2013) states that, "Closing the achievement gaps between the various groups of students cannot be accomplished without gap-specific targeted planning and implementation designed to make sure that capacity is built at both the district and school levels" (p. 3). Research that includes attention to gap status and specific related variables can assist stakeholders in planning and building instruction programs for districts and schools that will reduce mathematics achievement disparities, as well as increase college readiness in mathematics for its students. Furthermore, increasing college readiness in mathematics, "is fundamentally an instructional challenge that will require developing classroom environments that deeply engage students in acquiring the skills and knowledge they will need to gain access to and to succeed in college" (Roderick et al., 2009, p. 203). Through teacher led PD on reform practices centered on increasing student engagement that uses a cognitive apprenticeship framework, participant teachers can gain access to resources and strategies that may assist them in creating this mathematics learning community amongst other teachers and with learners in their classroom (Goos, 2004).

Specifically, teachers need access to PD that supports them in implementing NCTM processes and teaching practices (2000; 2014) and Common Core State Standards (CCSS) (Birman et al., 2000; Rousseau & Powell, 2005), with examples of teachers modeling embedded instructional strategies to ensure their mathematics students are prepared for college level mathematics (Roderick et al., 2009). The PD offered should use an effective framework (Desimone, 2007), such as CA, support teaches' cognitive shifts (Birman et al., 2000), require collaboration from teachers across the school district (Birman et al., 2000) and positively influence reform practice implementation according to existing research (Desimone, 2007). The PD should be flexible, feasible, and require multiple meetings in a variety of formats, e.g. Skype, Google Hangouts, (Ingvarson, Meiers, & Beaus, 2005). The PD should also incorporate ways to develop mathematics content knowledge, and require collective participation, as well as active learning of experienced and inexperienced teacher treatment participants (Birman et al., 2000, Desimone, 2007).

Existing Research.

Existing research suggests that reform practices, specifically those that encourage high levels of classroom discourse, may be associated with higher levels of mathematics achievement (Gee, 2002; Moschkovich, 2010; Schleppegrell, 2004). Several of NAEP's reform-oriented, instruction-related variables, such as collaborative problem solving and teacher knowledge of the NCTM standards (Lubienski, 2006), have been found to correlate with increased student achievement. Also, many researchers have addressed discourse practices in classrooms (Griffin et al., 2013; Herbel-Eisenmann, Choppin, Wagner, & Pimm, 2012) and frame mathematics knowledge as a social behavior achieved through discourse and interaction (Bell and Pape, 2012; Vygotsky, 1978). In contrast, other researchers reiterate teacher mediated discourse practices (Khisty & Chval, 2002; Lemke, 1990) versus student initiated discourse practices (Esmonde, 2009; Hand, 2010). Quantitative research that explores student and teacher exchanges in reformed mathematics classrooms is needed to assist teachers in making effective instructional decisions that better prepare students for higher level mathematics (Herbel-Eisenmann & Cirillo, 2009).

Research on reform practices and student achievement have shown that classroom factors such as student engagement in mathematics promote achievement in mathematics (Park, 2005; Ross & Wilson, 2012; Shin, Lee, & Kim, 2009; Wu and Huang, 2007). For example, Shin et al. found that when teachers shaped learning experiences to engage students in different learning activities, mathematics achievement increased (2009). Other school factors such as high stakes testing policy initiatives (Hamilton, Stecher, & Yuan, 2008), and teacher practices (Allensworth et al., 2009) were found to effect reform practice implementation.

Some school-based research, for example, suggest that tests, rather than standards, drive practices and that increased achievement occurs more often in high stakes versus low stakes testing situations (Jacob & Levitt, 2003; Steele, 2001). Jacob and Levitt found in their systematic analysis of teachers cheating on standardized assessments that high stakes testing results corrupted teacher and or administrator behavior(s), cheating occurred more often in low performing schools, and cheating was highly correlated to the incentives in place at the school (2003). Researchers did not consider classroom teaching practices or other classroom level factors when comparing cheating teachers and non-cheating teachers in their analysis. Research that considers classroom level factors, such as effective teacher PD and its relationship to classroom practices that promote positive student outcomes in mathematics, might provide alternatives to teachers and administers who are in need of strategies to increase their effectiveness (Birman, et al., 2000).

Also, prior research has shown high positive correlation between reform practices and student achievement for elementary mathematics students (Brahier & Schaffer, 2004), middle school mathematics students (Cady, 2006), and secondary mathematics and science students (Maclsaac & Falconer, 2002). Yet, a 2008 report from the Council of Chief State School Officers (CCSSO) stated, "Teacher professional development programs in the US did not meet standards for effective reflective practice that leads to optimal learning" (p. 4). Given the priority of students' mathematics readiness for high school students, secondary mathematics teachers need teacher-led PD where teachers observe, reflect, and discuss reform practices in mathematics classrooms (Birman et al., 2000).

Currently, each school district in the Commonwealth of Kentucky uses its own selected curriculum and policies, and provides its teachers with district wide PD that aligns with its own specific goals and visions. In February 2011, the Kentucky Department of Education (KDE) secured the state's commitment from all districts "to move 50 percent of their district's' high school graduates who are not college and/or career ready to college and/or career ready between 2011 and 2015" (KDE.org, 2011). In spite of this recent promise reaching its due date, the question remains as to which reform practices or teaching philosophies contribute the most towards developing college and career readiness in mathematics for students.

There is increasing pressure on school districts to be accountable for student mathematics achievement, and particularly college readiness. Reform efforts emphasize that high schools should be held accountable for their students' academic performance post-graduation; therefore, high school teachers need access to effective PD that improves instructional practices and that explores ways can teachers increase college readiness in mathematics(Long et al., 2009; Roderick et al., 2009). Various state initiative and programs have been created to assist educators and administrators in preparing students for college level mathematics (KDE, 2012). College readiness in mathematics remains as an expectation for all of the Commonwealth's students and the pressure falls onto administrators as well as secondary mathematics educators who are charged with the task of preparing students for college level mathematics. The challenge lies in deciding which reform practices teachers should implement with students to prepare them for college level mathematics. Also, educators need access to PD that focuses on these reform practices in mathematics classrooms and provides resources that assists them in implementing these reform practices (Birman et al., 2000; NCTM, 2000).

Research Question(s)

The hypothesis includes the following: Students' mathematics readiness should increase for students following treatment teacher's successful implementation of specific reform practices focusing on increased levels of student engagement. The research question includes several subparts that are addressed separately in the context of the proposed research study.

a) How does professional development, framed by a Cognitive Apprenticeship model, affect the implementation of teacher reform practices?

b) How does the use of teacher reform practices affect student engagement n mathematics?

c) How does the use of teacher reform practices affect mathematic readiness for high school students?

Hypothesis:

PD on reform practices that uses CA framework will impact teaching practice, and effective implementation of reform practices, which in turn promote student engagement, and will prepare students for college level mathematics.

This proposed study begins with the hypothesis that effective reform practices promote college readiness; however, polar opinions exist in the reform debates as to whether these practices sufficiently prepare students for collegiate mathematics and beyond. Currently, in the United States "there does not exist substantial numbers of students who have gone through the reform curricula and emerged competent to do further work in collegiate mathematics or in the workplace" (Schoenfeld, 2002, p. 270). Also evidence from schools that have used reform-oriented curricula and pedagogies has generally indicated that students of teachers who implement reform practices score at least as well as students of teacher control groups (e.g., Riordan & Noyce, 2001; Schoenfeld, 2002; Senk & Thompson 2003). Therefore, this study could not only provide empirical evidence as to what reform practices most benefit students in mathematics classrooms but also whether or not these practices prepare students for collegiate mathematics and beyond.

Additionally, this study could provide guidance to teachers in selecting a curriculum that use reform practices. The public school system in the state of Kentucky that is the focus of this investigation currently uses College Preparatory Mathematics (CPM) curriculum for high school mathematics, although many teachers use supplementary curriculum resources to teach the CCSS. Currently district administrators and specialist offer periodic PD for new and veteran teachers in the district on implementing CPM curriculum in middle school and high school mathematics classrooms. The teaching strategies modeled in the PD rely upon NCTM recommendations of effective teaching practices (2014) and "focus on how students' best learn and retain mathematics" (Sallee, et al., 2013, p. 1).

The research based principles that guide the CPM curriculum include the following:

> *Students should engage in problem-based lessons structured around a core idea. Guided by a knowledgeable teacher, students should interact*

in groups to foster mathematical discourse. Practice with concepts and procedures should be spaced over time; that is mastery comes over time (Sallee et al., 2013, p. 1).

Given the current state of reform implementation and curriculum foci in Kentucky in regards to secondary mathematics, teachers need access to reform curriculum that support successful CCSS implementation and PD on reform practices that engage students in learning mathematics.

Therefore this study employs classroom, student, and teacher variables to address relationships between reform teaching practices in high school mathematics classrooms, student engagement, teacher PD, and college readiness in mathematics. Classroom variables include teacher participation in PD and reformed teaching practices implemented across subjects and college readiness according to subject and class. Student variables include college readiness in mathematics and student engagement. Teacher variables include teacher participation in PD (treatment and control groups) and implementation of reformed teaching practices. Students' mathematics readiness is measured using the two earliest tests in the sequence of ACT instruments and district assessments (student and classroom variables), and reform teaching as measured using RTOP (teacher and classroom variables). The covariate in the analysis include all pretests for each measure.

Definition of Terms

Following are brief descriptions or operational definitions of key terms and constructs used throughout this document. These definitions lay a foundation for understanding teacher and student interactions in reformed secondary mathematics classrooms as well as teacher and their peer interactions during teacher led PD.

College Readiness. Conley (2007) defined college readiness as “the level of preparation a student needs in order to enroll and succeed, without remediation, in a credit-bearing general education course at a post-secondary institution that offers a baccalaureate degree or transfers to a baccalaureate program” (p. 5). Although colleges use coursework, college admissions exams, and state and national tests to determine college readiness, this focuses on standardized tests, particularly the ACT mathematics test, as a measure of college readiness in mathematics.

Reform. The goals of reform according to NCTM (2000) are “that all students should learn to value mathematics, become confident in their ability to do mathematics, become mathematical problem solvers, learn to communicate mathematically, and learn to reason mathematically” (p. 5). This view of reform suggest that instruction “emphasizes conceptual understandings of mathematics concepts that connect prior knowledge with new experience through active inquiry based learning that is socially constructed and student centered” (Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010, p. 310). The reforming of instruction and learning can be defined as “a movement away from the traditional didactic practice towards constructivism” (Anderson, 1994; Sawada, Piburn, Judson, Turley, Falconer, K, Benford, & Bloom, (2002, p. 15), where the classroom environment shifts from being teacher centered and lecture based, to being student centered including active engagement in discussions and shared problem solving strategies. Reform oriented teaching advances constructivism and includes "teacher actions and behaviors that pose tasks to bring about appropriate conceptual reorganization in students, guides students' mathematics ideas, and structures intellectual and social climates that encourage students to discuss, reflect on, and make sense of tasks" (Clements & Battista, 1990, p. 7). Reform recommendations consider how mathematics is taught, what mathematics is taught and the nature of teaching and learning in mathematics classrooms (NCTM, 2000).

A reformed classroom's culture focuses on learning in the best interest of students or participants versus traditional approaches to teaching and learning where the teacher remains as the only expert. The culture in a student centered classroom is, "a deep structure of students knowing how to understand", when to act, when to speak and how to be in the mathematics classroom; Culture informs human thought, activity, and mathematical conceptual understanding" (Ladson-Billings, 1997, p. 702). Student centered instruction engages students in learning mathematics (Gningue, Peach, & Schroder, 2013) and requires all members of the classroom community equitable access to learning mathematics (Ellis & Berry, 2005), as well as mutual student and teacher input when learning mathematics concepts. Also, organizations such as the Mathematics Association of America (MAA) argue that a student-centered approach to learning prepares students for mathematics better than a teacher-centered approach (MAA, 2008).

Reform practices focus on mathematics discourse that include interactive exchanges between teachers and students (Sawada et al., 2002). Instructional strategies that promote frequent discourse which is a social factor that some researchers claimed influenced achievement for students (Gay, 2002). In this classroom environment the teacher scaffolds instruction to insure all students make connections between what they know and the new topic being learned (Bell & Pape, 2012). Students utilize work space in ways that encourage cooperative learning (Malloy & Jones, 1998). The teacher provides opportunities for students to express what they know and to receive immediate feedback from the teacher as well as their peers (Russell, 2012). Students also feel comfortable taking risks, understanding that problem solving is part of the learning process (Malloy & Jones, 1998). Effective mathematics teaching should be in student centered classrooms where the teaching consistently contributes to achieving the goals of the mathematics instruction reform.

RTOP Instrument. For the purposes of this study, the RTOP instrument is used to reflect the degree at which reform practices occur in the observed mathematics classrooms. Reform practices include standards based teacher pedagogies that are student centered and encourage discourse, and inquiry amongst students in mathematics classrooms. The RTOP instrument assesses "the degree to which mathematics instruction in terms of classroom culture, communicative interactions, and student/teacher interactions take place" (Sawada et al., 2000, p. 14). Reformed classrooms include teachers whose observed reform practice implementation result in a high RTOP score (total range of score: 0 – 100).

Constructs of RTOP Instrument

Student Engagement. According to Attard (2012), mathematics engagement occurs when “mathematics is a subject students enjoy learning, students value their mathematics learning and see its relevance in their own lives now and in the future, and students see connections between the mathematics they learn at school and the mathematics they use outside of school” (p. 11). Gningue and colleagues stated, “An engaged student is involved in the lesson in meaningful ways through participation in classroom activities, collaboration with teachers and students, and individual reflection about learning” (2013, p. 632). Students engage in learning cognitively, behaviorally, and affectively (Fredricks, Blumenfeld, & Paris, 2004). For the purposes of this study, engagement is a multi-faced quantitative construct of cognitive, behavioral, and affective interactions that promote mathematics learning as measured through the RTOP instrument.

Also, engaged students interact with other students, and teachers to develop conceptual understanding while completing mathematics tasks. Researchers have found that clear instructional goals (Ladson-Billings, 1997), small group collaboration (Esmonde, 2002; Howe, McWilliam, & Cross, 2005; Howe, Tolmie, & Rodgers, 1992; Schwartz & Martin, 2004), and appropriate rigorous challenging tasks in the classroom (Shernoff, 2013) all engage students in learning mathematics. Others have suggested that student engagement “varies between the group members' reactions to mathematics classroom activities" (Uekawa et al., 2007, p. 5). In Uekawa and colleagues' (2007) study of urban high schools, student perceptions of the level of the challenge predicted their level of engagement. For the purposes of this study "engagement is a quantitative construct related to the amount of time students demonstrate cognitive behaviors" (Wu & Huang, 2007, p. 729). Engagement also includes individual students' classroom participation that results in measurable mathematics conceptual understanding according to a teacher observer.

Inquiry. In this approach to solving new or unfamiliar mathematics problems students learn to speak and act mathematically and inquisitively (Goos, 2004; Richards, 1991). Also inquiry oriented teachers "value the student's right to explore and negotiate in a supportive environment" (MacIsaac & Falconer, 2002 p. 483). Wood, Williams, and McNeal (2006) found higher levels of student mathematics thinking in reform oriented classrooms in which,, "classroom discourse patterns were characterized by inquiry-oriented approaches" (p. 232). For the purposes of this study, inquiry-based instruction "is a student centered pedagogy that uses purposeful extended investigations set in the context of real-life problems as both a means for increasing student capacities and as a feedback loop for increasing teachers' insights into student thought processes" (Supovitz, Mayer, & Kahle, 2000, p. 332).

Student Centered. Classroom cultures that are student centered position the students as facilitators of learning along with the instructor in that there is equal participation in the construction of knowledge. Elements of student centered classrooms include small group discussions, class discussions, hands-on activities, cooperative learning, student presentations and use of learning centers or stations (Leonard & Hill, 2008). In contrast, "a teacher centered classroom includes lecturing with limited class discussion, modeling problem solving and teacher led demonstrations" (Gningue et al., 2013, p. 213)

Mathematics Discourse. Embedded in socio-cultural, and socio linguistic practices, mathematics discourse emphasizes the role of social interaction in an individual's mathematics conceptual development (Vygotsky, 1978). Particularly, Vygotskian theorists are interested in mathematics curricula that revolve around active student engagement, negotiation, and participation in conceptual development (Sawada, Piburn, Falconer, Turle, & Benford, 2000). Classroom discourse becomes a focus of this construct. Discourse includes more than language, but other forms of verbal and non-verbal communication (Gee, 1996). Mathematical discourse practices include interactions that involve multi-semiotic systems such as speech (e.g., code shifting, conversations, songs), writing, (e.g. journals entries, learning logs) images (e.g., drawings diagrams, graphs), and gestures (e.g. movements, placement, signals). Mathematics discourse practices contrast social norms and socio-mathematical norms (Moschkovich, 2010), and considers student identity and related experiences (Gutierrez, 2008; Herbel-Eisenmann et al., 2012) in mathematics instruction.

Discourse Oriented Teaching. Teaching that has students participate and engage in knowledge construction through student-to-student and student-to-teacher interactions (Leonard & Hill 2008; Nathan & Knuth, 2003; Wood, 1999) defines the essence of discourse oriented teaching. William and Baxter (1996) describe Discourse Oriented Teaching (DOT) “as actions taken by a teacher that support the development of mathematics knowledge through discourse amongst students” (p. 22). Further, DOT is an attempt to account for “the inherently social nature of teaching and learning and to provide a more natural social scaffolding for the production of knowledge” (p. 25)

Equitable mathematics discourse practice in the classroom connects learning to the community, facilitates comfortable and productive participation, fits the learners’ communication practices (Herbel-Eisenmann et al., 2012), and enables students to build on existing mathematics knowledge and experiences (Moschkovich, 2010). The NCTM equity principle includes “excellence in mathematics education with high expectations and strong support for all students” (2000, p. 12). Equity in mathematics instruction must relate everyday student experiences to the classroom (Martin, 2006; Moody, 2004). Equity in mathematics instruction requires equitable distribution of resources to schools, students, and teachers; equitable quality of instruction; and equitable outcomes for students (Allexsaht-Snider & Hart, 2001; Martin, 2006).

Disadvantaged Students. All students that historically have performed at lower levels are considered disadvantaged students. This can include ethnic minorities (e.g., African-American and Hispanic students), students with disabilities, economically disadvantaged students (Blank, 2011), students not performing on grade level and English-language learners (ELL) (Rosenbaum & Becker, 2011).

For the purposes of this research study, reform practices include standards based teacher pedagogies that develop student centered instruction and encourage discourse, and inquiry amongst students in mathematics classrooms. These high school mathematics classrooms incorporate district suggested pacing of high school level curriculum content, organizational structures, and assessment strategies between students. The reform teaching PD used as an intervention in this study focuses on implementation of reform practices that engage teacher participants in learning, using CA domains (scaffolding, modeling, and reflecting) cognitively, and affectively. These cognitive shifts are hypothesized to impact reform practice implementation.

CHAPTER II

LITERATURE REVIEW

Introduction

To insure construct validity, a synthesis of research surrounding reform practices in mathematics and some science classrooms at elementary to post-secondary levels are explicated below. Research was reviewed on the impact of reform practices at various grade levels focusing on studies that would generalize to urban mathematics classrooms in the United States. This is followed by a description of the conceptual frameworks that guide the proposed study.

Literature Search

In order to locate relevant research on reform practices in mathematics, a search of electronic databases was conducted using the following search terms: *reform mathematics teaching*, *reform practice*, *student centered instruction, mathematics teacher professional development*. These terms were used in ERIC (EBSCO); PsychInfo (EBSCO), and Education Full Text databases. Articles located were then reviewed and ancestral searches of reference lists conducted in order to ensure that all relevant literature was located. The research studies published within the past ten years fell into one of two categories (1) elementary or middle school level and (2) high school or post-secondary level.

Elementary and Middle. Analytic and social scaffolding questioning, and dialogic discourse between students and teachers reform practices that improved elementary and middle school students' mathematics achievement (Attard, 2012; Hamilton, McCaffrey, Stecher, Klein, Robyn, & Bugliari., 2000; Le et al., 2009; Leonard & Hill, 2008; Nathan & Knuth, 2003; Jong et al., 2011). Leonard and Hill found that students were most successful when teachers used analytic scaffolding to guide inquiry oriented lessons with their students (2008). Analytic scaffolding is "the scaffolding of mathematical ideas for students" (Williams & Baxter, 1996, p. 24) and is intended to support students'' learning of mathematical content during classroom interaction (Nathan & Knuth, 2003). The teachers in Nathan and Knuth's study also encouraged narrative and paradigmatic modes of discourse to help students use reasoning and provide evidence to support their claims when completing mathematics and science computer based assessments in a third grade class (Leonard & Hill, 2008). The detailed classroom discussions proved to assist students in answering science assessment questions correctly (Leonard & Hill, 2008). But their findings did identify significant findings for the mathematics assessment (Leonard & Hill, 2008).

Elementary and middle school teachers who increase reform practices have more positive student outcomes in mathematics (ARC Center, 2003; Jong et al., 2007; Hamilton et al., 2000). The ARC Center (2003) conducted a study that compared matched groups on socioeconomic status (SES), reading levels, and ethnic composition, and English proficiency, where the average mathematic scores on standardized assessments were significantly higher in elementary and middle school classrooms where reformed practices were used Additionally, in a large scale study, Hamilton et al. (2000) found that pupils who received reformed teaching performed better on open response items but not significantly better on multiple choice items. Specifically, “the results indicate that there was not a strong relationship between teacher-reported instructional practices and student achievement during a given school year” (Hamilton et al., 2000, p. 17). Years later the study was extended and results indicated that the relationship between reformed teaching practices increased with longer exposure to sustained reformed practices, (Jong et al., 2007, p. 312). These studies were not based upon direct observation but the rather the assumption that these schools successfully implemented reformed curriculum. It is essential that future studies examine “the school contexts and observe classrooms to characterize teaching practices and learning opportunities accurately when making claims about pupil learning” or in this case of this proposed study students’ mathematics readiness (Jong et al., 2007, p. 312).

Teacher factors effect reform teaching implementation (Nathan & Knuth, 2003; Woolley, Strutchens, Gilbert & Martin, 2010; Rousseau & Powell, 2005). Nathan and Knuth (2003) found through classroom observations that middle school students were more successful in mathematics when teachers’ facilitated dialogic discourse reform practices through “rephrasing student statements to refine and clarify student ideas and promote conceptual development” (p. 179). In these classrooms, teachers demonstrated both analytical and social scaffolding by, “keeping discussions going, getting students involved, soliciting views, and reminding students of the social norms of the classroom” (Nathan & Knuth, 2003, p. 180). Woolley and colleagues (2010) found that teacher expectations and use of reform practices, directly influenced students’ standardized test scores in mathematics. In this study student motivation mediated the effects of perceived teacher expectations and the use of reform practice use on standardized test performance. Rousseau and Powell consider equity in terms of reform implementations in their action study (2005). They found that time on task and quality of instruction were contextual factors found to influence reform implementation (Rousseau & Powell, 2005). These teacher factors were not addressed in this study.

Also, long term implementation of reform practices has a greater impact on mathematics student outcomes than short term implementation (Le et al., 2009; Nathan & Knuth, 2003). Le and colleagues looked at the longitudinal effects over a three year period of reformed teaching to see its impact on mathematics and science achievement for elementary and middle school mathematics students. Their initial findings suggested that “the relationship between mathematics achievement and reform oriented practices was not significant” (Le et al., 2009, p. 211) but effects became stronger with prolonged exposure to reform oriented practices. In both Nathan and Knuth and Le and colleagues’ studies, the shift away from traditional teaching practices engaged students in learning mathematics and science though explorations and communications. Research that considers student engagement and conceptual development that leads to rigorous critical thinking would provide educators with insights on how to implement these practices into mathematics classroom (Cady, 2006). Additionally, research that considers engagement behaviorally, cognitively, and affectively in mathematics classrooms is needed.

When considering implementation of reform in elementary mathematics education Brahier and Schaffner (2004) found that teachers with the most experience underwent the most significant changes in their knowledge, beliefs, and teaching practices when attempting to implement reforms consistent with current standards. In this study the process of teachers working and supporting each other was fundamental to the change in practices but student achievement outcomes were not considered. Under similar conditions to the Brahier and Schaffner's study (2004),) Rickard (2005) found in his case study of reform practices that experienced teachers could more "closely align their teaching practices with reform goals for problem solving in middle school classrooms than inexperienced teachers" (p . 85).

Teacher PD for elementary and middle school in-service and pre-service teachers that focuses on reform practices increased reform implementation (Lubienski et al., 2008; Smith, et al., 2005; Swanson & Stevenson, 2002) for some studies. Smith and colleagues (2005) found that middle school teacher participation in PD after controlling for teachers' experience, education, and self-reported content knowledge was positively associated with increased use of reform teaching strategies. Conversely, Lubienski, and colleagues (2008) found in their analysis of student, teacher, and school factors that have influences on mathematics achievement that teacher PD did not significantly affect reform practice implementation.

High School and Post-Secondary. Studies that focused on high school students and reform practices were limited. In one five year longitudinal study Boaler and Staples (2008) found that when urban high school mathematics students were exposed to reform practices they were able to meet and in some cases surpass their suburban counterparts in mathematics achievement. On the other hand, Lawrenz, Huffman, and Gravely (2007) found that high school teachers who participated in PD utilized reform practices more frequently, however, there was no link between reformed teaching and student outcomes. Studies that consider teacher characteristics that promote reform practices in urban high school mathematics classrooms are needed (Manouchehri, 2004).

Student engagement and other classroom factors effected achievement in secondary classrooms (Manouchehri, 2004; McCaffrey, et al., 2001; Wu & Huang, 2005). In Manouchehri's study (2004) of motivation styles and reform practices, treatment and control groups were observed in mathematics classrooms; qualitative analysis showed that teachers with an autonomous motivation style were more likely to implement reform practices. Autonomy supportive teachers encouraged student initiative and maintained a non-controlling stance in their classrooms. Wu and Huang (2007) in their quantitative analysis investigated ninth graders' engagement in student centered versus teacher centered science classrooms. Their findings suggest that although students in student centered classes had significantly higher emotional engagement, their emotional engagement level had no significant impact on learner achievement (Wu & Huang, 2007). McCaffrey and colleagues considered the effects of curriculum on the relationship between instructional practices and student outcomes (2001). They found that tenth graders who were enrolled in standards based reformed curriculum increased in the mathematics achievement on both the multiple choice and opened ended tested items. These studies provide empirical evidence that reformed classrooms (e.g., standards based, student centered) positively affect measurable student mathematics outcomes.

Several studies that consider post-secondary observations of instruction in mathematics and sciences courses allude to the effectiveness of the RTOP instrument in analyzing instructor effectiveness (Amrein-Beardsley & Popp, 2012; Wainwright et al., 2004). In Amrein-Beardsley and Popp's (2012) study of university faculty effectiveness, participants saw value in peer observation processes using the RTOP instrument and the formative functions of the RTOP instrument outweighed its summative value. Additionally, various researchers of post-secondary reform efforts (McDuffie & Graeber, 2003; Wainwright et al., 2004), found that although some reform practices were prevalent in science and mathematics university courses, "additional feedback and support are needed for higher education faculty members to fully adopt reform-based instructional methodology" (Wainwright et al., 2004, p. 330)

Given available research, secondary and post-secondary educators need additional knowledge of reform practices such as increasing the levels of discourse which has the potential to engage students in learning and increase students' college readiness in mathematics (Cady, 2006). Smith Desimone and Ueno (2005) found in their study of mathematics teacher professional development that, "providing incentives for teachers to participate in content related activities and for districts and schools to focus their professional development programs on content-based activities has the potential to increase teachers' emphasis on reform oriented instruction and could help close these gaps [mathematics achievement gaps], p. 102). The question remains as to which reform practices in what context contribute the most towards high school students' mathematics readiness. Also because researchers have found a positive relationship between effective PD and reform practice implementation, teachers need ample PD opportunities to perfect their practice.

Theoretical Framework

PD facilitators must use appropriate definitions, constructs, and frameworks that provide an understanding of the dynamics between high school mathematics teachers and student learning in mathematics classrooms (Franke, Kazemi, & Battey, 2007). In an effort to address college readiness and engage students in mathematics classrooms a Cognitive Apprenticeship (CA) framework for teachers PD on reform practices is used. CA is the use of an apprentice model to support learning in the cognitive domain where scaffolding, modeling, mentoring, explaining, reflecting, articulating, exploring, and coaching are methods of teaching and learning (Dennen, 2004). Frameworks that address mathematics teacher and student actions in classrooms as well as cognitive shifts that influence teacher practice are provided. Hypothesis: Using the CA framework during the treatment PD on reform practices influence teacher cognitive shifts that result in a positive change in reform practice implementation.

Framework(s) Chosen for This Study

Several frameworks address mathematics teaching and learning in reformed classrooms. These include (a) social linguistic (b) social constructivist (c) constructivist and (d) mathematics talk community. Social linguistic teachers use mathematical discourse practices as a means of mathematical concept development through social interaction (Gee 1996, Von Glaserfeld, 1991). Social constructivist teachers embrace reform practices as they "encourage learners to create their own knowledge based on interactions with their environment and other students. Constructivism is the philosophy or belief that learners create their own knowledge based on interactions with other people" (Draper, 2002, p. 522). Constructivist frameworks have been used to understand the effects of socio-psychological factors on student engagement in high school mathematics classrooms. Lastly, teachers that teach from a mathematics talk community perspective, "develop talk trajectories that include questioning, explaining mathematics thinking, sources of mathematics ideas, student responsibility and a community in which the teachers and students use discourse to support the mathematical learning of all students", (Hufferd-Ackles et al., 2004, p. 82). Researchers have used these four frameworks as a backdrop in understanding social aspects of mathematics conceptual development in reformed classrooms.

Through the lens of a sociolinguistic framework, classroom interactions include “socio linguistic activities that require competency and fluency necessary to participate in mathematics discourse practices” (Moschkovich, 2010, p. 94). “Discourses are sociohistorical coordinations of people, objects (props), ways of talking, acting, interacting, thinking, valuing, and (sometimes) writing and reading that allow for the display and recognition of socially significant identities” (Gee, 1997, p. 256) When using the RTOP instrument to analyze teacher video observations MacIsaac and Falconer (2002) suggest the development of a common language between treatment participants and PD facilitator if the PD is to have the positive impact on reform practice implementation. The work between stakeholders in developing a common language or discourse of reform teaching took place during PD.

Similarly, social constructivism theorists understand the significance of socio-cultural contexts of learning, such as students’ motivation and learning behaviors in the classroom (Lim, Chae, Schinck-Mikel, & Watson, 2013). Social constructivism theorists argue that successful performance in mathematics is related to the needs, aspirations, and perspectives of the class of individuals where, the collective emphasis of group learning remains through all interactions (Von Glasersfeld, 1991). Students’ attitudes about themselves, their needs, and motivation for learning mathematics in constructivist classrooms all influence their cognitive development, their work, their thinking, and therefore their cultures of learning (Malloy & Jones, 1998). In a constructivist mathematics classroom, students negotiate shared meanings of mathematics concepts while working together in engaged learning groups (Ross & Wilson, 2007). Social constructivists understand how to position students as learners and doers given explicit expectations and peer interactions. They also work to insure student performance moves from being assisted, with peer or teacher, to being independent over time. Sociolinguistic, social cultural, and social constructivist frameworks reflect the theories of the early reform movement in the late 1990s when the RTOP instrument was originally created (Sawada et al., 2002).

Cognitive Apprenticeship .To insure the fidelity of treatment the teacher led PD will utilize the CA model of learning; like trade apprenticeship, this model focuses on novice and expert interactions (Collins, Hawkins, & Carver, 1991). CA is the use of an apprentice model to support learning in the cognitive domain where scaffolding, modeling, mentoring, explaining, reflecting, articulating, exploring, and coaching are methods of teaching and learning (Dennen, 2004). In this framework of learning, teacher participants interact as novice and expert learners while the PD facilitator situates learning for them to extend and receive feedback from their peers. The researchers' knowledge of the teachers' Zone of Proximal Development (ZPD) will assist in designating who is the expert or novice in a given activity. Negotiation of cognitive understanding and learner needs are considered in peer interactions. For the purposes of this study, three domains of this framework will be used throughout the treatment teacher PD sessions and are defined below. These domains fit into a PD model because the dual role of the facilitator as a practitioner. Also, after searching each domain separately scaffolding, modeling, reflecting domains were cited the most in other theories and/or frameworks in mathematics education.

Scaffolding. Originating in Vygtosky's work (1978), the scaffolding domain is "a metaphor for a structure put in place to help learners reach their goals and is removed bit by bit as it is no longer needed" (Dennen, 2004, p. 815). In practice, successful implementation of this domain depends on how the well the learner's needs are supported when addressing their learning of concepts procedures, strategies and metacognitive skills (McLoughlin, 2002). "Scaffolding refers to the supports the teacher provides to help students carry out the task. When a teacher provides scaffolding, the teacher executes parts of the task that he student cannot yet manage" (Collins, et al., 1991, p. 179). Scaffolded learning will take place during the PD between participants and as a whole group with the facilitator. The facilitator will provide support for participants' learning about reform practices during each PD session.

Modeling. Modeling is a domain used as a way of helping the learner "progress through the ZPD, where learners may observe the target action (behaviorally) or reasoning (cognitively) as presented by an expert or more experienced peer" (Dennen & Bruner, 2007, p. 817). Modeling involves an expert's' performing a task so that students can observe and build a conceptual model on the processes that are required to accomplish it. "In cognitive domains, this requires the externalization of usually internal processes and activities" (Collins et al., 1991, p. 178). In a learning context, the expert demonstrates then novices imitate their actions as the learner progresses through the ZPD.

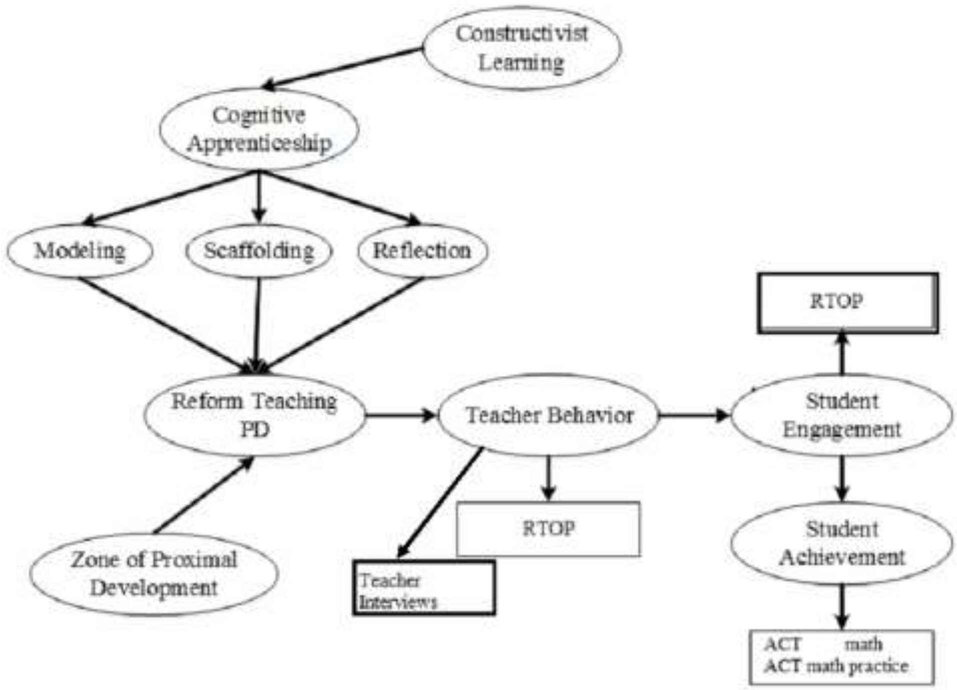
Reflecting. Reflection, as a domain and learning activity, occurs when the novices come to understand the activities being taught. "Reflection involves enabling students to compare their own problem-solving processes with those of an expert, another student, and, ultimately, an internal cognitive model of expertise. Reflection is enhanced by the use of various techniques for reproducing or replaying the performances of both expert and novice for comparison" (Collins et al., 1991, p. 179). Reflective articulation verbally and non-verbally will help participants better self-assess their understanding and engage them in knowledge integration of reform practices.

Vygotsky's Zone of Proximal Development (ZPD). Although this framework was originally used to explain the development of children in late elementary and middle school years (Vygotsky, 1978), researchers have utilized this construct in high school mathematics classrooms (Taylor, 1993) and beyond (Dennen & Bruner, 2007), where the experts include the teachers as well as the learners' peers. These teaching strategies support cooperative groups, provide opportunities for significant peer interactions, poses problems beyond students' comfort zone to maximize learning (Brown, 2009) and bridge learning experiences from novice to expert (Taylor, 1993).

In this learning context the teacher as the researcher facilitates discourse between the learner and the expert. This form of peer tutoring is explicit in PD planning and participant teacher interactions. Additionally, the learner has time to reflect upon these interactions and write their inner thoughts (Taylor, 1991) in regards to the concept (Bruner, 1987). Participants' thoughts shift from being individual to social, where the instructor has knowledge of student conceptual understanding to properly assign students as learner or expert. The goal is to have participants bridge their ZPD from learner or novice, towards a further developed position, to eventually an expert. These roles change cyclically (Csikszenthmihalyi, 1991), and depend on the concept discussed. These bridging experiences link learners towards cognitive shifts that should in turn influence behavior and cognitive understanding of concepts (Taylor, 1991).

Scaffolding, modeling, and reflecting domains of the CA framework were used during each teacher PD for treatment participants. Descriptions of how the framework was used throughout each PD are provided in the following chapter. Robust implementation of this model of learning during the PD is hypothesized to influence teaching reform practices enough to increase RTOP instrument scores over time (Figure 1); which should increase student engagement and increased levels of students' mathematics readiness.

Figure 1. *Cognitive Apprenticeship Framework*



Frameworks provide a backdrop for understanding teacher and student behaviors found in reformed classrooms as well as interactions between mathematics teachers in treatment teacher PD. The facilitator will work alongside participants as the expert, as well as designate expert and novice partners during the PD sessions. Given the novice and expert interactions of the CA framework, treatment effects were found with confidence; the effects of the PDe hypothesized to positively change participants' implementation of reform teaching. This study's treatment centered on a CA framework, where the PD for teacher participants used modeling, scaffolding, and reflecting domains to assist teachers in understanding and over time implementing reform practices in their mathematics classrooms.

CHAPTER III

METHODOLOGY

Introduction

This chapter addresses the research design and methods used to explain relationship(s) among variables in the proposed study: teacher professional development (PD), reform practices and student engagement; which were found to impact college readiness in mathematics for students in the literature review. The research questions were addressed using a quasi-experimental, parallel mixed design (Tashakkori & Teddlie, 1998). This chapter includes descriptions of the design, sample, data, instrumentation, and analysis for each research question. Threats to validity, reliability, and limitations conclude the chapter.

Overview of Study

Understanding the relationship(s) between student and classroom variables and college readiness required analysis over time. The initial classroom observation (pre observation) and assessment administration (pretest) began in early spring and concluded later in the semester of the same school year. The study took a total of 12 weeks, the length of one grading period. Observations and assessments took place on two occasions to avoid confounding effects with the treatment and also to establish a baseline before treatment. Pre and post classroom observations of each treatment and control teacher took place with a minimum of 50 minutes for each instructional observation. After the initial baseline observation(s), treatment teachers participated in three separate PD sessions where the control group did not participate; all district teachers were required to obtain 24 hours of PD annually to maintain teaching certification as noted in KRS158.070, (KDE, 2014). Efforts were made to contact treatment participants via email and the designated community blog page throughout the duration of the study. All documentation during each observation were collected and kept confidential. After developing a formal interview protocol data collection ended with formal interviews of treatment participants.

The study used classroom, student, and teacher variables to address whether relationships exist between reform teaching in secondary classrooms, student engagement, teacher PD, and college readiness in mathematics. The student variables included college readiness in mathematics, and student engagement. Classroom variables included PD teacher participation and RTOP total score and sub section scores. Teacher variables include reform practice implementation and treatment PD (treatment and control groups).

Research Question(s)

The research question includes three subparts that are addressed separately in the context of the variables of interest in the proposed research design.

a) How does professional development *(teacher variable)*, framed by a Cognitive Apprenticeship model, affect the implementation of teacher reform practices *(teacher variable)?*

b) How does the use of teacher reform practices *(teacher variable and classroom variable)* affect student engagement in mathematics *(student variable)*?

c) How does the use of teacher reform practices (*teacher and classroom variable*) affect mathematic readiness for high school students *(student variable)*?

Quasi Experimental Mixed Methods Parallel Design

This research study employs a quasi-experimental design as described by Shadish, Cook, and Campbell (2002), where the researchers, "test descriptive causal hypotheses about manipulable causes," and "support a counterfactual inference about what would have happened in the absence of treatment" (p. 14). Also, the study uses a mixed method parallel design according to Tashakkori and Teddlie (2010), where qualitative and quantitative analysis will occur concurrently. This allows a comparison and triangulation of data to sufficiently address each research question.

Validity of Design

To account for leveled variables and the flow of the research questions, a parallel, mixed methodology design was used in this study (Teddlie & Tashakkori, 2009, 2003). This method was most appropriate because it takes into account different varieties (QUAN and QUAL) of data, which allowed an interpretations of findings from both quantitative and qualitative analysis simultaneously after all data had been collected (Teddlie & Tashakkori, 2009). A "bottom-up" approach to the design was used, in which research questions and methods related to one another (Teddlie & Tashakkori, 2003), as it “enhances the quality of the interpretation” (p. 353). Each research question contained a mix of both quantitative and qualitative data collections and analysis. Parallel mixed designs (Teddlie & Tashakkori, 2009) are “a family of mixed method designs in which mixing occurs in an independent manner either simultaneously or with some time lapse.

Research design in Table 1 include both pre and post tests for students’ mathematics readiness and one pretest and one posttest for reform measures.

Table 1. *Research Design*

	ACTmath,ACT Plan math,	Diagnostic 3	Reform Teaching RTOP	**PD 1**	**PD 2**	**PD 3**	Reform Teaching RTOP	Proficiency3	ACT math practice
Treatment Teacher N =5	T_1	T_2	O_1	X_1	X_2	X_3	O_2	T_3	T_4
Control Teacher N=5	C_1	C_2	O_1				O_2	C_3	C_4
Student n = 207									

In Table 1 the subscript number indicates number of test, treatment, or observation that took place.in the sequence of the study. For example, T_1 indicates test 1for treatment classrooms and C_2 indicates test 2 for control classrooms. This table shows when observations and treatments took place during the study according to the mixed methods parallel research design.

The QUAL and QUAN strands are planned and implemented in order to answer related aspects of the same questions” (p. 31). This method aligns with this study as some variables are addressed in more than one research question; such as reform practices. Most importantly, combining experimental, interview, and observation data “helps the researcher identify omitted variables and helps improve model specification, which is essential if statistical modeling is to be trusted”, (Teddlie & Tashakkori, 2003, p. 401). In Table 2 each research question and its analysis components are provided. The data source and analysis tool for each question are included. Findings from quantitative and qualitative analysis were compared and converged to answer each research question. Description of the methodology used to address each research question, its instrumentation, data, and required analysis follows the sample and procedure descriptions.

Table 2. *Data Analysis Summary*

Research Question	Data Source	Instrument	Analysis Tool	
(a) How does professional development, framed by a CA model, affect the implementation of teacher reform practices?	Observed RTOP scores	RTOP	Descriptive statistics ANCOVA	QUAN
	Teacher Interview Blog Post Facilitator PD notes	Interview Protocol Community Blog	Constant comparative process	QUAL
(b) How does the use of teacher reform practices affect student engagement in mathematics	Observed RTOP scores	RTOP	Descriptive statistics	QUAN
	sectionIII Teacher Interview Blog Post Facilitator PD notes	Interview Protocol Community Blog	Parameter estimates Constant comparative process	QUAL

(c) How does the use of teacher reform practices affect mathematic readiness for high school students	Infinite Campus	ACTmathPlan, ACTmath Practice District Diagnostic3 District Proficiency3	Descriptive statistics ANCOVA	QUAN QUAN
	Teacher Interview	Interview Protocol	Constant comparative process	QUAL

Sample

This study generalizes to public high school secondary mathematics teachers from urban districts in the Midwestern states in the United States, and particularly high school mathematics teachers who teach students during accountability testing years (eighth grade-ACT Explore, sophomore-ACT Plan, and junior-ACT). All Kentucky high school seniors are required to enroll in a mathematics class that is an Algebra II equivalent or higher, therefore, some student groups included seniors and in some rare cases sophomores. Teacher participants had secondary mathematics teacher certification and highly qualified status as determined by the Kentucky Professional Standards Board (www.epsb.ky.gov). All teacher participants had prior training administering ACT and district written assessments. Students of teacher participants included students who qualify for extended services specified in an Individual Education Plan (IEP), Comprehensive, Honors, and Advanced Placement (AP) students, as well as English as a second language learners (ELLs). The final treatment sample included five treatment and five control participants with a total of 207 students.

Sampling Procedures. To obtain a sufficient sample size for analysis of all variables of interest, emails were sent soliciting participants to all high school principals and mathematics department chairpersons in the district. At the time of the study, the district had approximately 330 mathematics educators and resource teachers across all grade levels. Efforts were made to reach as many participants as possible; weekly emails were sent to department chairpersons until participants responded to email request. Additionally, invitations were sent to members of the local affiliate group of the National Council of Teachers of Mathematics (NCTM) secondary mathematics teachers with board members' permission.

Teachers replied to the email invite to participate as either a treatment or control group teacher participant. Each email invite contained a link which directs the prospective participant to complete a teacher survey questionnaire online via google documents. The invite requested information such as preferred day of week to meet for face to face PD, years of experience, class subject, and teacher knowledge of reform practices as adapted from Brahier and Schaffner's reform teacher questionnaire (2004, p. 178). Once teacher treatment and control groups were solidified, consent forms were administered, and collected. Class rosters of students were then sent to from treatment and control teacher participants. Characteristic data used to match treatment and control groups included teaching experience, school characteristics, scheduling format, and curriculum pacing. Matched treatment and control groups according to common characteristics insured the groups were comparable (see Table 3 below).

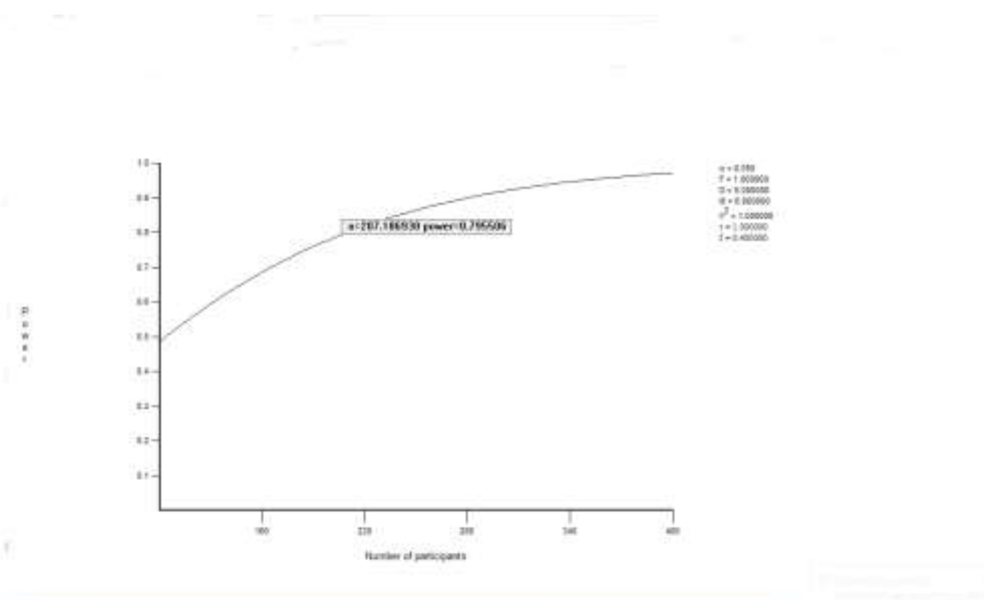
Table 3. *Matched Treatment and Control Group Comparisons*

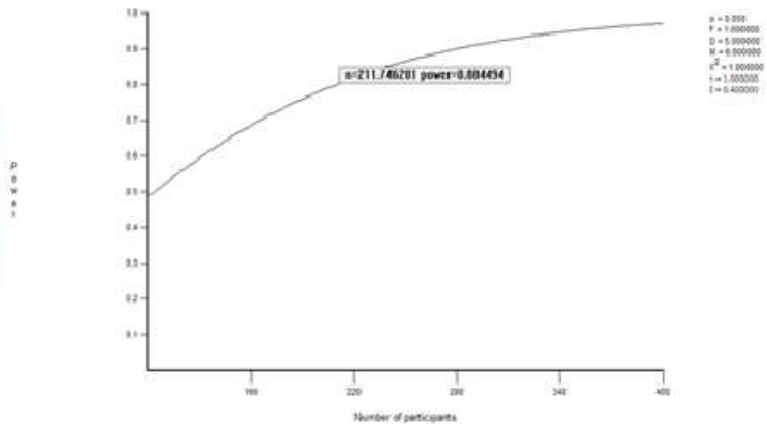
Group		Classroom	Teacher Participants	Student N	Teacher Experience
Treatment	*Algebra 2*	*Comp.*	*100*	*9*	*10-15*
Control	Algebra 2	Comp.	104	15	10-15
Treatment	*Algebra 2*	*Comp.*	*103*	*21*	*10-15*
Control	Algebra 2	Comp.	102	27	5-10
Treatment	*Geometry*	*Honors*	*107*	*21*	*15-20*
Control	Geometry	Honors	109	17	10-15
Treatment	*Geometry*	*Comp.*	*101*	*15*	*5-10*
Control	Geometry	Comp.	110	23	1-5
Treatment	*Algebra 1*	*Comp.*	*106*	*28*	*1-5*
Control	Algebra 1	Comp.	105	31	1-5

Treatment participants self-selected as a participant in the treatment group or a control group member. Once the treatment group had been finalized groups were matched then paired.

Sample Size, Power, and Precision. Participants included public high school mathematics teachers in an urban district with students classified as sophomore, junior, or senior. Findings from this research study should generalize to populations of students in similar districts (e.g. urban settings in a somewhat rural state). Teachers volunteered to participate in the study as either treatment or control participants making the sample for this study a convenience sample (Creswell, 2007).

Figure 2. *Power Analysis*





In order to increase power given small number of convenience sample participants, treatment and control groups were matched according to common characteristics (Gail et al., 1996), and pretest were used as covariates in ANCOVA analysis (Shadish, Cook, Campbell, 2002).

This study included five treatment and five control group participants, with a minimum of nine students in each group with a total of at least 207 student participants. Teachers were offered PD credit, up to six hours total, for time spent during treatment PD sessions. PD facilitator submitted proposal and received permissions from administrators to facilitate PD. Teachers who earned credit completed online evaluations before credit was applied to their required hours earned. The sample size was based upon participant volunteers or convenience sample selection. Larger sample sizes increase the robustness of quantitative analysis; therefore, reliability and validity violations were reported in the conclusion of this chapter. For example, the study would need a minimum of 280 student participants, six treatment and six control teacher participants with a minimum of 25 students per class, to insure a power of .80 and effect size of .25, according to a priori testing in Optimal Design software (Raudenbush et al., 2011). Smaller sample sizes decrease effect size estimates that assist with determining "the strength of treatment or intervention, as well as, the conclusions about group differences" (Creswell, 2007, p. 335). For example, the study could have a minimum of 200 student participants, eight treatment and eight control teacher participants with a minimum of 25 students per class, but a power estimate of .80 and effect size of .10, according to a priori testing in Optimal Design software (Raudenbush et al., (2011).

Teachers who elected to participate in the treatment group were expected to attend three separate PD sessions on reform teaching practices. Teachers who elected to participate in the control group did not attend the PD sessions; however, they agreed to release assessment scores, and classroom observations. Students of teacher participants had their parent and/or guardians complete a signed consent form. Once forms were signed, teacher participants collected them. All forms remained kept in a secure location. All student and teacher participant names were coded and changed to numbers. Efforts were made to ensure classroom observation videos, RTOP scores, and teacher/researcher field notes were stored electronically and confidentially. If requested, teacher participants were provided observation notes taken during their instruction. Treatment participants agreed to an interview at the conclusion of the study. Due to variances in class times throughout the district, and time necessary to accurately assign an RTOP instrument score, each observation required a minimum of 50 minutes of classroom instruction time. This ensured that the RTOP scores reflected reform practices with fidelity. Most high schools in this district operate on a trimester schedule with 70 minute class periods, while other high schools have varied forms of two trimester schedules or block scheduling. The 50 minute minimum insured the data reflected equal observation time for all teacher participants regardless of school schedule format. Each classroom observation took place during the entire time that is designated for that specified class period according to the individual classroom schedule.

Matched groups. Treatment and control participants were matched according to common characteristics. The matched groups included two treatment and control groups for each Geometry and Algebra II groups. There were one matched pair of Algebra I treatment and control groups. Teacher participants included high school mathematics teachers from one of Kentucky's largest public school districts who volunteered to participate in either treatment or control groups. Inferences from this sample, if significant, would generalize to public secondary mathematics teachers from other urban districts. The district of the study has 26 public high schools, each with a varying number of mathematics teachers, however, after all possible Algebra II teachers had been found other content area secondary mathematics teachers (i.e., Algebra 1, Geometry) were found in the study. This ensured the results generalize to secondary high school mathematics teachers in somewhat urban districts and that group sizes were comparable.

Data Analysis

The following section explains uses of mixed quantitative and qualitative portions of data and analysis to address each research question. Components of each question in terms of concepts/framework, instrumentation, data, and analysis are explained in the context of the quasi- experimental, mixed, parallel design.

RQ (a) How does professional development, framed by a Cognitive Apprenticeship model, affect the implementation of teacher reform practices?

Framework

In an effort to increase implementation of reform practices, address students' mathematics readiness for secondary students, and engage students in mathematics classrooms, a CA frame for the teacher PD was used. PD also incorporated Wilson and Bernes' model (1999) of effective PD found to promote reform implementation as well as positive teacher and student learning outcomes (Horn, 2005). Expectations of state and district requirements for quality professional development were met (see Appendix I), as well as Desimone's expectations for quality efficient PD. "Teacher participation in content related PD, after controlling for experience, formal education degrees, and self-reported content knowledge is positively associated with increased use of reform teaching strategies" (Smith, Desimone & Ueno, 2005, p. 101). In this model and learning context the PD facilitator encouraged frequent teacher interactions (Horn, 2005) and the activities during each session "seek to activate, rather than deliver, teacher learning," (p. 208). In this study the researcher participated as the PD facilitator (see Figure 1).

Researcher's Role

Roles included mathematics teacher, PD facilitator, mentor teacher, collaborator, and blog manager. The researcher taught high school mathematics in the district where the study took place, had collaborated with control and treatment participants in PDs for 13 years, and worked as a mathematics teacher in the district. The researcher had worked with various mathematics teachers as a resource teacher for the Kentucky Teacher Internship Program (KTIP). Also, the researcher had facilitated school level PD as well, as presented PD at regional and national level conferences that focused on secondary mathematics, curriculum, and instruction.

Treatment (Teacher Professional Development: PD1, PD2, PD3)

Self-selection occurred on the teacher level to either be a part of the treatment group or control group and College Preparatory Mathematics Curriculum (CPM), and Kentucky Core Academic Standards (KCAS) materials were used throughout each session. These were the most common curriculum materials used amongst participants according to teacher reporting. The PD focused on reform practices such as scaffold learning, modeling mathematical practices [treatment professional development session 1 (PD1)], student centered classrooms, classroom discourse or talk moves, cooperative learning groups [treatment professional development session 2 (PD2)], and discourse in mathematics classrooms, mathematics practices, conceptual development [treatment professional development session 3 (PD3)]. CA domains used throughout each treatment session included scaffolding, modeling, and reflecting concurrently. PD for teachers took place on three consecutive bi weekly two hour meetings during the spring semester until the end of the school year. Meetings took place at a local high school's media center after school during the week, via google hangout, and continually on community page interactions. Participants had access to a laptop, and internet during each face to face PD session (see Table 4). Each treatment session included elements of CA framework, video topic and discussions questions to focus the meeting, see Table 4.

Table 4. *Overview of Treatment Professional Development*

Session	CA Framework	Video Topic	Discussions Questions
PD1	Modeling	Owning the CCSS and 8 mathematical practices in Geometry class. Modeling Real World Situations in Algebra II Video Source: The Teaching Channel	Where do you see "modeling" of the CCSS eight mathematical practices in action? What other reform teaching practices do you see in the video clip? What are ways I can implement these reform practices in my mathematics classroom?

PD2	Scaffolding	-Talk Moves in Academic Instruction Geometry Transformations. Video Source: The Teaching Channel	Does PD, when and how often, inform how you implement reform practices in your classroom? What are some student centered elements you ensure are in place on a daily basis in your classroom? What other reform teaching practices do you see in the video clip?
PD3	Reflecting	Beyond Right Answers: Math and CCSS Daily Assessment with tiered Exit Cards". Video Source: The Teaching Channel	How can we as mathematics teachers in the district improve our instruction to promote student engagement in mathematics? How can we make time in class for students to develop a "deeper" conceptual understanding of learning targets? How can we get students to "own" the Common Core Mathematical Practices?

During the PD, the facilitator provided teachers with resources to assist them with reform practice implementation such as conversation starters, questions to probe student thinking, or activities to promote student engagement in mathematics classrooms. Teachers were provided videoed classroom examples of reform practices to insure they are well versed in authentic examples of the reforms. Teachers were assisted with identifying, planning, and future implementation of mathematics reform practices, particularly those found in mathematics talk communities (Hufferd-Ackles et al., 2004) for high school mathematics classrooms (Rousseau & Powell, 2005), as well as, discussed practices that employ mathematical discourse purported in the literature to most positively impact mathematics success for high schools students. The teacher led PD used Wilson and Bernes' model (1999) and Desimone's (2009) model of effective PD which was found to promote reform implementation as well as positive teacher and student learning outcomes (Horn, 2005). This model of PD involved communities of teacher learners who "redefine reform practices to fit their specific learning context" (Desimone, 2009, p. 192). The PD had a "content focus, active learning, coherence, duration, and collect participation" (Desimone, 2009, p. 185) amongst treatment participants.

During the video cycle more than one domain of the framework was used. The PD facilitator encouraged frequent teacher interactions (Horn, 2005) and the activities during each PD session were planned to "seek and activate, rather than deliver, teacher learning" (p. 208) using key concepts commonly discussed in the cognitive apprenticeship literature (Dennen & Burner, 2007).

Each video cycle included questions to focus the participant, a five to ten minute video of teacher experts modeling reform instructional strategies, and concluded with time for discourse amongst teacher participants. The interactions in person as well as on line encouraged discourse amongst the members of the community of practice.

Treatment participants were asked to attend three separate PD sessions (PD1, PD2, and PD3) after the initial baseline videoed classroom observation. Each session took place at a local high school in the district for two hours in person or via online through google hangout with a specific agenda that included an opening interactive activity, essential question(s), and video lesson analysis with intermitted discussion, future lesson planning and closure. The opening activity engaged participants in discussion about the essential questions. Teachers were provided with current research on topic of discussion. The video analysis cycle required participants to work in pairs based upon the common content they teach. Participants were given access to specified videos selected from Teaching Channel and Illustrative Mathematics websites.

Domains of the CA framework were used throughout each treatment PD session. Teacher and/or expert actions included "*modeling* demonstrating the thinking process, *coaching*: assisting and supporting student cognitive activities as needed (includes scaffolding), *reflection*: self-analysis and assessment, *articulation*: verbalizing the results of reflection, and *exploration*: formation and testing of one's own hypotheses" (Dennen & Burner, 2007, p. 427).

During each video cycle the participants discussed how and what they currently do in their classroom or school compared to what was seen in the modeled example. In this activity the facilitator and teachers used the reflection domain. In each video cycle the facilitator provided a video example of teachers embedding various instructional strategies throughout their mathematics lesson, using the model domain. Participants explored with the facilitator and discussed how these practices could be implemented in their classrooms to development students' conceptual understanding of the learning target currently being taught. Conversations generated new ideas, using the articulation domain. All reflection data, video blog post(s), were kept confidential and used during analysis. The closure in each PD session focused discussions back toward the essential question(s), provided opportunity for participants' questions, and planned for future lessons. During the interview participants used articulation and reflection domains to determine the effectiveness of the reform strategies implemented.

Curriculum. Content specific curriculum resources (e.g. CPM) used in each PD reflected CCSS from Algebra I, Geometry, and Algebra II. District pacing for each content area being taught was developed through collaboration with the district mathematics specialist and other mathematics educators. All teachers in the district are expected to teach the CCSS and address focus topics aligned with Quality Core Mathematics Standards specified in district pacing guide. Additionally, all Algebra II, Geometry, and Algebra II teachers must administer a district written formative and summative assessments according to the pacing and assessment window as designated in the curriculum pacing guide.

Each PD session power point presentation, participant resource handouts, and reflection posts were stored on a google community page online for access by group participants. Participants had access to the teacher videos specified for analysis and training via the mathematics community blog page.

Treatment PD1. The essential questions that focused the first session include the following, "What do reform practices look like? What are ways I can implement reform practices in my mathematics classroom?" The opening activity had a dual purpose of engaging participants and allowing time for the facilitator to formatively assess participants on their knowledge of reform practices. This time was also used to develop a common language between treatment participants and PD facilitator to positively impact reform practice implementation (MacIsaac & Falconer, 2002). Participants were provided examples and a definition of reform practices in action. For example, modeling techniques were used to explain to teachers how the RTOP instrument quantitatively measures their level of reform practice implemented.

The video cycle familiarized participants with other constructs measured during each classroom observation such as modeling CCSS the eight mathematical practices, scaffolded learning, and classroom discourse. The facilitator provided questions to focus participants while participants watched videos:

Where do you see "modeling" of the CCSS eight mathematical practices action?

What other reform teaching practices do you see in the video clip?

What are ways I can implement these reform practices in my mathematics classroom?

The first video came from the Teaching Channel network and showed how one Geometry teacher uses hint cards to scaffold learning for students during classroom investigations. The second Teaching Channel video showed how one high school Geometry teacher models two of the eight CCSS mathematical practices for students in her geometry class. The facilitator had partners discuss what these mathematical practices would look like in their classrooms. Treatment participants were encouraged to continue discussions online using the google community blog page. The facilitator brought the group together and led the whole group in a concluding discussion. In this discussion the teachers and facilitator referred to the definitions of classroom discourse, and reform practices. In this discussion a common language between PD facilitator and participants were established.

Treatment PD2. The essential questions that focused the second session include the following, "What are barriers to student centered instruction? What are ways I can use new reform practices in my classroom"? The opening activity had a dual purpose of engaging participants and allowing the PD facilitator an opportunity to formatively assess participants' knowledge of student centered versus teacher centered mathematics instruction. The session was facilitated via google hangout or face to face depending on teacher preference as specified in the teacher survey administered at the beginning of the study. The teacher survey asked participants which day of the week they preferred to meet, about their professional development, current textbook, demographics see Appendix B. Participants interacted via the hangout and community blog page with the facilitator. Questions to center discussions after watching the video included the following:

Does PD, when and how often, inform how you implement reform practices in your classroom?

What are some student centered elements you ensure are in place on a daily basis in your classroom?

What other reform teaching practices do you see in the video clip?

Scaffolding techniques were used when leading participants through video viewing cycles. During the video cycle teachers discussed student centered classrooms where "students engage in and negotiate mathematical meanings where cognitive, social, and cultural differences are honored and respected" (Malloy & Malloy, 1998, p. 248). Pairs of participants watched designated videos downloaded from the community blog page. Participants discussed the questions posted on blog and other observations made from the videos. Discussions included student engagement, discourse, and purposeful teacher actions in the classroom. The facilitator provided comments and scaffolded questioning to probe teacher participate thinking about student engagement activities. The facilitator also provided examples of student centered activities on blog page. Participants were expected to use community blog page to reflect about reform practice implementation in their mathematics instruction and interact with other participants at least once a week. Facilitator posted questions weekly to encourage teacher participation.

Treatment PD3. The essential questions that focused the third PD session included the following: "What are barriers to student discourse in mathematics classes? And what are ways I can use paraphrasing techniques in my mathematics classroom"? The opening activity had a dual purpose of engaging participants in a think pair share activity while allowing formative assess of participants' knowledge of conceptual and procedural knowledge in mathematics classrooms. When "sharing" participants discussed with the group the activities they have used in their classroom to promote mathematics versus skills and concepts. The facilitator had large post-it chart paper that lists concept versus skill in the center. Participants shared out responses about where they believed the activities should be placed. The facilitator listed them in the appropriate category on the chart paper. Reflective or paraphrasing domains of CA were prevalent throughout conversations with treatment participants when defining and providing examples of conceptual concepts activities used in secondary mathematics classrooms.

Participants then watched a video on implementing CCSS in high school mathematics and classrooms teachers discussed and reflected with a partner paired to match their content. In this conversation they became familiar with at least two of the eight CCSS mathematical practices to complete the next task. Participants were provided handouts of mathematical practices and practice implementation strategies (see Appendix F). After selecting CCSS according to the district pacing guide for high school mathematics courses and the learning target they currently teach, participants wrote out the concepts they would address in their classrooms to teach a particular CCSS and/or learning target. After explicating the concept, participant pairs considered how the mathematical practice(s) selected can be used to teach the concept to students. In this conversation, participants highlighted or documented teacher and student tasks. Next, participants planned to implement these tasks in future planning and/or delivery of a lesson and considered a group assessment that would help determine students' conceptual understanding of the CCSS content standards, eight mathematical practices and learning target. Facilitator assisted teachers with planning and implementation this lesson. Questions to center discussions during video cycle included the following:

How can we as mathematics teachers in the district improve our instruction to promote student engagement in mathematics?

How can we make time in class for students to develop a "deeper" conceptual understanding of learning targets?

How can we get students to "own" the Common Core Mathematical Practices?

Once the video cycle was complete the facilitator brought the group together and led the whole group in a concluding discussion. Participants were expected to share any future ideas for next steps, blogs, or post on the community blog page. These facilitated discussion(s) on the page, provided feedback, resources, and additional support for teachers interested in creating lesson plans, activities, or assessments that emphasize reform practice implementation.

Instrumentation

The RTOP provided a score to measure reform teaching with values ranging from 0 to 100. The Reform Teaching Observation Protocol (RTOP) (Piburn & Sawada, 2000; Sawada et al., 2002) instrument measures presence of reform practices and levels of student engagement observed in the science or mathematics classroom. For this study the RTOP instrument measured reform practices, pedagogies that encourage student centeredness, discourse, and inquiry and student engagement in the observed lesson. The RTOP instrument measures reform practices; “the instrument arises from research-based literature that describes inquiry-oriented, standards-based teaching in mathematics” (Sawada et al., 2000, p. 14).

Teacher interviews and blog posts provided information about teacher implementation of practices as well. The interview questions were adapted from the RTOP instrument manual (Sawada et al., 2002) and essential questions used during the PD sessions. The interview protocol required interviewee to refer to the post observation or a post treatment lesson in their response. Interviews took approximately eight to ten minutes (see the RTOP protocol Appendix A). Interviews were conducted with four of six treatment teacher participants. Two treatment teachers were not available for the interview. One teacher changed careers before concluding the study. Another teacher dropped out of the study after attending one session due to personal reasons. The purpose of the interviews were to gain insight on treatment teacher perceptions of the PD in terms reform practice implementation as a result of participating in the treatment PD sessions, student engagement, and student conceptual understanding during an observed lesson taught post teacher treatment. The topics explored in the interview included, student engagement in mathematics class, student conceptual understanding in mathematics class, teacher implementation of reform practice, and CA framework used during PD. Student engagement (Attard, 2012) and reform practice implementation, (Desimone, 2007), were variables that impacted student mathematics achievement according to research. The overall goal included understanding which factors that relate teacher implementation of reform practices, given CA framework, and to understand treatment effects on teachers' classroom practices.

Questions asked in the interview provided qualitative data for analysis. At the time of the interview two participants, 100 and 106, had completed a lesson that were planned with the PD facilitator post RTOP observation. The first four questions and subparts had the interviewee describe student engagement and conceptual understanding during a lesson they taught post PD. The remaining four questions and its subparts asked the teacher about the PD and the CA framework. Interviews took place in a school setting during the treatment teachers' planning period, after school, in a quiet location. The total interview was recorded with an iPhone and transcribed later. Interviews took eight to ten minutes each.

Qualitative Analysis

The constant comparative process was used to analyze qualitative data where, information from data collection was compared and organized into themes or categories (Creswell, 2007). One theme established a priori included changes in reform implementation. This theme was selected given synthesis of research surrounding reform practices in mathematics classrooms for secondary levels in the literature review. Additional categories included scaffolding, modeling, and reflecting domains of CA framework. All qualitative data (treatment teacher interviews, researcher field notes, and blog posts) were collected, printed, and put into a three ring binder to conduct analysis. Each entry was read several times; categories, and themes that emerged from data (Moustaka, 1994) were noted.

One emerged theme included the development of a mathematics community of learners. Themes were then adjusted to accurately reflect included data using an iterative process (Creswell, 2014). Findings include themes prevalent throughout all qualitative data sources that address the specified research question.

First, all data were highlighted and coded to match the theme or category. The data were read and highlighted, a specific color, items that were identified as belonging in the category or theme. All qualitative data were read several times until all themes had been identified and coded in the data to address the research question. For example, each domain of CA used throughout the treatment PD1, PD2, PD3 was coded a different color: scaffolding (purple), modeling (light green), and reflecting (pink). Figures 3 and 4 are passages from field notes coded as teacher modeling for students in mathematics classrooms. In figure 3 the teacher models for students how to graph linear inequalities.

Figure 3. *Field Note Excerpt Treatment Teacher 106 Algebra I Post Treatment*

A student shares response and teacher goes over the solutions with the class and models for students how to graph the inequalities using the slope and the y intercept. One student then asks, "How do you do the zero thing". Teacher says, "If I plug zero in for x and y to see if the origin is a solution to the inequality. After plugging in zero if it's false then shade opposite the side of the line from the origin".

In the following excerpt a control Algebra I teacher, 105, models for students how to solve a system of linear equations using the distributive property. In this example the teacher guides small groups of students and uses a white board to demonstrate for students necessary steps to solve the problem.

Figure 4. *Field Note Excerpt Control Teacher 105 Algebra I Post Treatment*

Make sure this example is in your notes. Teacher writes the following problem on a small white board and then stands in front of the group motioning to get their attention.

$$\begin{cases} 6y - 5x = 20 \\ 4(3x - 2) + y = 2 \end{cases}$$

*She (*the teacher*) then says, "When combing terms you have to make sure the terms are the same first. Does the term have an x? If so, then you add them. If not move on". Teacher then begins to solve the second equation. One student asks, "How did you get 12? The teacher states, "You multiple 3 and 4 using the distributive property". She draws arrows to items on the white board.*

$$4\,(3x - 2) + y = 2$$

$$12x - 8 + y = 2$$

These occurrences were coded as teacher modeling reform practices for students in mathematics classrooms because the teacher in both observations modeled for students a mathematical procedure as an expert.

Second, themes were added or adjusted to accurately reflect included data and address the research question. Changes in student engagement and conceptual understanding were changed to teacher reported changes in student engagement and conceptual understanding. One theme that emerged included teacher perceptions of mathematics as a community of learners and/or teacher PD. Six occurrences of this theme were observed in the qualitative data. In Figure 5 Algebra II treatment teacher, 103, talks about mathematics PD for high school teachers when responding to question eight of the interview (see Interview Protocol Appendix C).

Figure 5. *Interview Excerpt Treatment Teacher 103 Algebra II Post Treatment*

I really think we should keep something like this going. Teachers need to work together and support one another - it's about creating a community like mathematics resource teachers worked to do in the past.

This interview response was coded as teacher knowledge and/or beliefs of PD because the teacher referenced support from the district that once promoted a mathematics teacher learning community.

After compiling themes and triangulating data from all sources, a textual description was merged into a final description that detailed reform practice implementation of treatment teacher participants in this study. Quantitative and qualitative analysis results were combined, as suggested in the parallel, mixed methods design.

Quantitative Analysis

Quantitative analysis began with recording all data prior into Excel spreadsheet for assumption testing (Tabachnick & Fidell, 2007). Dependent variables included all post tests and were continuous measures. The covariate of group differences were evaluated for homogeneity of variance and for correlations to dependent variables (DV)'s. Scatterplots of DVs were plotted then analyzed to determine normalcy (Tabachnick & Fidell, 2007). No significant outliers were found in measures.

A 2 × 2 between subjects ANCOVA at was conducted with independent variable treatment, pretests as covariates, and posttests as dependent variables. "The goal is to obtain maximum adjustment of the dependent variables with minimum loss of degrees of freedom for error" (Tabachnick & Fidell, 2007, p.

200). Mean differences between the treatment and control group on the posttest were compared after the posttest scores were adjusted for differences in pretest scores due to pretests. Differences between subjects based upon pretests as covariates were removed so that the only remaining differences relate to the effects of the grouping treatment or control. This enhanced the prediction of students' mathematics readiness and reform teaching without causality. The statistical analysis tested the null hypothesis that students' mathematics readiness, engagement, and reform teaching do not differ with group placement. Description of ANCOVA model are detailed in quantitative analysis section of RQ(c)

RQ (b) How does the use of teacher reform practices affect student engagement in mathematics**?**

To address whether teacher reform practices had an effect on student engagement in mathematics, student engagement was measured using sub section III, and IV from the RTOP instrument and questions three and four from the interview protocol. The RTOP instrument measured reform practices and student engagement in mathematics classrooms. According to Attard (2012) mathematics engagement occurs when, "mathematics is a subject students enjoy learning, students value their mathematics learning and see its relevance in their own lives now and in the future, students see connections between the mathematics they learn at school and the mathematics they use outside of school" (p. 11). The IV, RTOP sub score, included teacher professional development (group placement), reform teaching practices (RTOP teacher score) and student engagement (RTOP subsection III, IV and teacher interview).

Instrumentation

The Reform Teaching Observation Protocol (RTOP) (Piburn & Sawada, 2000; Sawada et al., 2002) instrument measures the presence of reform practices and levels of student engagement. For this study the RTOP instrument measured reform practices, pedagogies that encourage student centeredness, discourse, and inquiry and student engagement in the observed lesson. The RTOP instrument measured reform practices; “the instrument arises from research-based literature that describes inquiry-oriented, standards-based teaching in mathematics” (Sawada et al., 2000, p. 14).

Teacher interviews and blog posts provided information about teacher implementation of practices. The interview questions are adapted from RTOP instrument manual (Sawada et al., 2002) and essential questions used during the PD sessions. The interview protocol required interviewee to refer to the post observation or a post treatment lesson in their response. Interviews took approximately eight to ten minutes. See Protocol (Appendix C).

Data

The RTOP was used as pre and post reform measures of reform practices used in the classroom during mathematics instruction. The RTOP score relied upon observation of at least 50 minutes of instruction for each treatment and control teacher participant. The assessment has five subscales: I. Lesson and Design Implementation, II. Prepositional Pedagogic Knowledge III. Procedural

Pedagogic IV. Classroom Culture-Communicative Interactions and V. Classroom Culture-Teacher Student Interactions. Each subscale was derived from theoretical frameworks that address mathematics teaching and learning (sociolinguistic, sociocultural, and social constructivist) in reformed classrooms (Sawada et al., 2002). The assigned score included the sum of total assigned points added together from each category and was used as the RTOP score for a particular teacher participant. Both treatment and control groups used the same mathematics content in the classes observed throughout the duration of the study.

Treatment teachers were asked to elaborate on student engagement in interview and the sub scores from RTOP sub section III were used to determine student engagement. RTOP sub section scores range from values of 0 to 20 where the higher score indicates higher levels of reform practices observed. Scorers selected from a Likert scale a numerical value (range 0 – 4) that represents the intensity of the reform practice observed. RTOP scores were collected and grouped according to each teacher participant and subject. Group means for each subscale of the RTOP was calculated and recorded as a part of descriptive statistics during analysis.

NCTM's view of reformed teaching includes, "conceptual understanding that connects prior knowledge with new experiences through active inquiry based learning, socially constructed, and student centered" (Jong et al., 2010, p. 310). "RTOP operationally defines and assesses reform teaching in mathematics classrooms (MacIsaac & Falconer, 2002); its items address behaviors that occur in mathematics classrooms between the teacher and students" (p. 480). Table 5 includes reliability information for each of the five RTOP sub sections. Cronbach alpha values close to one indicate a high and consistent reliability in scoring of the particular sub section from the RTOP instrument. These values limit violations to construct validity. Table 6 include sample questions from RTOP instrument subsections III and IV used to measure student engagement and student conceptual knowledge.

Table 5 *RTOP Instrument*

RTOP	Cronbach Alpha	Score
Class session RTOP score (RTOP)	.94	Reform Practice score 50 or higher
Lesson Design and Implementation	.915	
Propositional Pedagogic Knowledge	.670	
Procedural Pedagogic Knowledge	.946	
Classroom Culture-Communicative	.907	
Classroom Culture-Student Teacher relationships	.872	

Table 6. *RTOP Sample Questions Subsection III and IV*

III. Lesson Design and Implementation		
2)	The lesson was designed to engage students as members of a learning community	0 1 2 3 4
3)	In this lesson student exploration preceded formal teacher presentation	0 1 2 3 4
IV. Classroom Culture and Interaction		0 1 2 3 4
7)	The lesson promoted strongly coherent conceptual understanding.	0 1 2 3 4

(Piburn & Sawada, 2000)

For the purposes of this study, reformed classrooms included teachers whose observed reform practice implementation resulted in a higher RTOP score (50 - 100); RTOP scores strongly correlate with student conceptual gains and effective teaching (MacIsaac & Falconer, 2002; Sawada et al., 2002).

Qualitative Analysis

A constant comparative process was used to analyze qualitative data (Creswell, 2007). One theme established a priori included changes in student engagement. This theme was selected given synthesis of research surrounding reform practices in mathematics classrooms for secondary levels in the literature review. All qualitative data (treatment teacher interviews, researcher field notes, and blog posts) had been collected, printed, and put into a three ring binder to conduct analysis. Teacher reported changes in student conceptual understanding emerged from data. Each entry was read several times (Moustaka, 1994) and themes were adjusted to accurately reflect included data using an iterative process (Creswell, 2014). Findings include all themes prevalent throughout all qualitative data sources that address the specified research question.

First, data were read, then any items that were indicators of changes in student engagement were highlighted blue. All qualitative data were read several times until the theme had been identified and coded in the data to address the research question. In Figure 6, a passage from interview data were coded for changes in student engagement.

Figure 6. *Interview Excerpt Treatment Teacher 106 Algebra I Post Treatment*

> *Uhm I feel like students were really engaged in the activity. Uhm we used clickers that day and so they were extremely excited whenever they were able to see their answers immediately they had the feedback uhm they actually got competitive with each other. They would actually smack talk whenever someone would get the wrong answer and they got the right tone.*

This occurrence was coded as changes in student engagement because the teacher reported what she observed as students engaging in learning mathematics.

Student conceptual understanding emerged from data and were highlighted red in the analysis. Figure 7 shows an occurrence coded as student conceptual understanding. This excerpt came from field notes recorded post treatment in a Geometry classroom. In this trigonometry lesson students explored properties of right triangles.

Figure 7. *Field Note Excerpt Treatment Teacher 107 Geometry Post Treatment*

Teacher walks around class and helps students with hands up, providing feedback. Teacher feedback/comments toward students include: "Draw the picture. Can you solve it a different way"? Teacher comments help students with further inquiry and feedback encourage conceptual understanding when solving. "Make sure you have a well labeled diagram. Think about a formula that may be relevant information. If you need to add to your diagram do so and think about the types of figures you have after adding additional segments in. Are you should that is going to be the sides that meet up to make a triangle? What else do you know about that triangle? How do you know that these two sides go with these two angles? What must be true? Think about your trig ratios." The interaction between teacher and individual students continue. After receiving feedback each time students restart problem again. The cycle continues for 25 minutes

This occurrence was coded student conceptual understanding because teacher questioning prompted students to adjust their answers until they arrived at a conceptual understanding reflected in a correct solution.

Themes were then adjusted to accurately reflect included data and address the research question. Occurrences may have fit into more than one category. For example the following field note excerpt in Figure 8 was coded as both student engagement and student conceptual understanding.

Figure 8. *Field Note Excerpt Control Teacher 105 Post Treatment*

1:34 Teacher begins with provided feedback for front group. Student from the group asks Teacher questions and she gives feedback on the error of combining like terms. One student in the group asks if his/her answers are right. Teacher brings the group together and models how to combine like terms when solving systems of linear equations. Teacher looks over work and offers feedback on the problems completed.

This occurrence was coded as both student engagement and student conceptual understanding because it showed students engaged in the learning activity as a group. Through student interactions with one another other and the teacher they were able to arrive at a higher conceptual understanding reflected in a correct response as reported by the teacher.

After compiling themes and triangulating data from all sources, findings from qualitative analysis were combined with findings from quantitative analysis to fully address the research question.

Quantitative Analysis

During quantitative analysis scatterplots of distributions of the DV reform teaching (RTOP scores) for treatment and control matched groups were plotted to check for normalcy (Tabachnick & Fidell, 2007). Descriptive statistics that include means and standard deviations aggregated according to treatment or control status assisted in determining reform teaching implementation across classes. Also, a comparison of scores from sub sections III assist in determining any changes in student engagement. Since no assumptions were violated, ANCOVA analysis proceeded. Details of ANCOVA model are discussed in RQ(c).

RQ (c) How does the use of teacher reform practices affect mathematic readiness for high school students?

To address the research question, college readiness as measured by ACT test sequence of three exams was be used to measure student mathematics success in terms of college readiness. Kentucky statute KRS 158.6451 requires all Kentucky public school students to take the Educational Planning and Assessment System (EPAS) tests from ACT, Inc., including ACT Explore for eight graders, ACT Plan for tenth graders, and the ACT for eleventh graders (KDE, 2015, p. 5). Benchmark scores are "empirically derived, based on actual student college performance, and predict the likelihood a student would earn a B or better in a college algebra course before finishing high school; which is associated with a 50% chance for a student to earn a grade of B or better and a 75% chance of a C or better in college entry-level mathematics courses" (ACT Inc., 2014, p. 3). Also, college readiness benchmark scores "offer a different and unrelated measure of student success when compared to other national normalized assessments" (ACT Inc., 2014, p. 4), making it ideal for measuring mathematics achievement in this study. Rather than comparing students' mathematics test scores to those of other students, the benchmark scores compare student performance against a standard measure of mathematics college readiness. This comparison allows stakeholders to predict college course success for each individual student based upon state benchmarks. Students who meet benchmark scores in mathematics are "likely on track to be successful in college algebra, provided students continue with a similar level of commitment to coursework and study habits" (ACT Inc., 2014, p. 4). College readiness benchmarks for the ACT determine "the level of achievement required for students to have a high probability of success in selected credit-bearing first year college courses", (ACT Inc., 2009, p. 2).

Additionally, ACT college readiness benchmark scores help mathematics teachers understand the areas where students need to improve to reach success in college level mathematics. Scores offer a "common language used to help define college readiness and relate state standards to postsecondary expectations" (ACT Inc., 2014, p. 3). To control for attrition, only the researcher scored and recorded ACT mathematics practice assessments in the study.

Instrumentation

To address the proposed research, four instruments were used to collect mathematics achievement data. Student ACT Explore, ACT Plan mathematics, ACT mathematics, and ACT practice mathematics assessment instruments measured students' mathematics readiness distally (ACT, Inc., 2014). District written assessments, one diagnostic and the other summative, measured students' mathematics readiness.

Treatment teacher blog post, PD facilitator field notes, and interview data were used during qualitative analysis. Treatment participant posts included items during any Community blog posts or interactions. Interview questions were based upon literature about reform teaching and student engagement.

Pre and Post Assessments. Threats to internal validity related to instrumentation due to changing assessments are minimized given the positive correlation between pre and post assessments. The pre assessment for Algebra I, Geometry, and Algebra II students are the ACT Explore math, ACT Planmath, and the ACT math respectively. The post assessment for all classes was the ACTmathpractice test. A positive strong correlation exists between ACT Plan mathematics assessment and ACT mathematics test (r = .94), (Koenig, Frey, & Detterman, 2008). Table 7 shows a positive correlation between all ACT testing instruments.

Table 7. *Means and Correlations for ACT tests*

Mathematics(N = 210, 651) Correlation

	Means	EXPLORE	PLAN	ACT
EXPLORE	16.6	1.00		
PLAN	18.9	.74	1.00	
ACT	21.2	.74	.82	1.00

(ACT Inc., 2011, p. 85)

ACT Explore Mathematics Test PRE. This measure is the first of three ACT assessment instruments administered throughout the district. This assessment was used to measure the initial students' mathematics readiness of freshman Algebra I students. The assessment uses a common scale score ranging from 1 – 25. The instrument contains 35 items and students have one minutes to 35 minutes to answer each question. The mathematics portion of the ACT Explore includes three subparts: Pre-Algebra, Algebra, and Geometry.

Students are considered college ready in mathematics if they score at least a 17 out of 25 in the mathematics section of the assessment. The district currently uses Explore as an entry point into ACT's College and Career Readiness System. ACT Explore, "Assesses academic progress, provides an early indicator of college readiness, helps students understand and begin to explore the wide range of career options open to them, and assists them in developing a high school coursework plan that prepares them to achieve their post high school goals" (KDE, 2015, p. 23).

ACT Plan Mathematics Test PRE. This assessment was used to measure initial students' mathematics readiness of sophomore Geometry students in the study. Students earn a common scale score ranging from 1 – 32. The instrument contains 45 items and students have approximately one minute to answer each question. The mathematics portion of the ACT Plan includes three subparts: Pre-Algebra, Algebra, and Geometry. Students are considered college ready in mathematics if they score at least a 19 out of 32 in the mathematics section of the assessment. The KDE recognizes the importance of ACT Plan testing for all students, as it focuses attention on both career preparation and improving academic achievement (KDE.org, 2011). The ACT Plan precedes the ACT and is an indicator of student performance on the ACT. Also, the ACT Plan provides a midpoint review of 10th graders' progress toward their education and career goals in time for interventions (ACT Inc., 2014).

ACT Mathematics Test PRE. This assessment was used to measure initial students' mathematics readiness of junior Algebra II students in the study.

Students are considered college ready in mathematics if they score at least a 19 out of 36 in the mathematics section of the assessment. The instrument contains 60 items and students have one minutes to answer each question. Students earn a common scale score ranging from 1 – 36. The mathematics portion of the ACT includes six subparts: Pre-Algebra, Elementary Algebra, Intermediate Algebra and Coordinate Geometry, Plane Geometry, and Trigonometry. "The items included in the Mathematics Test cover four cognitive levels: knowledge and skills, direct application, understanding concepts, and integrating conceptual understanding" (ACT Inc., 2014, p. 3). The ACT measures what a student has learned in mathematics during school and "determines a student's mathematics readiness to make successful transitions to college and work after high school. In this context, content-related validity is particularly significant", (ACT Inc., 2014, p. 51).

***ACT Mathematics Practice Test POST*.** This assessment was used to measure post students' mathematics readiness of freshman-Algebra I, sophomore-Geometry, and junior-Algebra II students in the study. Students are considered college ready in mathematics if they score at least a 19 out of 36 possible points in the mathematics section of the assessment. Instrument psychometrics are identical to those of the actual ACT mathematics assessment. This measure provided scores that reflected students' mathematics readiness data at the conclusion of the study. Data from ACT instruments assessments were used in quantitative analysis.

District PRE and Proficiency POST Assessments. The mathematics department in the district collaborates with teachers in the district to write diagnostic and proficiency assessments for the purposes of administering district wide on four separate occasions throughout the school year. Cronbach alpha reliability scores are within significant range for each assessment (.81) (JCPS, 2015).

Data

As suggested in the design, qualitative and quantitative data are used to address the research question. Quantitative data sources include assessment scores from each assessment of the following instruments: ACT Explore mathematics, ACT Plan mathematics, ACT practice mathematics, ACT mathematics, and the RTOP observation protocol. Qualitative data include teacher interviews, researcher field notes, and blog posts.

Qualitative Analysis

The constant comparative process was used to analyze qualitative data (Creswell, 2007). One theme established a priori included, changes in students' mathematics readiness. This theme was selected given synthesis of research surrounding reform practices in mathematics classrooms for secondary levels in the literature review. All qualitative data (treatment teacher interviews, researcher field notes, and blog posts) had been collected, printed, and put into a three ring binder to conduct analysis. Each entry was read several times (Moustaka, 1994) and themes were adjusted if necessary to accurately reflect included data using an iterative process (Creswell, 2014). Findings include themes prevalent throughout all qualitative data sources that address the specified research question.

First, all data were highlighted orange and coded as indicators of changes in students' mathematics readiness. In Figure 9, a passage from observation field notes were coded for changes in students' mathematics readiness.

Figure 9. *Field Note Excerpt Geometry Treatment Teacher 107 Post Treatment*

> *After a couple more exchanges teacher says, "I'm done giving you hints now. Begin working on your second and third attempt at the problem. Teacher then circulates room and looks at individual students' papers giving feedback and checking attempts at solving the problem. Teacher brings them together at 12:32 to give them more information. "Can you maybe label the sides of the triangle? Don't' give up you are almost there." Teachers brings class together for another hint, 12:37, and draws the diagram to show the special right triangle relationship students should have developed through the questioning process. One students who was successful exclaimed, "Yes"!*

This occurrence was coded as possible changes in mathematics readiness because student actions during the inquiry exercise were rigorous enough to possibly impact mathematics readiness.

After compiling themes and triangulating data from all sources, findings from qualitative analysis were compared with findings from quantitative analysis to fully address the research question.

Quantitative Analysis

A 2 × 2 between subjects ANCOVA at was conducted with independent variable treatment, all pretests as covariates, and all posttests as dependent variables. The statistical analysis tested the null hypothesis that students' mathematics readiness, engagement, and reform teaching do not differ with group placement.

Model of Analysis

A student's change in mathematic readiness, engagement, and a teacher's level of reform practices can be represented by a straight line trajectory, a curvilinear trajectory, or a discontinuous trajectory, but because there are two assessment scores for both students' mathematics readiness and reformed teaching, a general linear model was used. Curvilinear and discontinuous models require at least four scores per student (Tabachnick & Fidell, 2007). Each student in the study had two assessments points for students' mathematics readiness, engagement, and reformed teaching for the study; these points determine students' initial mathematics readiness, engagement, and baseline reform teaching practices, as well as their rates of change during the study.

For each student, the intercept represents the baseline of students' mathematics readiness, student engagement, and reform teaching practices, their classes prior to treatment. The slope for students' mathematics readiness, engagement, and reformed teaching represents growth between the pre and post assessments. A fixed intercept would mean that the "group" effect is random; in other words, the levels observed in that group were samples from a larger population (Tabachnick & Fidell, 2007, p. 407). Multivariate testing showed significance in variance estimates of random effects across the sample; this insures an accurate prediction of treatment effects considering, the average adjusted post test score of students' mathematics readiness, average adjusted post reform teaching score for each group, and the average adjusted post student engagement score (Tabachnick & Fidell, 2007).

Assumption Testing

SPSS software was used to create a general linear model that included covariates ACTmathPRE, RTOPPRE, EngagePRE, and DA3 and their effect on dependent variables ACTmathPOST, RTOPPOST, EngagePOST, and PA3 with between subject factor treatment-1 and control-0. The total N of 230 was reduced to 207 with the deletion of cases with missing values. Test for homogeneity of covariate matrices was significant for all multivariate tests, which supports homogeneity variance-covariance matrices (Tabachnick & Fidell, 2007). Distribution of mathematics readiness and reform practices were equally spread across the sample. There were positive correlations between the pretest and posttest (see Table 7), meeting the criteria of linearity of covariates and dependent variables. Additional details of assumption testing are described in the next chapter.

Validity and Reliability

Teachers administered ACT instruments and district assessments during normal classroom instruction time as prescribed by district policy. Teacher participants administered post ACT practices assessments under similar classroom conditions to limit validity threats due to maturation. Also, "ACT scores, sub scores, and skill statements based on the ACT College Readiness Standards are directly related to student educational progress and can be readily understood and interpreted by instructional staff, parents, and students" (ACT, 2014, p. 51). All assessments scores were coded according to student ID to insure confidentiality.

All treatment participants were trained in scoring instructional observations using the RTOP instrument during the first PD session. The researcher and PD facilitator had been trained using RTOP instrument to score videoed classroom observations. RTOP instrument had inter-rater reliability of .95 (Sawada et al., 2002). This limited threat to construct validity and insured reform teaching measures are determined with fidelity. Also, the CA framework of learning was used throughout entire PD to limit internal validity effect due to instrumentation and treatment implementation. PD took place during three two hour sessions. Three domains of the CA framework were used to inform participants of reform practices (Hufferd-Ackles et al., 2004) respectively (see Appendices F, G, and H).

Internal Validity

To minimize threats to internal validity related to treatment affects, teacher participants used the same mathematics classroom from the beginning to the end of the study for all data collections. Student data remained consistent and were obtained from the same student groups throughout the study. Attrition threats occurred due to transient students and teachers, as well as schedule changes. Cooperation and advanced scheduling on behalf of school administration and teacher participants in collecting data would help minimize this threat. All teacher participants collaborated with the PD facilitator in getting permission from student parents and support from school principals.

Trustworthiness of Data

Student engagement and implemented reform practices both involve embedded classroom practices that take place in normal school settings; therefore, these data was collected during the classroom observation of the school day as a regular component of the instructional program through RTOP instrument. RTOP total score was determined after each scheduled observation and/or videoed observation.

College readiness was measured through ACT testing instruments (ACT Explore mathematics, ACT Plan mathematics and ACT mathematics score), and district written assessments (Diagnostic3, Proficiency3) were obtained from Infinite Campus district data files (see Table 8). Teacher participants administered the ACT practice mathematics assessment at the conclusion of the study to compare with the baseline college readiness scores at the beginning of the study. The comparison of ACT base line assessment and the ACT practice assessment for both treatment and control groups provided information of students' mathematics readiness for students. District written diagnostic and proficiency assessments were used to measure college readiness and are analyzed similarly.

Table 8. *Students' Mathematics Readiness Measures for Classrooms*

	ACT math PRE	ACT math POST	Diagnostic PRE	Proficiency POST
Algebra 2	ACT math	ACTmath practice	Algebra II, Diagnostic 3	Algebra II, Diagnostic 3
Geometry	ACT math	ACTmath practice	Geometry, Diagnostic 3	Geometry, Diagnostic 3
Algebra 1	ACT Plan	ACTmath practice	Algebra I, Diagnostic 3	Algebra I , Diagnostic 3

Various steps were taken to insure all teacher participants and student assessment data were kept confidential. Scored student ACT practice mathematics assessments, content teacher's RTOP score, and all district assessment data were collected. District assessment scores from each treatment and control participant were obtained from Infinite Campus data. All assessment scores were stored in a confidential excel file then converted over to a SPSS data file for analysis. Classroom observation notes were made available for teachers as feedback if requested. All other notes from classroom observations and/or videos were stored confidentially. Notes from each PD session were collected and stored. Finally, interviews of teacher participants were voice recorded and stored. Treatment group interactions were monitored on the community blog page. Table 9 provides a timeline for data collect used during the study that includes PD sessions and measures used for both treatment and control teachers. Total teacher and student sample sizes are provided.

Table 9. *Data Collection Timeline*

	ACTmath (Plan, or ACT)	District Diagnostic3	Reform Teaching RTOP	**PD 1**	**PD 2**	**PD 3**	Reform Teaching RTOP	District Proficiency3	ACTmath practice
Treatment N =5			☑	☑	☑	☑	☑		
Control N=5			☑				☑		
Student n = 207	☑	☑						☑	☑

Students' mathematics readiness data was collected at the beginning and conclusion of the study to control for the threat of prior knowledge. To insure treatment fidelity, teachers were expected to communicate as often as needed for collaborate and reflection about reform implementation. Classroom observations occurred before the first and after treatment PDs to accurately measure treatment effects.

After each cycle of observations were scored using the RTOP instrument. The RTOP scores were used to compare scores of reform teaching practices for both treatment and control groups. All recorded observations were stored in a Google drive and/or Drop Box file kept confidentially. Participants' and students' identities were coded to protect confidentially.

Limitations

There were limitations with regards to treatment fidelity, assessment scores, and group independence. To insure treatment fidelity several attempts were made to communicate with teachers via email and phone; however, there was a possibility that teachers had preconceived notions of reform implementation prior to the PD. All teachers involved were well informed throughout the length of the study. To control for inter-rater reliability the trainer had colleague who was trained using the RTOP instrument to blind score one random classroom video from both treatment and control groups. Also some groups had unmeasurable differences, which may have led to statistical regression threats. These differences include scheduling format (i.e., trimester, block), other school factors such as grading scale. Distinguishing group factors observed during qualitative analysis and mentioned in the following chapter. Attrition occurred given the length of the study; however the design should account for this threat. Due to convenience sampling, generalizing is an issue when interpreting results. Also, attrition due to teacher and or student changes during the student year caused the statistical findings to lack power.

In future studies, the sample could include participants from schools throughout the state to extend generalizability to larger populations. Other demographic factors such as gap status could be used to determine if there were any significance differences given the interaction of these covariates. Given the nature of mathematics discourse practices, the interaction between this treatment and ethnicity may provide insights on how to insure equitable student to student interactions for English Language Learners (ELL). “Kentucky’s goal is 100 percent proficiency for all students. The distance from that goal or gap is measured by creating a student Gap Group, an aggregate count of student groups that have historically had achievement gaps. Student groups combined include ethnicity/race (African American, Hispanic, Native American), Special Education, Poverty (free/reduced-price meals) and Limited English Proficiency that score at proficient or higher”. (p. 5, KDE, 2012). Furthermore, researchers could consider other teacher level factors in determining if teacher to student interactions affect mathematics achievement as measured in college readiness.

CHAPTER IV:

RESULTS

Introduction

The chapter results are organized according to research questions.

a) How does professional development, framed by a Cognitive Apprenticeship model, affect the implementation of teacher reform practices?

b) How does the use of teacher reform practices affect student engagement in mathematics?

c) How does the use of teacher reform practices affect mathematic readiness for high school students?

An overview of analysis, a brief description of student, teacher, and classroom variables employed in the study, and overall results are provided. Each research question is addressed separately with results and a summary of findings.

The study uses nested classroom, student, and teacher variables to address whether relationships exist between reform teaching practices in high school mathematics classrooms, student engagement, teacher PD, and college readiness in mathematics. Student variables include college readiness in mathematics, and student engagement. Teacher variables include PD teacher participation (treatment and control groups) and implementation of reformed teaching practices measured via RTOP. The manipulated or independent variable included the same teacher variable. Dependent variables included post treatment reform teaching practices (RTOP teacher score) and post treatment student engagement (RTOP sub section III, and teacher interview data). College readiness in mathematics was measured using the two earliest tests in the sequence of ACT instruments and district assessments as both a student and classroom variable. Implemented reform teaching practices, measured using RTOP, were used as both teacher and classroom variables. The covariates in the analysis included all pretests.

RQ (a) How does professional development, framed by a Cognitive Apprenticeship model, affect the implementation of teacher reform practices?

To address how professional development, framed by a Cognitive Apprenticeship model, effects the implementation of teacher reform practices, the facilitator "sought to understand teacher participant perceptions, experiences, and multiple realities" that influence reform practice implementation before, during, and after PD that uses CA framework (Creswell, 2007, p. 675). Teacher variables included PD teacher participation (treatment and control groups) and implementation of reformed teaching practices measured via RTOP. RTOP scores were used to measure reform as a classroom variable. Analysis showed treatment teacher reflections on reform practice implementation and the development of mathematics teacher learning community. Classroom means were compared, ANCOVA, and changes in reform practices given participation in treatment and classroom similarities were noted.

Reflections of teacher reform practice implementation

There were nine occurrences coded as of treatment teacher reflections about the PD in qualitative data. Teachers who participated in each of the three PD sessions offered were able to see benefits of the PD and implemented new reform practices in a planned lesson. When asked about their perception(s) of the PD experiences treatment teacher responses varied. The following excerpt was coded as a reflection of teacher reform practice implementation. An Algebra I teacher, 106, stated,

> *Throughout this PD I collaborated with the other Algebra I teachers and we discussed our future plans in terms of pacing, scaffolding, differentiation, things like that; so, we are able to make sure we are not moving too quickly for some students but that all students are able to progress still and there is nobody sitting still being bored. Uhm, so I think just the conversations that we had-the brainstorming and planning was helpful and needed*.

One geometry teacher participant, 101, stated in reference PD1 session attended, "*I rarely get to work with mathematics teachers from across the district; I relish this opportunity especially when the agenda includes opportunities for me to learn and take something away to bring back to my classroom*."

An Algebra II treatment participant, 100, stated,

> *"I really have not attended any* (math PD's) *this year because we don't have very many offered. Math PDs that I have enjoyed, where I actually*

created a lesson, taught a lesson, or was more hands on- I was able to walk away with something I could use in my classroom -it wasn't always a sit and get and listen. I was able to try things for myself so I can see how the kids are feeling I would make the mistakes they would possibly make so I can be ready to take them around the loop or detours when they get to them.

These responses show the benefits of PD that supports interaction amongst novice and expert participants (Dennen, 2010) using the reflecting domain of the CA framework, where participants take away a tangible lesson or idea and then used them in their high school mathematics classrooms. Teachers collaborated with other common subject treatment teachers, sharing ideas of classroom activities that use reform practices in instruction. Most important, the specific practices used the in lessons had not been implemented prior to the treatment.

Changes in Implementation of Reform Practices.

Preliminary testing that included normalcy and Wilks' Lambda test of equal variance were significant for all pretest data. The Wilks' Lambda test insured the mean score of treatment and control groups occurred equally throughout the data during the study for both groups. Additional normalcy testing of dependent variables are addressed in RQ (c). Results from the test for all pretest and included in Table 10 below.

Table 10. *Wilks' Lambda Test*

Effect (Wilks' Lambda)	Value	F	Hypothesis Df	Error df	Sig.
Intercept	.815	11.238	4	198	.000*
ACTmathPRE	.484	52.808	4	198	.000*
RTOPPRE	.385	79.028	4	198	.000*
DA3PRE	.768	14.976	4	198	.000*
EngagePRE	.319	105.843	4	198	.000*
Treatment	.755	16.072	4	198	.000*

Note.*p<.05.

Analysis of covariance, see Table 11, showed significant differences between RTOP pre and post assessments, F (1, 201) = 6.101, $p<.05$. The strength of the relationship between RTOPPRE and RTOPPOST assessment scores was partial eta squared effect size η^2 = .03 with observed power of .691, see Table 11. There were also significant treatment effects on RTOP scores, F (1, 201) = 42.366, $p<.05$. The strength of treatment effect was partial eta squared effect size η^2 = .174 with observed power of 1.00. In table 12 overall RTOP scores show that RTOPPRE treatment scores were significantly higher than control teacher scores overall.

RTOPPOST means for treatment teachers were not significantly higher than control teachers' overall RTOP mean. However, when comparing matched group means, treatment teachers' students scored significantly high than control teachers' students after treatment, see Table 13 for matched group comparisons. These results suggest that the PD did have a significant effect on reformed practice implementation as observed using RTOP for matched group classrooms.

Table 11. *ANCOVA Summary*

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	ACTmathPOST	1790.161a	5	358.032	60.537	.000*
	RTOPPOST	10997.091b	5	2199.418	72.064	.000*
	PROF3POST	36066.205c	5	7213.241	3.586	.004*
	EngagePOST	832.539d	5	166.508	99.378	.000*
Intercept	ACTmathPOST	3.875	1	3.875	.655	.419
	RTOPPOST	509.007	1	509.007	16.678	.000*
	PROF3POST	4272.024	1	4272.024	2.124	.147
	EngagePOST	.039	1	.039	.023	.880
ACTmathPRE	ACTmathPOST	1202.769	1	1202.769	203.366	.000*
	RTOPPOST	75.403	1	75.403	2.471	.118
	PROF3POST	2265.807	1	2265.807	1.127	.290
	EngagePOST	9.393	1	9.393	5.606	.019*
RTOPPRE	ACTmathPOST	36.081	1	36.081	6.101	.014*
	RTOPPOST	8818.175	1	8818.175	288.926	.000*
	PROF3POST	2.844	1	2.844	.001	.970
	EngagePOST	227.036	1	227.036	135.504	.000*
DA3PRE	ACTmathPOST	48.975	1	48.975	8.281	.004*
	RTOPPOST	1050.532	1	1050.532	34.420	.000*
	PROF3POST	12197.939	1	12197.939	6.065	.015*
	EngagePOST	21.460	1	21.460	12.808	.000*
EngagePRE	ACTmathPOST	9.269	1	9.269	1.567	.212
	RTOPPOST	1632.888	1	1632.888	53.501	.000*
	PROF3POST	141.728	1	141.728	.070	.791

	EngagePOST	60.819	1	60.819	36.299	.000*
Treatment	ACTmathPOST	1.887	1	1.887	.319	.573
	RTOPPOST	1293.035	1	1293.035	42.366	.000*
	PROF3POST	4548.212	1	4548.212	2.261	.134
	EngagePOST	106.986	1	106.986	63.853	.000*
Error	ACTmathPOST	1188.776	201	5.914		
	RTOPPOST	6134.629	201	30.521		
	PROF3POST	404256.852	201	2011.228		
	EngagePOST	336.775	201	1.675		
Total	ACTmathPOST	61047.000	207			
	RTOPPOST	1231686.000	207			
	PROF3POST	1521389.030	207			
	EngagePOST	45756.000	207			
Corrected Total	ACTmathPOST	2978.937	206			
	RTOPPOST	17131.720	206			
	PROF3POST	440323.057	206			
	EngagePOST	1169.314	206			

Note.*p<.05.

Table 12. *RTOP Descriptive Statistics*

	treatment	Mean	Std. Deviation	N
RTOPPRE	0	64.80	9.011	112
	1	66.52	8.327	97
	Total	65.60	8.722	209
RTOPPOST	0	62.65	7.834	112
	1	59.02	8.019	97
	Total	60.97	8.107	209

Data disaggregated to show matched groups were created to compared means according to classrooms, see Table 13. Treatment teacher means were significantly higher for all matched pairs except for one Algebra II pair, and one geometry pair, $p<.05$*.

Table 13. *Classroom Pre/Post RTOP Scores*

Participant		Subject	PreRTOP	PostRTOP	Difference
Treatment	*100*	*Algebra II*	57	60	+3
Control	104	Algebra II	72	71	-1
Treatment	*103*	*Algebra II*	71	89*	+18
Control	102	Algebra II	59	83	+24
Treatment	*107*	*Geometry*	78	86	+8
Control	109	Geometry	73	89	+16
Treatment	*101*	*Geometry*	74	79*	+5
Control	110	Geometry	57	67	+10
Treatment	*106*	*Algebra I*	60	71*	+11
Control	105	Algebra I	53	68	+15

Note.*$p<.05$.

Also parameter tests were conducted to see how variable means impacted dependent variable RTOPPOST means, see Table 14. RTOPPRE means significantly impact RTOPPOST means and Diagnostic 3 test means significantly impacted RTOPPOST means at 95% confidence interval, $p<.05$*.

Table 14. *Multivariate Parameter Estimates RTOPPOST*

Parameter	B	Std.Error	T	Sig	Lower Bound	Upper Bound	Partial Eta Sq	Power

Intercept	11.711	3.2967	2.952	.004*	3.889	19.533	.042	.836
DA3PRE	.119	.020	5.867	.000*	.081	.159	.146	1.00
RTOPPRE	1.133	.067	16.998	.000*	1.002	1.265	.590	1.00
EngagePRE	-1.344	.184	-7.314	.000*	-1.71	-.981	.210	1.00

Note.*p<.05.

Researcher's Role

During the PD's appropriate definitions, constructs, and frameworks were used to provide an understanding of the dynamics between high school mathematics teachers and student learning in mathematics classrooms (Franke, Kazemi, & Battey, 2007) and promote positive changes in reform practice implementation. Appropriate videos with teacher experts modeling reform practices were provided for teachers. Flexibility was offered in terms of meeting formats, face to face and online PD sessions. Instructional resources for treatment participants wanting to implement strategies in future lessons were provided. After reading over field notes from the first PD instructional support was made available for two treatment participants, 100 and 106, as requested. Figure 10 was data coded as mathematics teacher community.

Figure 10. *Field Note Excerpt Teacher Collaboration*

> *Facilitator will collaborate with two teachers* (Algebra II, and Algebra I) *from the treatment group to create a lesson, which will focus on implementing mathematical practices. In this lesson students will make sense of problems and persevere in solving them* (I can solve problems

without giving up). *Additionally, the teachers will have a planning conversation with the facilitator about ways to emphasize conceptual development and engagement amongst students while being explicit about what mathematics concepts discussed throughout the lesson. Through coaching and exploring (CA framework) observer should see an increase in use of reform teaching practices (i.e. mathematical practice implementation, student centered learning) for both teacher Participants who engage in this PD activity.*

Blog posts were sent weekly via the community page (see Appendix G). In each blog post the teacher participants were asked to respond about a particular instructional practice discussed during a PD session. Teachers were *coached* through setting up SMART equipment, and selecting from the eight mathematical practices best suited to use in lessons. Coaching was a domain of CA not intentionally used in the PD but emerged. For example Algebra I teachers in the session decided to focus on the mathematical practice "attend to precision" in class when teaching the substitution method to students solving systems of linear equations. The PD facilitator coached teachers and helped them generate ideas of activities for their Algebra I classrooms. The interview excerpt was placed in all three categories: modeling, reflecting, and scaffolding domains of framework.

> *Uhm I collaborate with the other Algebra I teacher and we discussed what our plans are in terms of pacing, scaffolding, differentiation things like that-so we are able to make sure we are not moving too quickly for*

some students but that all students are able to progress still and there is nobody sitting still being bored. Uhm so I think just the conversations that we have-the brainstorming and planning is helpful.

Participant Response

Of the six treatment teacher participants two, one Algebra I, 106, and one Algebra II teacher, 100, attended all three professional development sessions offered as part of the treatment. The low participant response weakened the ability to attribute changes in reform practices treatment. However positive reflections from teacher attest to the benefits of CA framework were found for teacher participants that attended all sessions offered. Also, significant empirical analysis support this finding.

Additionally, a mathematics teacher community developed as a result of the treatment. All six participants attended at least one of the three sessions offered and expressed a desire to continue district collaboration. All materials (see Appendix F), handouts and videos were available online via the Google community blog page created specifically for treatment teacher access. Teachers from around the world have joined this community group with a total of 22 additional members.

After the completion of the study, PD facilitator continued to collaborate with treatment teacher participants in brainstorming PD opportunities for high school mathematics teachers. The PD facilitator encouraged treatment teacher, 103, to present a PD session on implementing eight mathematical practices in high school mathematics classrooms during a local mathematics affiliate meeting the following school year. Also, the PD facilitator collaborated with Algebra II teacher 100, and other high school mathematics teachers from the district in creating a Quadratics Project for Algebra II students adapted for ECE, Comprehensive, and Honors students aligned to CCSS. This involvement provides evidence of the development of a mathematics community of teachers that continue to collaborate, network, and discuss reform practice implementation in high school mathematics classrooms throughout the school district.

Emerged Themes

Changes in Teacher Perception of PD. During analysis, nine occurrences were coded as changes in teacher perceptions of PD. An Algebra II treatment teacher participant, 100, mentioned the importance of mathematics teacher collaboration.

> "*When I have issues where I am not being successful in the classroom on one of the practices or just teaching the standards; the collaboration allows feedback from other teachers. Things I would not have thought of like "I'm doing this in my classroom" and I'm like "OK I have never thought about trying that". A lot of times we collaborate in developing lessons; so if you have to do all the lessons and all the assessments yourself you aren't putting all you can in teaching. But if you were able to split that up you can put more emphasis on attending to precision and trying and get the students to do that as well.*

Treatment participants also established a reliable community of mathematics teachers across the district to collaborate with in the future. There were four occurrences coded in the data as mathematics learning community. The PD incorporated three specific domains of the CA framework where learners were "challenged with tasks slightly more difficult than they can accomplish on their own and must rely on assistance from and collaboration with others to achieve these tasks" (Dennen & Bruner, 2007, p. 436). The following interview excerpt was coded as treatment teacher belief/attitude about PD and elements of mathematics learning community. Algebra II participant, 103, stated, *"It's good to talk with other mathematics teachers to see how things are going in their classrooms and understand what teaching and learning looks like for other mathematics teachers-especially for classrooms with similar populations.*

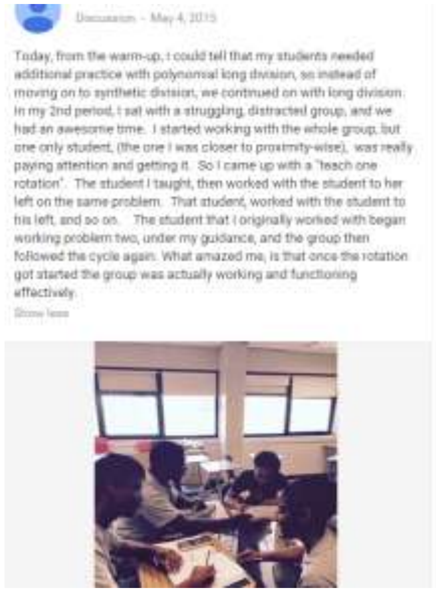
In terms of the flexibility of the PD, all treatment teachers interviewed appreciated PD that valued their time, was content specific, and involved district collaboration. Algebra I Treatment teacher, 106, stated,

> "*Honestly as long as I am getting good information it doesn't matter what the format is. I think the format we had was good because we were in a group and we also incorporated the math video and we talked about the instructional strategies. Watching the teacher who was successfully scaffolding and modeling things for her students was very helpful too because like I said I need to kind of see in order to be able to do so uhm I think it was really good.*

In her response she showed how the CA domain of modeling not necessarily the modality of the PD, impacted her reflection about instructional practices. Statements were coded for changes in teacher perception of PD. Treatment teacher, 101, stated, *"I am glad when the PD facilitator respects my time; that way I can still participate but at my convenience. I do like meeting face to face as an option as well. I hope we can keep it going"*. Both responses reflect the teachers' value of peer interaction in a face to face settings. Changes in teacher perception of PD were found; teachers were responsive to pragmatic PD that valued their time and was specific to their needs as mathematic teachers (Desimone, 2007).

Student Engagement and Conceptual Understanding. There were three occurrences coded as both student engagement and conceptual understanding; however, one excerpt supported teacher cognitive changes as well. One treatment participant, 100, posted a picture, reflection, video post from a lesson where she encouraged interaction amongst student study groups during an Algebra II. The lesson activity required students to explore polynomial functions. In the blog post and interview she described the Teach One activity in her Algebra II class. This response was coded as teacher reported student engagement and conceptual understanding.

Figure 11. *Blog Post*


Discussion - May 4, 2015

Today, from the warm-up, I could tell that my students needed additional practice with polynomial long division, so instead of moving on to synthetic division, we continued on with long division. In my 2nd period, I sat with a struggling, distracted group, and we had an awesome time. I started working with the whole group, but one only student, (the one I was closer to proximity-wise), was really paying attention and getting it. So I came up with a "teach one rotation". The student I taught, then worked with the student to her left on the same problem. That student, worked with the student to his left, and so on. The student that I originally worked with began working problem two, under my guidance, and the group then followed the cycle again. What amazed me, is that once the rotation got started the group was actually working and functioning effectively.

Show less

"*Ok. When I started the lesson, I can't remember exactly the problem, I used a real world problem. I threw it up there and got some feedback from the kids. I'm thinking it's very frustrating when students see algebraic equations and inequalities they are like, 'What does this have to do with math'? So, I gave them a real world problem as an introduction to the lesson and began to ask them about process; how you solve it, what would you need, how you would use the numbers, and how much it would cost. So they were trying to figure it out in groups at first and then together as a class we made connections with the picture and the equation. Then I showed an equation and asked how numbers or coefficients match up with what we talked about. We also discussed how one can make those connections. I wanted them to make the connection with the real world".*

This response reflects the cognitive shifts teachers made that were catalysts for reform practice implementation (Dennen, 2004). The Teach One activity encouraged student interaction that researchers have found to promote conceptual development through social interaction (Clements & Battista, 1993). In the "Teach One" activity the teacher began by explaining a concept to a student who then taught another student. The dialogue pattern continued until all students in the class were familiar with the concept/process. The teacher participant applied her new found knowledge of social construction of knowledge and classroom discourse towards the "Teach One" activity during this lesson on finding polynomial roots. She encouraged student participation, engagement, and her perception of conceptual development in a lesson after attending treatment PD. At the conclusion of the study, this Algebra II teacher's RTOP scores significantly increased. After developing a new focus on making connections with students, the real world, and mathematics content, this Algebra II teacher, 100, observed and later described increases of student engagement.

> *What I posted was…I actually took pictures of students working in groups where you can actually see one student leaning over teaching another student and the paper. Uhm I tried to capture that group where there was one on one (teaching one) so in the group you see two different sets of students one student teaching the other. So that is a description of what I posted and I have a video clip which I tried to post it on that blog page but I could not post. But the video clip recorded the conversations that were taking place where the kids where actually using mathematics*

and demonstrating their conceptual understanding or their lack of conceptual understanding.

This interview excerpt showed how attending the PD provided the opportunity to reflect upon and understand the impact of real world applications to engage students when teaching CCSS.

Another Algebra I treatment teacher 106, was able to apply reform instructional practices during a lesson on systems of equations where students used SMART Board response clickers and various questioning strategies to instruct and engage students. Prior to treatment, the teacher had never used SMART Board response clickers in the classroom. As a treatment teacher who actively participated in PD, she was able to apply new information from the PD towards a future lesson with the support and coaching of the PD facilitator. This excerpt was one of four occurrences coded as reflections on reform practice implementation. When asked how the videos posted on the blog and seen during the PD assisted her with the teaching/planning of her lesson, she responded,

> *"Tt's always good. I wasn't a traditional teacher; I did not do student teaching or anything like that, so, it's always good to see people run their math classes. Even though I have observed other teachers it's never been anything where I am getting a lot of math content; where I am able to apply to one of my math classes. Just being able to see that and being able to see a really effective classroom and students being engaged where teachers are able to scaffold the instruction-that was good for me to apply to my classroom".*

This response was coded as teacher reflections on reform practice implementation, scaffolding, and student engagement.

Summary of Findings RQ (a)

There were significant changes in reform practice implementation in favor of treatment participants. After adjusting for covariates, treatment teachers are expected to score higher on RTOP post assessments than control teachers, 95%, CI [1.002, 1.265]. Student performance on diagnostic assessment relate to reform practices implemented and measured post treatment. When addressing changes in teacher reform practice implementation, two themes emerged after analyzing qualitative data: changes in teacher perception of mathematics PD, and development of a mathematics teacher learner community. Elements of the framework were prevalent in PD and results support the hypothesis. Modeling scaffolding, reflecting domains of CA framework used during treatment were a catalyst for teacher cognitive shifts that resulted in changes in reform practice implementation.

RQ (b) How does the use of teacher reform practices affect student engagement in mathematics?

Student Engagement

Student engagement pretest scores significantly impacted RTOP post scores, F (1, 201) = 53.501, $p<.05$. The strength of the relationship between was a partial eta squared effect size η^2 = .21 with observed power of 1.00. There was a significant difference between student engagement pretest and posttest means, F (1, 201) = 36.299, $p<.05$. The strength of the relationship between was partial eta squared effect size η^2 = .153 with observed power of 1.00. Table 15 include student engagement means according to matched treatment and control groups. Treatment effects on student engagement post scores were not significant.

Table 15. *Classroom Pre/Post Student Engagement*

Participant		Subject	Pre Student Engagement	Post Student Engagement	Difference
Treatment	*100*	*Algebra II*	6	12	+6
Control	104	Algebra II	15	18	+3
Treatment	*103*	*Algebra II*	16	17	+1
Control	102	Algebra II	10	18	+8
Treatment	*107*	*Geometry*	14	18	+4
Control	109	Geometry	15	19	+4
Treatment	*101*	*Geometry*	17	16	-1
Control	110	Geometry	10	16	+6
Treatment	*106*	*Algebra I*	14	18	+4
Control	105	Algebra I	10	13	+3

Multivariate parameter estimates show that DA3PRE assessment means, RTOPPRE means, and EngagePRE means significantly impacted EngagePOST means, see Table 16.

Table 16. *Multivariate Parameter Estimates EngagePOST*

Parameter	B	Std.Error	T	Sig	Lower Bound	Upper Bound	Partial Eta Sq	Power
DA3PRE	.017	.005	3.579	.000*	.008	.026	.060	.945

RTOPPRE	.182	.006	11.641	.000*	.151	.213	.403	1.00
EngagePRE	.259	.043	6.025	.000*	.174	.344	.153	1.00

Note.*p<.05.

Classroom student engagement scores ranged from six to 19 where the higher scores indicated higher levels of engagement observed. Scores were collected and class means for each subsection of the RTOP are also included in Table 15. These values show how matched participants scored pre and post study RTOP scores for section III Student engagement means measured at the baseline of the study relate to the implementation of reform practices measured post treatment.

Several items were coded as both student engagement and changes conceptual knowledge and were later changed to teacher reported changes. One specific treatment teacher, 100, who aspired to implement more reform practices in her classes after attending all three PD sessions (see Table 4), reflected upon her students' conceptual understanding. This interview excerpt was one of the four occurrences coded as student engagement and conceptual understanding. An Algebra II treatment teacher, 100, responded in the following excerpt.

> *Hhmm..... it* (conceptual understanding) *definitely occurred during the teaching rotation-at times the student I taught went to teach the next person. While teaching* (each other) *they were asking questions about the process that did not even come to me or the student I was teaching; so, I stood there listening to the response and to see if they really understood. I continued to listen to see if this was repetition of what I said or if they*

really understand what was taking place. Even though this (question) did not come up during my teaching the student was able to respond correctly demonstrating that they understood what was taking place with the concept itself.

A geometry treatment participant, 101, stated, *"It's important to keep the questions flowing during a lesson between you and the students and amongst the students themselves. That is how I measure student engagement in my classes."* In general, treatment teacher interview responses reflected the impact of student discourse in mathematics classrooms to promote conceptual understanding of mathematics topics (Herbel-Eisenmann, 2005) and student engagement.

Student Conceptual Understanding. Four occurrences of student conceptual understanding were found throughout qualitative data and were changed to teacher reported changes. Observed RTOP values ranged from 10 to 19 where all treatment teaches scored a minimum value of 14 during the post observation. Table 17 showed conceptual knowledge measured using RTOP.

Table 17. *Classroom Pre/Post Conceptual Understanding*

Participant		Subject	PreIV	PostIV	Difference
Treatment	*100*	*AlgebraII*	10	14	+4
Control	104	AlgebraII	14	17	+3
Treatment	*103*	*AlgebraII*	19	19	0
Control	102	AlgebraII	13	19	+6
Treatment	*107*	*Geometry*	15	16	+1

Control	109	Geometry	16	18	+2
Treatment	*101*	*Geometry*	13	14	+1
Control	110	Geometry	12	11	1
Treatment	*106*	*Algebra I*	16	18	+2
Control	105	Algebra I	10	14	+4

Themes that included student engagement and conceptual understanding were renamed as teacher reported changes in student engagement and teacher reported changes in conceptual understanding. Teachers' perceived changes may not have reflected actual changes in student conceptual understanding.

Changes in Teacher Knowledge and/or Beliefs. Teacher knowledge and/or beliefs about reform practices were a catalyst for their reform practice implementation. Several treatment teacher interview responses reflected these changes. The following interview excerpt was coded as teacher reported changes in student engagement, teacher reported changes in conceptual knowledge, modeling, and changes in teacher knowledge and/or beliefs. When asked the question, **"**How did the focus on conceptual knowledge development in the PD session effect your teaching concepts in everyday lessons and describe an example", Algebra I teacher participant, 106, stated*, "I remember in the PD we watched a video of a classroom and teacher running her classroom. It kind of was a little bit of inspiration; a teacher modeling what I could say to my students. I was then able to use that in my lesson too.* Treatment teacher, 100, stated, when asked the same question, *"I think they* (PD video cycles) *were helpful; they brought a lot of things to light like different avenues and ways we can go as far as the lesson. Especially, when working collaboratively with others. It* (the video example) *showed how possible it is, even with time, our kids, behavior, and students not being at the level they need to be on. The videos demonstrated teachers being successful, sticking with the standards and mathematical practices, and it was encouraging for the most part. This can be done; we don't have to stay stuck in this little rut we can move forward.*

Teachers who had expressed a minimal knowledge of reform practices were able to apply this new knowledge to practices as observed in analysis (Figure 11). The blog post in Figure 11 shows the response from a treatment teacher who implemented student centered strategies with real world emphases. Of all six treatment teacher participants, one Algebra II teacher, 100, and one Algebra I teacher, 106, demonstrated changes in reform implementation through an observed lesson created collaboratively with a peer or the PD facilitator. Algebra I teacher scores were low compared to Algebra II or Geometry teachers. Table 18 shows overall the RTOP scores from pre to post treatment. Matched subject group scores are shown according to each sub section of the RTOP pre and post study implementation. Total RTOP scores for each treatment and control teacher bolded.

Table 18. *Matched Group RTOP Scores*

Subject	RTOPPRE	RTOPPOST

Group		I	II	III	IV	V		I	II	III	IV	V	
Treatment	*Algebra 2 100*	13	13	6	10	15	**57**	12	14	12	14	8	**60**
Control	Algebra 2 104	14	14	15	14	15	**72**	16	16	18	17	19	**71**
Treatment	*Algebra 2 103*	14	12	16	19	10	**71**	18	17	17	17	20	**89***
Control	Algebra 2 102	11	10	10	13	15	**59**	15	12	18	19	19	**83**
Treatment	*Geometry 106106*	14	16	14	15	19	**78**	17	16	18	16	19	**86**
Control	Geometry 109	12	13	15	16	17	**73**	17	16	19	18	19	**89**
Treatment	*Geometry 101*	15	14	17	13	15	**74**	15	16	16	14	18	**79***
Control	Geometry 110	11	13	10	12	11	**57**	14	13	16	11	13	**67**
Treatment	*Algebra 1 106*	5	12	14	16	13	**60**	10	12	16	18	15	**71***
Control	Algebra 1 105	10	11	10	10	12	**53**	12	13	13	14	16	**68**

Note.
*p<.05.

When comparing matched treatment and control classrooms, treatment teachers scored significantly higher than control participants for one Algebra II pair, one Geometry pair, and for the Algebra I pair see table 18.

Summary of Findings RQ (b)

Student engagement scores relate to RTOP post assessment scores. The treatment had a non-significant effect on post student engagement scores. Teacher reported changes in conceptual knowledge in mathematics class, as well as changes in teacher beliefs about teacher PD emerged from analysis. Future studies would consider further analysis of student conceptual understanding in mathematics classrooms and clearly define conceptual understanding for teacher participants.

RQ (c) How does the use of teacher reform practices affect mathematic readiness for high school students?

To address how the use of teacher reform practices affect mathematic readiness for high school students, analysis proceeded with ANCOVA for dependent variables ACTmathPOST, RTOPPOST, and PROF3 matched treatment and control groups with covariates ACTmathPRE, RTOPPRE, and DA3. Assumptions of evaluations, sphericity and linearity were met for dependent variables. Before employing ANCOVA testing of assumptions are necessary to insure tenable outcomes and findings (Tabachnick & Fidell, 2007). As a result, the 2 x 2 between-within subject ANCOVA for college readiness in mathematics distally and proximally as well as reform practices was employed with coded independent variable PD (0-control group, 1-treatment group). Adjustments were made for the covariates. There were no univariate or multivariate outliers at $p < .001$, and Wilks' Lambda test of equal variance estimates showed that random effects across the sample were significant when considering the four dependent variables, see Table 10.

Students' Mathematics Readiness

Between subjects testing showed non-significant differences between mean DA3PRE scores and mean PROF3POST scores. There was no significant different ACTmathPRE and ACTmathPOST scores across groups. Observed differences between treatment and control groups means were due to chance. Table 19 shows overall means, spread, and variance for all variables.

Table 19. *Overall Descriptive Statistics*

Variable	N	M	SD	Skewness	Variance	Kurtosis
ACTmathPRE	207	14.88	3.675	.136	13.514	1.034
ACTmathPOST	207	16.75	3.803	.514	14.461	.703
DA3PRE	207	50.36	20.659	-.134	426.801	-.777
PROF3POST	207	72.27	46.233	11.071	2137.491	146.256
RTOPPRE	207	64.25	8.649	.234	74.810	-1.528
RTOPPOST	207	76.60	9.119	.055	83.164	-1.455

Also parameter tests were conducted to see how variable means impacted dependent variable ACTmathPOST means, see Table 20. DA3PRE means significantly impacted ACTmathPOST means, ACTmathPRE test means significantly impacted ACTmathPOST means, and RTOPPRE means significantly impacted ACTmathPOST means at 95% confidence interval.

Table 20. *Multivariate Parameter Estimates ACTmathPOST*

Parameter	B	Std. Error	T	Sig	Lower Bound	Upper Bound	Partial Eta Sq	Power
DA3PRE	.026	.009	2.878	.004*	.008	.043	.040	.817
ACTmathPRE	.712	.050	14.261	.000*	.613	.810	.503	1.00

RTOPPRE	.072	.029	2.470	.014*	.015	.130	.029	.691

Note. *p<.05

Normalcy Testing

Preliminary analysis of dependent variables ACTmathPRE, ACTmathPOST, DA2PRE, PA3POST , RTOPPRE, RTOPPOST included an explanation of histogram distribution, with a description of variance, skewness, and kurtosis (Tabachnick & Fidell, 2007). Tables that include descriptive statistics of ACTmathPRE, ACTmathPOST, DA3PRE, PA3POST, RTOPPRE, and RTOPPOST variables provided a picture of the shape, spread, central tendency, and normalcy of dependent variable data spreads (Tabachnick & Fidell, 2007), well as assisted with assumption testing required for further analysis.

To test for normality of data, skewness, kurtosis, and z scores for skewness and kurtosis were computed for all dependent variables. Skewness and kurtosis values are zero when data has a normal distribution spread (Tabachnick & Fidell, 2007). A normal distribution is a "mathematics model that is used to represent data collected in behavior research" (p. 120) that "provides a reasonably good model of the frequency distribution", (p. 120). Normal distributions are symmetrical, unimodal about its mean, and asymptotic, where the mean median and mode of the distribution are equal (p. 121).

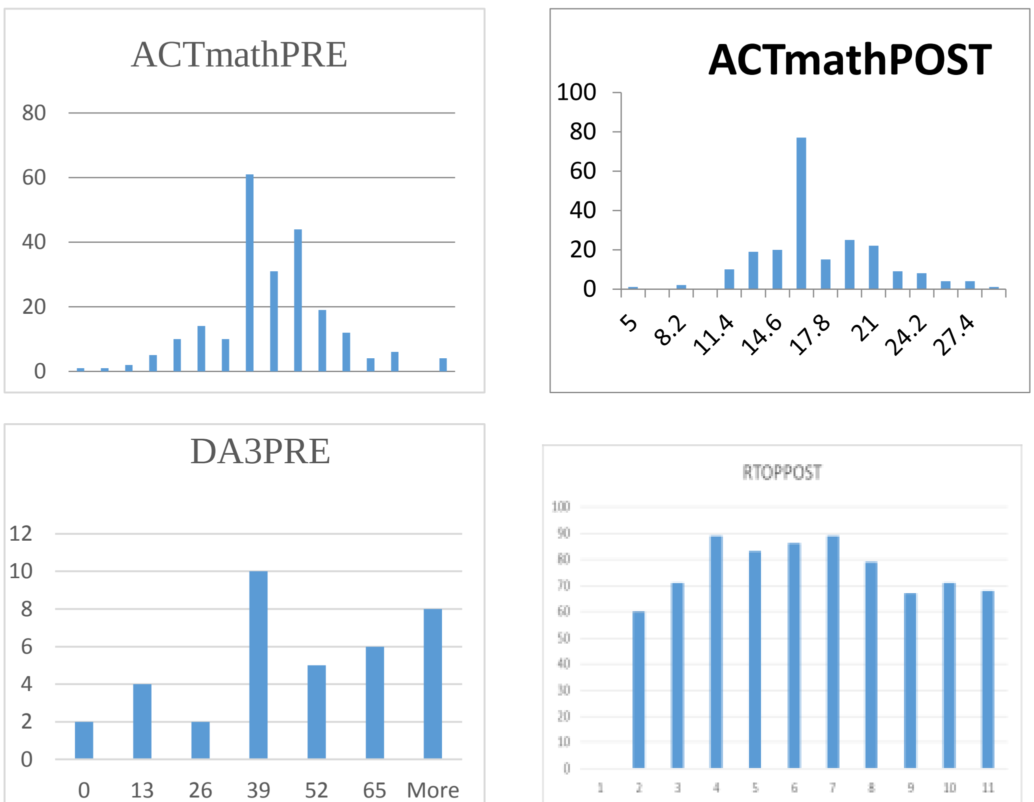
Standard error for skewness (.169) and kurtosis (.337) were the same for all variables; skewness measures the asymmetry of data spread whereas kurtosis measures the peakness of data distribution. Normal distributions have zero values of standard error for skewness and kurtosis. The values for standard error found indicate that "the underlying distribution of the sample does deviate slightly from a distribution that would otherwise be considered normal" (Tabachnick & &Fidell, 2007, p. 78). "Dividing either score by its standard error provides a z score that if greater than ±1.96 and suggests that data are not normal with respect to that statistic" p. 120. Positive skewness means "there is a pileup of observations to the right and the left tail is too long" (Tabachnick & Fidell, 2007, p. 79). Positive kurtosis indicates "a distribution that is too peaked with short, thick tails" (Tabachnick & Fidell, 2007, p. 79). Z score values that exceed ±1.96 by a considerable amount would deviation too much from a normal distribution and therefore violate assumptions of normalcy necessary for further analysis.

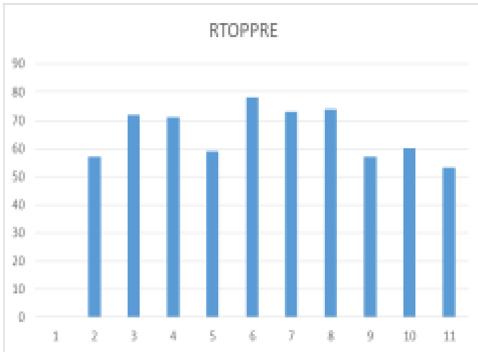
Distributions for ACT math pre and post assessments appeared normal; however, z scores for skewness and kurtosis were not within range according to Corder and Forman (2009). To pass the normality assumption z scores for skewness and kurtosis should be between -1.96 and 1.96 (Corder, Forman, 2009). ACTmathPre z score for kurtosis (3.1) was out of range but within range for skewness (.80). ACTmath Post z scores for kurtosis (2.09), and skewness (3.04) were both out of range. DA3 data was somewhat normal with high scores towards the right. Z scores for skewness (2.31) and kurtosis (.79) were within range for kurtosis only. PROF3POST data were without a shape, with extremely high z scores for skewness (11.07) and kurtosis (146.27); both are beyond the significance range.

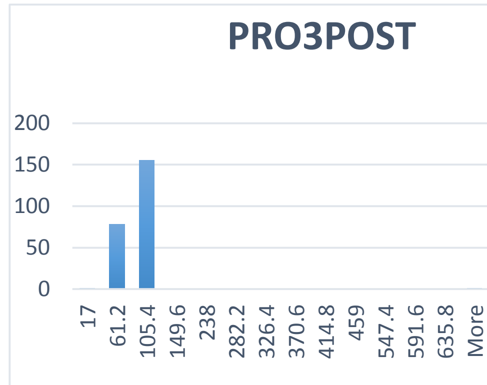
Table 19 provides descriptive statistics, including skewness, variance, and kurtosis for each variable. RTOPPRE and RTOPPOST distributions were widely spread with no prevalent curve; skewness values were positive for both pre and post assessments and kurtosis were negative for both. RTOPPRE data were not centered on the mean value; z scores for skewness (1.38) and kurtosis (-4.53) were not within range according to Corder and Forman (2009). RTOPPOST data were somewhat centered; z scores for skewness (.325) and kurtosis (-4.317) were within range for skewness only.

Nonnormal kurtosis and skewness produces "an underestimate of the variance of a variable" (Tabachnick & Fidell, 2007, p. 79), multivariate analysis results were impacted because of the data lack of normalcy. Given histogram, kurtosis, skewness, and z scores outside of the significance range, the data were not normal. Normal distributions "insure and accurate variance interpretation of variables with minimal error" (Tabachnick & Fidell, 2007, p.79). As previously noted, z scores for skewness and kurtosis values closer to zero indicate a distribution that is symmetrical about the mean, unimodal, asymptotic and therefore normally distributed. Although DA3PRE data meets the criteria partially, PROF3POST scores and DA3PRE scores were used in the model for further analysis testing. RTOPPRE and RTOPPOST data were not centered on the mean teacher score but were also included. Aside from z scores being several points beyond range, ACTmathPRE and ACTmathPOST variables meet the assumption of normalcy and were used in further analysis. According to Wilcox, (2002), “Arbitrarily small departures from normality can result in very poor power when using any method based on means, and the power of conventional ANCOVA methods can be reduced substantially when there is skewness or heteroscedasticity” (p. 405). The research accounts for these factors when interpreting results of final analysis.

Figure 12. *Frequency Histograms of Variables*







Data sources for frequency histograms include classroom assessment scores pre and post treatment implementation for all students of study participants.

Summary of Findings RQ (c)

Teacher reported changes in student engagement and conceptual understanding were found. Teachers who participated in each of the three PD sessions offered saw benefits of the PD and used reform practices in a planned lesson. Students' mathematics readiness means were not significantly different proximally or distally given treatments. However, treatment participants established a reliable community of mathematics teachers across the district to collaborate with in the future and had the opportunity to reflect upon their own classroom practices.

CHAPTER V: IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

This chapter provides a summary of the study, implications of results according to each research question, recommendations, and a final conclusion.

Summary of Study

This study considered student, classroom, and teacher factors to address students' mathematics readiness of students, reformed high school mathematics classrooms, and reform implementation of teachers given the lack of research that considers these factors on the secondary mathematics level. Understanding the connections between high school students' mathematics readiness and engagement, mathematics teachers' participation in PD, and implementation of reform practices in mathematics classrooms required analysis of these factors over time. Longitudinal studies mentioned in literature review showed increases in students' mathematics readiness (Boaler & Staples, 2008) and student engagement (Wu & Huang, 2007), as well as conceptual knowledge development for high school student whose mathematics teachers implemented more reform practices. To increase student engagement and students' mathematics readiness of students, treatment teacher participants were provided PD that used an effective framework (Dennen, 2004) and clearly defined, modeled, and supported reform practice implementation (Smith, Desimone, & Ueno, 2005) in high school mathematics classrooms.

In addition to an increase reform practice implementation for all treatment participants in general, themes emerged from the study that showed a combination of student, teacher, and classroom factors to impact reform practice implementation and students' mathematics readiness. These include changes in teacher perception and knowledge of reform practices, and teacher reported changes in student engagement and conceptual understanding. Although, discourse and interactions between teacher participants and PD facilitator positively impacted reform implementation for treatment participants who participated in all treatment sessions, positive changes in students' mathematics readiness would require additional time and measures to prove empirically.

Implications

Teachers who participated in each of the three PD sessions offered were able to see benefits of the PD and reform practice implementation. PD that allowed interaction amongst novice and expert participants, Cognitive Apprenticeship (Dennen, 2004), influenced teachers' perception of mathematics teacher PD and positively impacted teacher participants implementation of reform practice (Lawrenz, Huffman, & Gravely, 2007). Teachers were more eager to participate in PD that valued their time, aligned to mathematics content (Desimone, et al., 2002), and allowed mathematics teacher collaboration from across the district.

Implications from these findings would suggest administrators support quality, targeted PD, for mathematics teachers. District leaders and school administrators can designate mathematics teacher leaders in their buildings as well as reach out for experts from the district. Teachers could meet periodically throughout the school year and communicate often using a variety of formats. Mathematics teacher leaders could include National Board Certified Teachers (NBCT), department chairperson(s), resource teachers, or mathematics educators. Times, meeting, and locations would meet the needs of PD attendees. Also, more time should be allowed for teachers to meet and collaborate across the district to work on common problems, issues, and strategies during designated PD days throughout the school year.

Future studies could include other teacher variables such as teacher content knowledge to see how it contributes towards increasing students' mathematics readiness for high school students and reform practice implementation.

Algebra I and Algebra II teachers who participated in all three PD sessions were able to reflect upon changes in student engagement and conceptual knowledge after attending treatment PD. Teacher to student and then student to student interactions from blog post and treatment interviews show conversations and notes that support this finding. Also, changes in teachers' perceptions and beliefs of PD findings showed knowledge and beliefs about reform practices and PD influenced teacher implementation of reformed practices post treatment. Teachers who were the most knowledgeable of eight mathematical practices were more likely to use them in their mathematics classrooms than control teachers. Assistance from a peer expert and PD facilitator contributed towards reform practice implementation. Embedded instructional strategies observed included an Algebra II, 100, teacher's blog post of Teach One Activity and Algebra I, 106, teacher's use of scaffolding questioning with smart board clickers.

Implications from these findings about embedded instruction strategies suggest teachers increase their knowledge of reform practices as a catalyst for student success in high school mathematics classrooms. Teacher implementation of reform practices engaged students in learning through student to student and teacher to student interactions. These interactions show that mathematics students reflect, and repeat what they are taught, which promotes conceptual knowledge changes.

Also, new thinking about reform practices occurred for teachers who discover new knowledge of reform practices in PD through interaction with peer experts. Increases in interaction among students, as well as, student engagement, and conceptual changes may promote positive learning outcomes and students' mathematics readiness for students over time. The relationship between reform practice, student engagement in mathematics, and students' mathematics readiness would require further research and longer time in between observations to determine significant changes. Studies would consider additional student variables such as learner's mathematics self-efficacy and students' mathematics readiness.

Connections between reform practice implementation and students' mathematics readiness were not empirically supported. RTOP scores over the duration of the study significantly increased but this increase was not associated with an increase in college readiness distally or proximally. Using pretest as a covariates helped removed variance due to the positive correlations however differences in means that remained were due to chance.

Implications from these findings suggest that differences in students' mathematics readiness may be attributed to reform practices implemented, therefore, high school administrators must insure that their mathematics teachers have access to PD that is effective PD that influences reform implementation in positive and meaningful ways. Administrators can encourage teacher implementation of reform practices through school policies. These policies can insure PD for mathematics teachers meet the criteria for research based PD. Such polices should support effective content-focused PD for mathematics teachers that connects to their classroom as well as meet the criteria for research based PD (Driskell, Bush, Roanu, Niess, Pugalee, Rakes, in press; Locks-Horsley, tiles, Mundry, Love, & Hewson, 2010; Sztain, 2011). For example, administrators could support teacher leadership by allowing mathematics teacher leaders equal teaching and leadership/mentoring responsibilities. Mathematics teacher leaders would have input on curricular decisions that impact reform practice implementation. Also, teacher leaders can assist with writing district assessments and help mathematics teachers in their building track and implement reform practices in their classrooms. All stakeholders can help increase students' mathematics readiness for students by supporting targeted PD for mathematics teachers and mathematics teacher leaders. The PD in this study not only used CA framework, but linked specific mathematics content to students present in the mathematics classroom communities. Teachers need PD that helps them relate mathematics content to the students they teach. The PD would remain teacher centered and support reform implementation and school administrators can play a vital role in insuring PD meets needs of mathematics teachers.

Limitations

Limitations due to sampling, impact interpretation of PD treatment effects, confidence in group placement, and external validity. Treatment teachers had difficulty participating in all three treatment session and posting on community blog. Lack of anonymity on community blog page may have caused teachers to hesitate instead of posting ideas in fear of recognition. Given the convenience sample used in the study, findings would generalize to sample participants not necessary to a similar population of high school mathematic teachers. This study began with six treatment and six control group participants, with a minimum of nine students in each class. Five treatment teachers attended at least one session, two treatment teachers attended two PD sessions, and two teachers attended all three sessions. One treatment and one control participant, 108 and 111, dropped out of the study before completion. Reliability and validity violations as a result of sample size are taken into consideration when interpreting results

Due to selective sampling, generalizing is an issue when interpreting results. The selected sampling excluded students who had not taken ACT Plan as a 10th grader, or transferred to JCPS from outside the district after the study's' implementation. Also, attrition due to teacher and or student changes during the student year caused the statistical findings to lack strength and power. Teacher buy in and rapport with PD facilitator were vital in treatment teacher participations and reform implementation.

Also, there were several limitations with regards to treatment fidelity, assessment scores, and group independence. Attempts were made to communicate often with teachers, but low participation due to outside factors such as lack of incentive, or availability, limited treatment effects. Offering a monetary incentive may assist with this limitation in future studies. Incentives would require teachers to provide data (i.e. assessment scores, post observations) in a timely manner. Also, school factors such as Traditional versus Magnet schools could have impacted students' mathematics readiness of students, although, they were not addressed in this study.

To control for inter-rater reliability the PD facilitator had a colleague trained using the RTOP to blind score one pretest and one posttest from treatment and control group. Scores were within $\pm$ two points. This shows that the scores between facilitator and colleague were comparable and reliable. Date (i.e. homecoming, holiday) and time (i.e. May Observations, afternoon observations) of observations may have negatively influenced scores. Groups may have had differences (i.e., Honors, Comprehensive) not considered as possible statistical regression threats. In future studies, group factors should be determined as early as possible group prior to the first observation to minimize these threats.

Recommendations

In future studies, the sample could include participants from schools throughout the state to extend generalizability to larger populations. Mathematics teachers in a school could be engaged in a multi-year effort that focused on common goals and objectives in which teachers helped define and develop the PD activities and evaluation. Researchers may also consider other demographic factors as a different covariate in the analysis (i.e. socio economic status or gender) to determine if there were any significance differences given the interaction of these covariates. Further study of interactions between teachers and their students may provide insight on how to insure more students engage in mathematics classes. Also, researchers could consider other teacher level factors in determining if specific teacher to student interactions affect mathematics achievement as measured in college readiness such as teacher knowledge, orientation, and experience.

This study found an increase in reform practices for treatment teacher participants but did not consider high stakes testing and its impact on treatment teacher's participation in policy initiatives to increase students' mathematics readiness for students. Current research that considers classroom practices and assessment measures has shown that high stakes testing influences policy initiatives (Hamilton, Stecher, & Yuan, 2008), and impact reform practice implementation of teachers. Jacob and Lewitt (2003) found in their study of education policy and college readiness that high stakes testing results corrupted teacher practice(s). In this study teachers were more likely to employ unethical tactics when reporting student scores on high stakes achievement tests. Research that considers high stakes testing (Hamilton, Stecher, & Yuan, 2008) and other variables would provide additional information about reform implementation for high school mathematics teachers. Possible research questions could include the following:

(1) How does high stakes testing influence high school mathematics teacher implementation of reform practices?

(2) How does teacher experience influence reform implementation and student engagement for high school students?

(3) How does high stakes testing influence high school students' engagement in mathematics classrooms?

Conclusion

Educational research that considers multi-level factors, students' mathematics readiness, student conceptual knowledge and engagement, as well as, reform practice implementation, has the potential to influence policy that can result in positive changes for high school mathematics students' preparing for college level mathematics. Education reform efforts in the state hold schools accountable for their students' mathematics readiness; therefore, stake holders specifically high schools teachers, need access to research and effectively targeted PD that helps them increase students' mathematics readiness (Driskell, et al., (in press); LocksHorsley, et al. 2010; Roderick et al., 2009; Sztain, 2011). The treatment PD had participants seek to understand "student's thinking about mathematics as well as teacher's thinking about teaching mathematics" (Blanton, Berenson, & Norwood, 2001, p. 227). As a result, mathematics teachers who put in the time to increase their knowledge and implementation of embedded strategies benefitted from the PD alongside their students. Teacher beliefs, knowledge, and access to effective PD influenced their participation and usage of reform practices that support student engagement and student conceptual knowledge development in mathematics classroom communities. Classroom discourse, interactions among students and teachers, as wells as teacher discourse with colleagues impacted student engagement, student conceptual knowledge, and students' mathematics readiness over the duration of the study. Teacher knowledge and implementation of reform practices increased significantly. Student engagement in mathematics classes positively impacted teachers' reform practice implementation post treatment.

PD for high school mathematics teachers in this study used a framework, Cognitive Apprenticeship, which required content specific teacher interactions, expert teacher modeling, coherence, and active participant learning to promote positive changes in students' mathematics readiness (Birman, et al., 2001). This study's treatment provided teachers with resources that contributed towards increases in reform implementation, and were a catalyst for students' mathematics readiness, student engagement, and student conceptual knowledge development. Also, the findings align with other studies that found links between teacher knowledge gains and changes in classroom practices (CCSSO, 2014). Future PD would connect teacher knowledge changes in instructional practice to measurable student outcomes. Most importantly the PD would help participants established a mathematics teacher community that serves as a model for mathematics communities prevalent in reformed high school mathematics classrooms.

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APPENDIX A

RTOP: Reformed Teaching Observation Protocol

Teacher Candidate: ____

Observer: ____

Grade Level: ______________ Date of Observation: ________________________

Lesson Plan & Implementation

	Never Occurred Very Descriptive
1.) Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	0 1 2 3 4
2.) The lesson was designed to engage students as members of a learning community.	0 1 2 3 4
3.) In this lesson, student exploration preceded formal presentation.	0 1 2 3 4
4.) This lesson encouraged students to seek and value alternative modes of investigation or of problem solving	0 1 2 3 4
5.) The focus and direction of the lesson was often determined by ideas originating with students.	0 1 2 3 4

		Never Occurred Very Descriptive
Propositional	6.) The lesson involved fundamental concepts of the subject.	0 1 2 3 4
	7.) The lesson promoted strongly coherent conceptual understanding.	0 1 2 3 4
	8.) The teacher had a solid grasp of the subject matter content inherent in the lesson.	0 1 2 3 4
	9.) Elements of abstraction (i.e., symbolic representations, theory building) were encouraged where it was important to do so.	0 1 2 3 4
	10.) Connections with other content disciplines and/ or real world phenomena were explored and valued.	0 1 2 3 4

Procedural Knowledge	11.) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	0 1 2 3 4

12.) Students made predictions, estimations and/or hypotheses and devised means for testing them.	0 1 2 3 4
13.) Students were actively engaged in thoughtprovoking activity that often involved the critical assessment of procedures.	0 1 2 3 4
14.) Students were reflective about their learning.	0 1 2 3 4
15.) Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0 1 2 3 4

Classroom Culture content

		Never Occurred Very Descriptive
Communicative Indicators	16.) Students were involved in the communication of their ideas to others using a variety of means and media.	0 1 2 3 4
	17.) The teacher's questions triggered divergent modes of thinking.	0 1 2 3 4
	18.) There was a high proportion of student talk and a significant amount of it occurred between and among students.	0 1 2 3 4
	19.) Student questions and comments often	0 1 2 3 4
	determined the focus and direction of classroom discourse.	0 1 2 3 4
	20.) There was a climate of respect for what others had to say.	0 1 2 3 4
	21.) Active participation of students was encouraged and valued.	0 1 2 3 4

Student/ Teacher Relationships	22.) Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0 1 2 3 4
	23.) In general the teacher was patient with students.	0 1 2 3 4
	24. The teacher acted as a resource person, working to support and enhance student investigations.	0 1 2 3 4
	25.) The metaphor "teacher as listener" was very characteristic of this classroom.	0 1 2 3 4

Feedback

APPENDIX B: Teacher Survey

In completing this survey, I agree to participate in this study.
1. What is your school location number in the district?
2. I am able to influence other teaches in my school
3. I am comfortable with writing a lesson plan so that my students are actively engaged.
4. My students are actively engaged in asking questions throughout class-time.
5. My students are actively engages in experiences (physically or mentally) throughout class-time.
6. I try out new approaches to teaching mathematics in my class.
7. I use discrepancy to motivate learning
8. I use curiosity to motivate learning.
9. My class time focuses on activities that relate to student understanding of concepts.
10. My students have the opportunity to experience the relationship of concepts to their everyday lives.
11. During the lessons I appropriately vary methods to facilitate student conceptual understanding; i.e., discussion, questions, brainstorming, investigations, reporting of strategies, etc.
12. I integrate content and process skills during class-time.
13. I rely heavily on textbook tests.
14. It is important to me that my students know their basic facts in mathematics
15. I am aware of my student's understanding of content and modify my lesson when necessary.
16. As student misperceptions become apparent, I facilitate student efforts to resolve misperceptions, i.e., gathering evidence facilitating discussion with or among students.
17. My math class experiences have an appropriate balance between depth and breadth.
18. I am active in the outreach to parents and the community.
19. I make use of calculators and technology in my math teaching.
20. I discuss events in my classroom with other teachers in my building.
21. I am more anxious teaching mathematics than any other subject.
22. I rely heavily on my own tests made from my objectives.
23. It is important to me that students can solve problems in mathematics.
24. I am comfortable teaching mathematics.
25. I feel comfortable handling questions from my high ability students.
26. I use math worksheets in my class.
27. All my students move at a pace appropriate to their abilities.

For the next part use the following response format. For each question select the number that reflects your opinion for each statement.

28. I am familiar with the NCTM Standards on teaching mathematics
29. I am familiar with current research in my field
30. I am familiar with various curricular projects funded by the NSF.
31. Students are always the focus of my teaching.
32. I am aware of the diversity of students in my classroom.
33. I believe that boys and girls can learn mathematics equally well.
34. I am aware that the problems and difficulties I experience are universal.
35. I don't believe that technology is necessary in teaching mathematics.
36. I can teach towards all ability levels.
37. I am enthusiastic about learning from my colleagues through the exchanges of beliefs and ideas.
38. I am comfortable with the way I am teaching mathematics.
39. I would like my students to expand their math skills and enjoy it.
40. There are alot of things I would like to do in my classroom that I never get around to because of the pressures of proficiency testing.
41. What are your total years of experience teaching high school mathematics?
42. Have you attended district provided professional development (e.g. CPM new or veteran training) during 2014-2015 school year?
43. What subjects do you teach?
44. What day of the week is best for attending after school professional development

Brahier & Schaffner 2004

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APPENDIX C: Interview Protocol

Research Questions

a) How does professional development, framed by a Cognitive Apprenticeship model, affect the implementation of teacher reform practices?

b) How does the use of teacher reform practices affect student engagement in mathematics?

c) How does the use of teacher reform practices affect mathematic readiness for high school students?

Questions of Treatment Participants

1. Describe the engagement of your students during your lesson.
   a. How many of your students were fully engaged in the class activity?
   b. How intensely were they engaged?
   c. What did you notice about students who were not engaged?
   d. Was the level of engagement typical of this class?
   e. What strategies to you use to engage more students?
   f. Is it possible to engage all students in this classroom?
2. How do you involve all learners in the mathematics community (classroom engagement)?
3. Was student engagement different from this lesson than with other lessons before the PD? Why or why not?
4. How did you start this lesson?
   a. Describe the introduction.
5. How did the students start; did they have an opportunity to explore before starting on the task?
6. Did the lesson promote a strong conceptual understanding of the concepts?

a. Describe an example of how a lesson activity promoted conceptual understanding

b. Describe how the lesson supported procedural fluency

6. What else would you have needed in the lesson to better promote student understanding?

7. How did the focus on conceptual knowledge development in the PD session effect your teaching concepts in everyday lessons? Describe an example.

   a. Did you blog on the community webpage High School PD? If so, Describe an example of a blog you posted that illustrates your activity.

8. Did the videos shown in the PD where teachers **modeled** how to implement the mathematical practices to teach mathematics concepts assist you with planning lessons for your classes? If so, how?

9. How does mathematics teacher collaboration affect how and when you implement mathematical practices in your classroom to engage students in learning mathematics concepts?

APPENDIX D ACT mathematics Practice Assessment

1. A weekly fee for staying at the Pleasant Lake Campground is \$20 per vehicle and \$10 per person. Last year, weekly fees were paid for v vehicles and p persons. Which of the following expressions gives the total amount, in dollars, collected for weekly fees last year?

A. $20v + 10p$
B. $20p + 10v$
C. $10(v + p)$
D. $30(v + p)$
E. $10(v + p) + 20p$

2. If $r = 9$, $b = 5$, and $g = -6$, what does $(r + b - g)(b + g)$ equal?

F. −20
G. −8
H. 8
J. 19
K. 20

3. A copy machine makes 60 copies per minute. A second copy machine makes 80 copies per minute. The second machine starts making copies 2 minutes after the first machine starts. Both machines stop making copies 8 minutes after the first machine started. Together, the 2 machines made how many copies?

A. 480 **B.** 600 **C.** 680 **D.** 720 **E.** 960

4. Marlon is bowling in a tournament and has the highest average after 5 games, with scores of 210, 225, 254, 231, and 280. In order to maintain this exact average, what *must* be Marlon's score for his 6th game?

F. 200
G. 210
H. 231
J. 240
K. 245

5. Joelle earns her regular pay of \$7.50 per hour for up to 40 hours of work in a week. For each hour over 40 hours of work in a week, Joelle is paid $1^{1/2}$ times her regular pay. How much does Joelle earn for a week in which she works 42 hours?

A. \$126.00 **B.** \$315.00 **C.** \$322.50 **D.** \$378.00 **E.** \$472.50

6. Which of the following mathematical expressions is equivalent to the verbal expression "A number, x, squared is 39 more than the product of 10 and x" ?

F. $2x = 39 + 10x$
G. $2x = 39x + 10x$
H. $x^2 = 39 - 10x$

J. $x^2 = 39 + x^{10}$

K. $x^2 = 39 + 10x$

7. If $9(x - 9) = -11$, then $x = ?$

A. $-92/9$

B. $-20/9$

C. $-11/9$

D. $-2/9$

E. $7/9$

8. Discount tickets to a basketball tournament sell for \$4.00 each. Enrico spent \$60.00 on discount tickets, \$37.50 less than if he had bought the tickets at the regular price. What was the regular ticket price?

F. \$ 2.50
G. \$ 6.40
H. \$ 6.50
J. \$ 7.50
K. \$11.00

9. The expression $(3x - 4y^2)(3x + 4y^2)$ is equivalent to:

A. $9x^2 - 16y^4$

B. $9x^2 - 8y^4$

C. $9x^2 + 16y^4$

D. $6x^2 - 16y^4$

E. $6x^2 - 8y^4$

10. A rectangle has an area of 32 square feet and a perimeter of 24 feet. What is the shortest of the side lengths, in feet, of the rectangle?

F. 1 **G.** 2 **H.** 3 **J.** 4**K.** 8

11. In ABC, the sum of the measures of $\angle A$ and $\angle B$ is 47°. What is the measure of $\angle C$?

A. 47° **B.** 86° **C.** 94° **D.** 133° **E.** 143°

12. In the school cafeteria, students choose their lunch from 3 sandwiches, 3 soups, 4 salads, and 2 drinks. How many different lunches are possible for a student who chooses exactly 1 sandwich, 1 soup, 1 salad, and 1 drink?

F. 2
G. 4

H. 12
J. 36
K. 72

13. For 2 consecutive integers, the result of adding the smaller integer and triple the larger integer is 79. What are the 2 integers?

A. 18, 19 **B.** 19, 20 **C.** 20, 21 **D.** 26, 27**E.** 39, 40

14. A function $f(x)$ is defined as $f(x) = -8x^2$. What is $f(-3)$?

F. -72
G. 72
H. 192
J. -576
K. 576

15. If $3^x = 54$, then which of the following must be true?

A. $1 < x < 2$
B. $2 < x < 3$
C. $3 < x < 4$
D. $4 < x < 5$
E. $5 < x$

16. What is the least common multiple of 70, 60, and 50 ?

F. 60
G. 180
H. 210
J. 2,100
K. 210,000

17. Hot Shot Electronics is designing a packing box for its new line of Acoustical Odyssey speakers. The box is a rectangular prism of length 45 centimeters, width 30 centimeters, and volume 81,000 cubic centimeters. What is the height, in centimeters, of the box?

A. 75 **B.** 60 **C.** 48 **D.** 27 **E.** 18

18. Four points, *A*, *B*, *C*, and *D*, lie on a circle having a circumference of 15 units. *B* is 2 units counterclockwise from *A*. *C* is 5 units clockwise from *A*. *D* is 7 units clockwise from *A* and 8 units counterclockwise from *A*. What is the order of the points, starting with *A* and going clockwise around the circle?

F. *A*, *B*, *C*, *D* **G.** *A*, *B*, *D*, *C*
H. *A*, *C*, *B*, *D*
J. *A*, *C*, *D*, *B*
K. *A*, *D*, *C*, *B*

19. A group of cells grows in number as described by the equation $y = 16(2)^t$, where t represents the number of days and y represents the number of cells. According to this formula, how many cells will be in the group at the end of the first 5 days?

A. 80 **B.** 160 **C.** 400 **D.** 512 **E.** 1,280

GO ON TO THE NEXT PAGE.

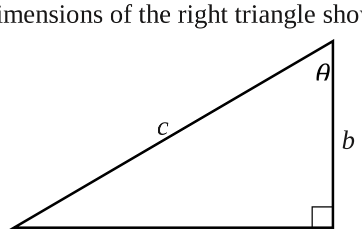
20. The length of a rectangle is 3 times the length of a smaller rectangle. The 2 rectangles have the same width. The area of the smaller rectangle is A square units. The area of the larger rectangle is kA square units. Which of the following is the value of k ?

F. 1/9
G. 1/3
H. 1
J. 3
K. 9

21. $(a + 2b + 3c) - (4a + 6b - 5c)$ is equivalent to:

A. $-4a - 8b - 2c$
B. $-4a - 4b + 8c$
C. $-3a + 8b - 2c$
D. $-3a - 4b - 2c$
E. $-3a - 4b + 8c$

22. The dimensions of the right triangle shown below are given in feet. What is sin θ ?



F. $\frac{a}{b}$
G. $\frac{a}{c}$
H. $\frac{b}{c}$
J. a/b
K. a/c

23. In a basketball passing drill, 5 basketball players stand evenly spaced around a circle. The player with the ball (the passer) passes it to another player (the receiver). The receiver cannot be the player to the passer's immediate right or left and cannot be the player who last passed the ball. A designated player begins the drill as the first passer. This player will be the receiver for the first time on which pass of the ball?

A. 4th **B.** 5th **C.** 6th **D.** 10th **E.** 24th

24. Lines p and n lie in the standard (x,y) coordinate plane. An equation for line p is $y = 0.12x + 3{,}000$. The slope of line n is 0.1 greater than the slope of line p. What is the slope of line n ?

F. 0.012
G. 0.02
H. 0.22
J. 1.2
K. 300

25. The expression $-8x^3(7x^6 - 3x^5)$ is equivalent to:

A. $-56x^9 + 24x^8$

B. $-56x^9 - 24x^8$

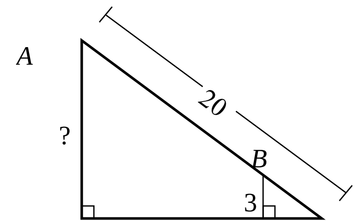
C. $-56x18 + 24x15$

D. $-56x18 - 24x15$

E. $-32x^4$

26. $-3|-6 + 8| = ?$
F. −42
G. −6
H. −1
J. 6
K. 42

27. In right triangle ___ ACE below, ___ BD is parallel to AE___, and BD is perpendicular to ___EC at D. The length of AC is 20 feet, the length of ___ BD is 3 feet, and the length of___ CD is 4 feet. What is the length, in feet, of AE ?



A. 10
B. 12
C. 15
D. 16
E.17

28. As part of a lesson on motion, students observed a cart rolling at a constant rate along a straight line. As shown in the chart below, they recorded the distance, y feet, of the cart from a reference point at 1-second intervals from $t = 0$ seconds to $t = 5$ seconds.

t	0	1	2	3	4	5

y	14	19	24	29	34	39

Which of the following equations represents this data?

F. $y = \quad t + 14$
G. $y = \quad 5t + \quad 9$
H. $y = \quad 5t + 14$
J. $y = 14t + \quad 5$
K. $y = 19t$

29. The inequality $6(x \quad 2) \ \ 7(x < 5)$ is equivalent to which of the following inequalities?

A. $x < 23$

B. $x \quad 7$

C. $x \ \ 17$

D. $x \ \ 37$

E. $x \ \ 47$

30. The sides of a square are 3 cm long. One vertex of the square is at (2,0) on a square coordinate grid marked in centimeter units. Which of the following points could also be a vertex of the square?

F. (<4, 0)

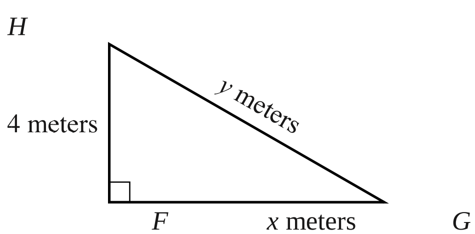
G. (0, 1)

H. (1,<1)

J. (4, 1)

K. (5, 0)

31. For △*FGH*, shown below, which of the following is an expression for y in terms of x ?



A. $\sqrt{x \quad 4}$

B. $\sqrt{x^2 \quad 4}$

C. $\sqrt{x^2 \quad 8}$

D. $\sqrt{x^2 < 16}$

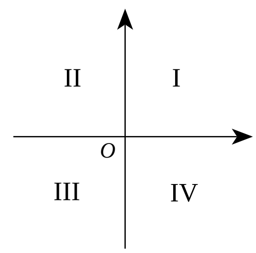
E. x^2 16

32. A bag contains 12 red marbles, 5 yellow marbles, and 15 green marbles. How many additional red marbles must be added to the 32 marbles already in the bag so that the probability of randomly drawing a red marble is __35 ?

F. 13
G. 18
H. 28
J. 32
K. 40

33. What are the quadrants of the standard (x,y) coordinate plane below that contain points on the graph of the equation $4x < 2y$ 8 ? y quadrants of the

standard (x,y)x coordinate plane



A. I and III only

B. I, II, and III only

C. I, II, and IV only

D. I, III, and IV only

E. II, III, and IV only

34. The graph of $y < 5x^2$ 9 passes through (1,2a) in the standard (x,y) coordinate plane. What is the value of a ?

F. 2

G. 4

H. 7

J. <1

K. <8

35. Jerome, Kevin, and Seth shared a submarine sandwich. Jerome ate —$^1{}_2$ of the sandwich, Kevin ate —$^1{}_3$ of the sandwich, and Seth ate the rest. What is the ratio of Jerome's share to Kevin's share to Seth's share?

A. 2:3:6

B. 2:6:3

C. 3:1:2

D. 3:2:1

E. 6:3:2

36. A particular circle in the standard (x,y) coordinate plane has an equation of $(x < 5)x^2 + y^2$ 38. What are the radius of the circle, in coordinate units, and the coordinates of the center of the circle?

<u>radius center</u>

F. $\sqrt{38}$ (5,0)

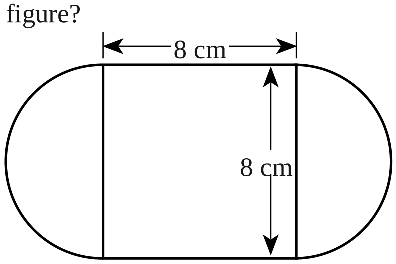
G. 19 (5,0)

H. $\sqrt{38}$ (5,0)

J. 38 (<5,0)

K. 19 (<5,0)

37. The figure below consists of a square and 2 semicircles, with dimensions as shown. What is the outside perimeter, in centimeters, of the figure?



A. $8 + 8\pi$

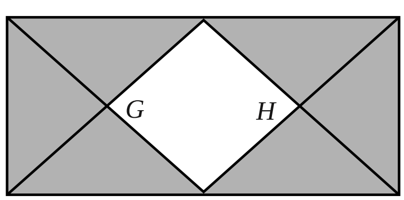
B. $16 + 8\pi$

C. $16 + 16\pi$

D. $32 + 8\pi$

E. $32 + 16\pi$

38. In the figure below, points *E* and *F* are the midpoints of sides *AD* and *BC* of rectangle *ABCD*, point *G* is the intersection of *AF* and *BE* , and point *H* is the intersection of *CE* and *DF* . The interior of *ABCD* except for the interior of *EGFH* is shaded. What is the ratio of the area of *EGFH* to the area of the shaded region?



B *F* *C*

A *E* *D*

F. 1:2

G. 1:3
H. 1:4
J. 1:6
K. Cannot be determined from the given information

39. The coordinates of the endpoints of *CD*, in the standard (x,y) coordinate plane, are (−4,−2) and ___ (14,2). What is the x-coordinate of the midpoint of *CD* ?

A. 0 **B.** 2 **C.** 5 **D.** 9 **E.** 10

40. What is the surface area, in square inches, of an 8-inch cube?

F. 512
G. 384
H. 320
J. 256
K. 192

41. The equations below are linear equations of a system where a, b, and c are positive integers.

$$ay + bx = c \quad ay - bx = c$$

Which of the following describes the graph of at least 1 such system of equations in the standard (x,y) coordinate plane?

I. 2 parallel lines
II. 2 intersecting lines
III. A single line

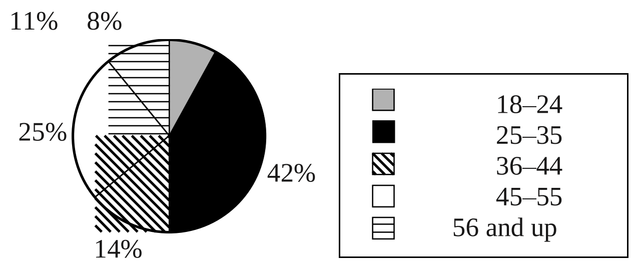
A. I only
B. II only
C. III only
D. I or II only
E. I, II, or III

42. Which of the following equations has $-i$, i, and 0 as its only roots?

A. $x^2 - 1 = 0$
B. $x^2 + 1 = 0$
C. $x^2 + x + 1 = 0$
D. $x^3 - x = 0$
E. $x^3 + x = 0$

43. range) that the first person called for jury duty is in the age range of 25−35 years?

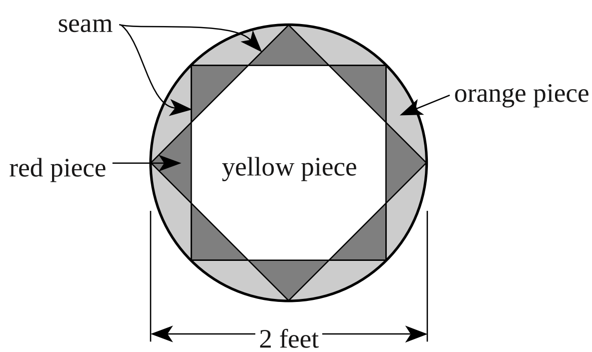
Distribution of Registered Voters by Age



A. 1:3
B. 7:8
C. 7:43
D. 21:29
E. 42:25

Use the following information to answer questions 44–46.

The figure below shows the design of a circular stainedglass panel on display at Hopewell's Antique Shop. Seams separate the pieces of the panel. All red triangular pieces shown are congruent and have a common vertex with each adjoining triangular piece. The 2 squares shown are inscribed in the circle. The diameter of the panel is 2 feet.



44. The design of the stained-glass panel has how many lines of symmetry in the plane of the panel?

F. 2
G. 4
H. 8
J. 16

45. What is the area of the stained-glass panel, to the nearest 0.1 square foot?

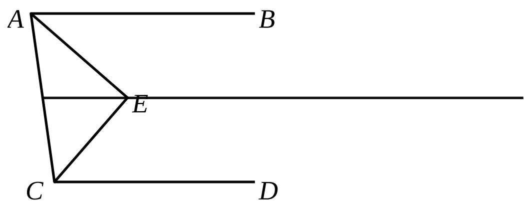
A. 3.1 **B.** 4.0 **C.** 6.2 **D.** 8.0 **E.** 12.6

46. Kaya wants to install a new circular stained-glass window in her living room. The design of the window will be identical to that of the panel. The diameter of the new window will be 75% longer than the diameter of the panel. The new window will be how many feet in diameter?

F. 1.50

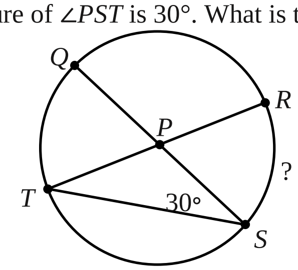
G. 2.50
H. 2.75
J. 3.50
K. 4.00

47. In the figure below, ___ *AB* *CD*, *AE* bisects ∠*BAC*, and *CE* bisects ∠*ACD*. If the measure of ∠*BAC* is 82°, what is the measure of ∠*AEC* ?



A. 86° **B.** 88° **C.** 90° **D.** 92° **E.** Cannot be determined from the given information

48. In the circle shown below, chords *TR* and *QS* intersect at *P*, which is the center of the circle, and the measure of ∠*PST* is 30°. What is the degree measure of minor arc *RS* ?



F. 30° **G.** 45° **H.** 60°
J. 90°
K. Cannot be determined from the given information

49. For what value of *a* would the following system of equations have an infinite number of solutions?

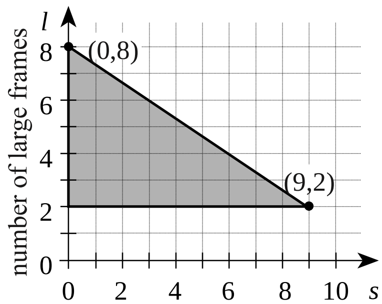
$$2x - y = 8$$
$$6x - 3y = 4a$$

A. 2
B. 6
C. 8

D. 24
32

Use the following information to answer questions 50–52.

Marcia makes and sells handcrafted picture frames in 2 sizes: small and large. It takes her 2 hours to make a small frame and 3 hours to make a large frame. The shaded triangular region shown below is the graph of a system of inequalities representing weekly constraints Marcia has in making the frames. For making and selling s small frames and l large frames, Marcia makes a profit of $30s + 70l$ dollars. Marcia sells all the frames she makes.



number of small frames

50. The weekly constraint represented by the horizontal line segment containing (9,2) means that each week Marcia makes a minimum of:

F. 2 large frames. **G.** 9 large frames.
H. 2 small frames.
J. 9 small frames. **K.** 11 small frames.

51. For every hour that Marcia spends making frames in the second week of December each year, she donates \$3 from that week's profit to a local charity. This year, Marcia made 4 large frames and 2 small frames in that week. Which of the following is closest to the percent of that week's profit Marcia donated to the charity?

A. 6% **B.** 12% **C.** 14% **D.** 16%
E. 19%

52. What is the maximum profit Marcia can earn from the picture frames she makes in 1 week?

F. \$410 **G.** \$460 **H.** \$540 **J.** \$560
K. \$690

53. If $f(x) = 3x + 2$, then $f(a + b) = ?$

A. $3a + 3b + 2$
B. $3a + 3b + 4$
C. $3x + 2 + a + b$
D. $3x + 2 + 3a + 3b$
E. $3x + 4 + 3a + 3b$

54. A formula for finding the value, A dollars, of P dollars invested at i% interest compounded annually for n years is $A = P(1 + 0.01i)^n$. Which of the following is an expression for P in terms of i, n, and A ?

F. $A - 0.01i^n$

G. $A + 0.01i^n$

H. 1_______ +A0.01i n__________A

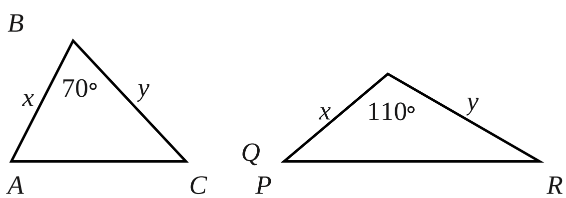
J. $(1 - 0.01i)^n$__________A

K. $(1 + 0.01i)^n$

55. A sighting from sea level to the top of a lighthouse was 60°. The lighthouse is known to rise 180 feet above sea level. What is the distance (to the nearest foot) between the observer and the base of the lighthouse?

F. 104 **G.** 180 **H.** 208 **J.** 254
K. 311

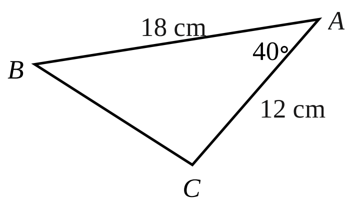
56. Triangles ABC and PQR are shown below. The given side lengths are in centimeters. The area of ABC is 30 square centimeters. What is the area of PQR, in square centimeters?



F. 15 **G.** 19 **H.** 25 **J.** 30
K. 33

57. Triangle ABC is shown in the figure below. The measure of $\angle A$ is 40°, AB = 18 cm, and AC = 12 cm.
Which of the following is the length, in centimeters, of___
BC ?

(Note: For a triangle with sides of length a, b, and c opposite angles $\angle A$, $\angle B$, and $\angle C$, respectively, the lawof sines states ____a__sin $\angle A$ = ____b__sin $\angle B$ = sin___c___$\angle C$ and the law of cosines states $c^2 = a^2 + b^2 - 2ab \cos \angle C$.)



A. $12 \sin 40°$

B. $18 \sin 40°$

C. $18^2 - 12^2$

D. $12^2 + 18^2$

E. $12^2 + 18^2 - 2(12)(18) \cos 40°$

58. What is the sum of the first 4 terms of the arithmetic sequence in which the 6th term is 8 and the 10th term is 13 ?

F. 10.5
G. 14.5
H. 18
J. 21.25
K. 39.5

59. In the equation $x^2 + mx + n = 0$, m and n are integers. The *only* possible value for x is –3. What is the value of m ?

A. 3

B. –3
C. 6

D. –6
E. 9

60. The solution set of which of the following equations is the set of real numbers that are 5 units from −3 ?

F. $|x + 3| = 5$

G. $|x - 3| = 5$

H. $|x + 5| = 3$

J. $|x - 5| = 3$

K. $|x + 5| = -3$

APPENDIX E District Assessments

Algebra II Diagnostic 3

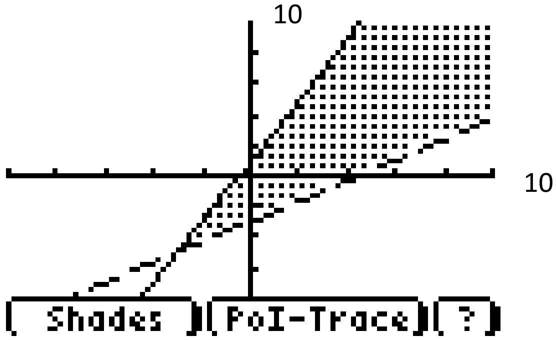
1) Which system of inequalities describes the following graph?

a. $\begin{cases} y > 2x + 1 \\ y \leq \frac{2}{3}x - 3 \end{cases}$

c. $\begin{cases} y \leq 2x + 1 \\ y > \frac{2}{3}x - 3 \end{cases}$

b. $\begin{cases} y < 2x + 1 \\ y \leq \frac{2}{3}x - 3 \end{cases}$

d. $\begin{cases} y \geq 2x + 1 \\ y < \frac{2}{3}x - 3 \end{cases}$



2) The corner point in the solution set of this system of inequalities is $\left(\frac{5}{2}, 6\right)$.

$$\begin{cases} y \geq ax + 4 \\ 5y \leq -4x + 40 \end{cases}$$

Which point is also in the solution set of the system of inequalities?

a. $(-1, 9)$
b. $(-2, 7)$
c. $(3, 4)$
d. $(6, 8)$

3) Given the following system of inequalities:

$$\begin{cases} 4x + y \geq 14 \\ x + y \geq 8 \\ x \geq 0 \\ y \geq 0 \end{cases}$$

Which point minimizes the objective function, $C(x, y) = 4x + 2y$?

a. (0, 14)
b. (0, 8)
c. (2, 6)
d. (8, 0)

4) Determine the sum $\begin{bmatrix} 3 & 0 & 0 & 1 \\ 8 & -2 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 3 & 0 & 0 \\ 8 & -2 & 0 \end{bmatrix}$ if it exists.

a. $\begin{bmatrix} 4 & 1 & 1 & 1 \\ 5 & -5 & -3 & -3 \end{bmatrix}$

c. $\begin{bmatrix} 6 & 0 & 0 & 2 \\ 16 & -4 & 0 & 0 \end{bmatrix}$

b. $\begin{bmatrix} 6 & 6 \\ 14 & 14 \end{bmatrix}$

d. The sum does not exist

5) Evaluate det $\begin{vmatrix} 3 & 2 \\ -2 & 1 \end{vmatrix}$.

a. –12
b. –1
c. 7
d. 12

6) What is the value of y for the system $\begin{cases} 4x - y + z = 2 \\ x - 2y - 3z = 3 \\ -5y - 4z = -14 \end{cases}$.

a. $y = 6$
b. $y = 5$
c. $y = 3$
d. $y = -4$

7) What is the product of $(-3 + i)$ and $(4 - 3i)$?

a. $-9 + 13i$
b. $-15 + 13i$
c. $-9 - 5i$
d. $-15 - 5i$

8) If $c - d = 5$ and $c = -2 + 3i$, what is the value of d?

a. $-3 + 3i$
b. $-7 + 3i$
c. $-3 - 3i$
d. $-7 - 3i$

9) Rationalize $\frac{1-i}{1+i}$.

a. 1
b. –1
c. i
d. $-i$

Algebra II Proficiency 3

1. Find the 50th term of the sequence 8, 2, –4, –10 ...

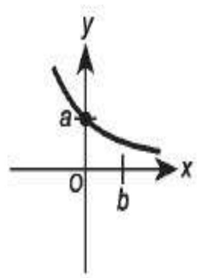
a. –272
b. –281
c. –286
d. –293

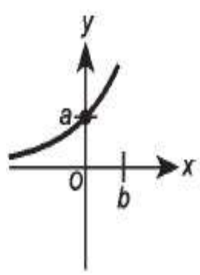
2. Write an explicit formula for the geometric sequence $a_1 = -4$, $a_2 = 8$, $a_3 = -16$ and find the 5th term.

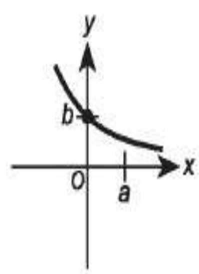
a. $a_n = -4(2)^n$ and $a_5 = -64$
b. $a_n = -4(-2)^n$ and $a_5 = 128$
c. $a_n = -4(-2)^{n-1}$ and $a_5 = -64$
d. $a_n = -2(-4)^{n-1}$ and $a_5 = -512$

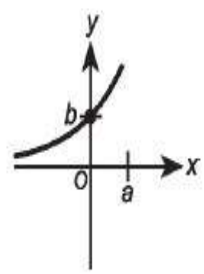
3. What is the graph of $y = ab^x$ where $a > 0$ and $0 < b < 1$?

a. b. c. d.









4. Multiply and simplify
$\sqrt{x} \bullet \sqrt[5]{x}$.

a. $\sqrt[5]{x}$
b. $\sqrt[6]{x}$
c. $\sqrt[7]{x^{10}}$
d. $\sqrt[10]{x^7}$

5. Write the expression $\sqrt{18} + \sqrt{32} - \sqrt{2}$ in simplest form.

a. $6\sqrt{2}$
b. $4\sqrt{13}$

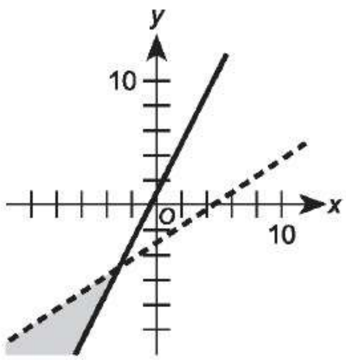
c. $9\sqrt{2}$

d. $2\sqrt{13}$

6. Solve $\sqrt{x+8} - 6 = -4$ for *x*.

a. –8
b. –4
c. 4
d. 14

7. Which system of inequalities describes the following graph?



a. $\begin{cases} y > 2x + 1 \\ y \le \frac{2}{3}x - 3 \end{cases}$

c. $\begin{cases} y \ge 2x + 1 \\ y < \frac{2}{3}x - 3 \end{cases}$

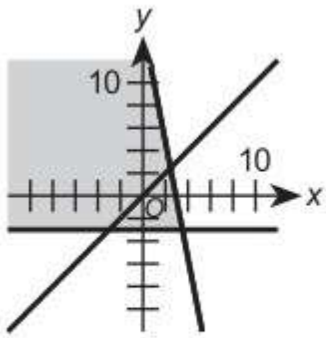
b. $\begin{cases} y < 2x + 1 \\ y \le \frac{2}{3}x - 3 \end{cases}$

d. $\begin{cases} y \le 2x + 1 \\ y > \frac{2}{3}x - 3 \end{cases}$

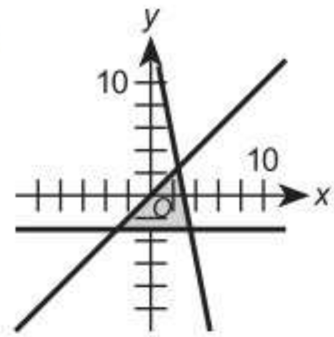
8. Which graph represents the solution set to this system of inequalities?

$$\begin{cases} y \le x \\ y \ge -3 \\ y \le 15 - 5x \end{cases}$$

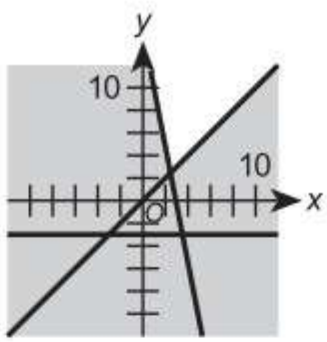
A.



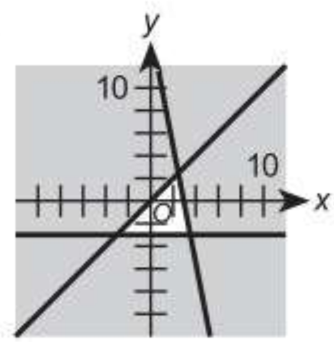
C.



B.



D.



9. Given the following system of inequalities:

$$\begin{cases} x + y \le 6 \\ x - y \le 6 \\ x \ge 0 \\ y \ge 0 \end{cases}$$

Which point maximizes the objective function, $P(x, y) = 3x + 4y$?

a. (0, 0)
b. (0, 6)
c. (4, 0)
d. (5, 1)

10. Determine the sum $\begin{bmatrix} 3 & 0 & 0 & 1 \\ 8 & -2 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 3 & 0 & 0 & 1 \\ 8 & -2 & 0 & 0 \end{bmatrix}$ if it exists.

a. $\begin{bmatrix} 4 & 1 & 1 & 1 \\ 5 & -5 & -3 & -3 \end{bmatrix}$

c. $\begin{bmatrix} 6 & 0 & 0 & 2 \\ 16 & -4 & 0 & 0 \end{bmatrix}$

b. $\begin{bmatrix} 6 & 6 \\ 14 & 14 \end{bmatrix}$

d. The sum does not exist

11. Evaluate det $\begin{vmatrix} 4 & 9 \\ 3 & -6 \end{vmatrix}$.

a. –51
b. –3
c. 3
d. 54

12. What is the value of *x* for the system $\begin{cases} 4x - y + z = 2 \\ x - 2y - 3z = 3 \\ -5y - 4z = -14 \end{cases}$.

a. $x = -9$
b. $x = -4$
c. $x = .45$
d. $x = 3$

13. What is the product of $(4 - 3i)$ and $(-7 - 2i)$?

a. $-23 + 13i$
b. $-23 - 29i$
c. $-34 - 29i$
d. $-34 + 13i$

14. If $c - d = 7$ and $c = 3 - 4i$, what is the value of *d*?

a. $-4 - 4i$
b. $-4 + 4i$
c. $4 - 4i$
d. $4 + 4i$

15. Rationalize $\frac{1+i}{1-i}$.

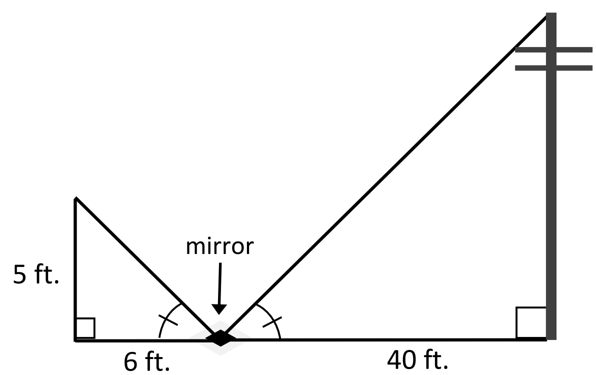
a. –1
b. 1
c. $-i$ d. i

Geometry Diagnostic 3

1. A tree planted on level ground is supported by cords of equal length and is perpendicular to the ground as shown in the figure below. The cords are tied to the tree 3 ft above the ground and are staked at points *C* and *Z* which are equidistant from the tree. Which statement explains how you can prove $\angle C \cong \angle Z$?

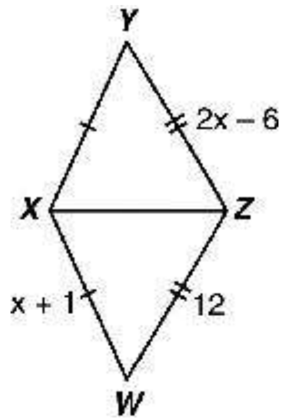
A. $\angle C \cong \angle Z$ by the AA theorem
B. $\Delta ABC \cong \Delta XYZ$ by the AAS theorem, and $\angle C \cong \angle Z$ because corresponding parts of congruent triangles are congruent
C. $\angle C \cong \angle Z$ by the ASA theorem
D. $\Delta ABC \cong \Delta XYZ$ by the SSS theorem, and $\angle C \cong \angle Z$ because corresponding parts of congruent triangles are congruent

2. Ronnie places a mirror 40 feet away from the base of a utility pole. When he stands 6 feet away from the mirror, he can see the top of the pole. If Ronnie's eye height is 5 feet, how tall is the utility pole to the nearest foot?



A. 8 feet
B. 33 feet
C. 48 feet
D. 200 feet

3. In the figure below, $\Delta XYZ \cong \Delta XWZ$.



What is the length of $\overline{XY}$?

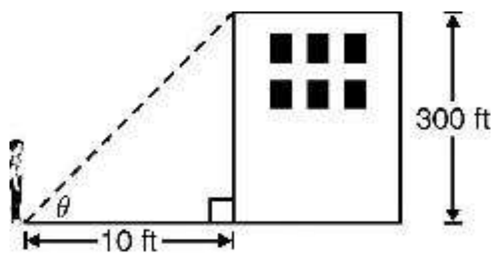
A. 7

B. 9

C. 10

D. 12

4. A person stands 10 feet away from the base of a 300-foot office building.



Which equation could be used to find *x*?

A. $\frac{\sin 88.1^\circ}{300} = \frac{\sin 90^\circ}{x}$

B. $\frac{\sin 88.1^\circ}{x} = \frac{\sin 90^\circ}{300}$

C. $\frac{\sin 300^\circ}{88.1} = \frac{\sin x^\circ}{90}$

D. $\frac{\sin x^\circ}{88.1} = \frac{\sin 300^\circ}{90}$

5. Jennifer and Robbie stand 50 ft apart on opposite sides of a statue. The angle of elevation from Jennifer's feet to the top of the statue is 46°, while the angle of elevation from Robbie's feet to the top of the statue is 52°. How tall, to the nearest tenth of a foot, is the statue?

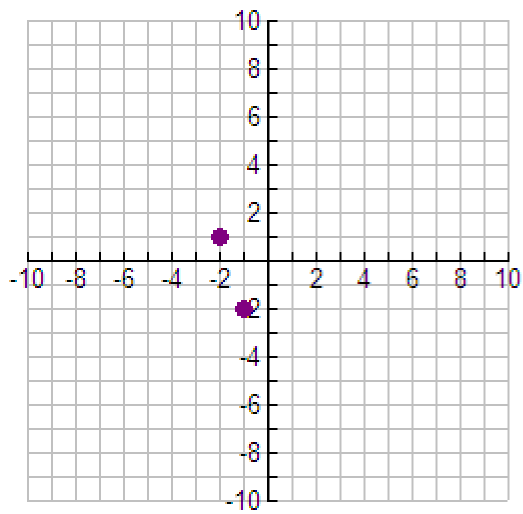
(Note: Assume the statue and both people stand on level ground.)

A. 22.4
B. 25.9
C. 26.4
D. 28.6

6. The radius of circle O is 15 m. Two radii, $\overline{OA}$ and $\overline{OB}$, form an angle of 80°. To the nearest tenth of a meter, how long is chord $\overline{AB}$?

A. 14.8
B. 15.0
C. 19.3
D. 21.2

7. Two vertices of a square are shown on the coordinate grid below.



What could be the coordinates of the other two vertices of the square?

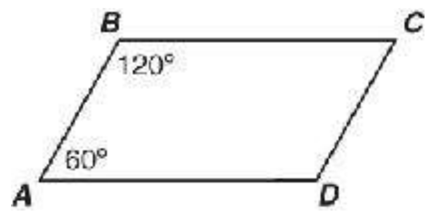
A. (1, 2) and (2, –1)

B. (1, 2) and (2, 1)

C. (–1, 2) and (2, –1)

D. (–1, 2) and (2, 1)

8. Two of the angle measures of Parallelogram *ABCD* are 60° and 120°, as shown below.



Which statement gives the measures of Angle *C* and Angle *D* with supporting reasons?

A. $m\angle C = 120°$ and $m\angle D = 60°$, because the sum of the angles in a parallelogram is 360° and opposite angles of a parallelogram equal 180°

B. $m\angle C = 60°$ and $m\angle D = 120°$, because the sum of the angles in a parallelogram is 360° and opposite angles in a parallelogram are congruent

C. $m\angle C = 30°$ and $m\angle D = 60°$, because one set of opposite angles of a parallelogram is equal to 90° and the other set is equal to 180°

D. $m\angle C = 180°$ and $m\angle D = 180°$, because the sum of the measures of Angles *A* and *B* equals 360° and $180° + 180° = 360°$

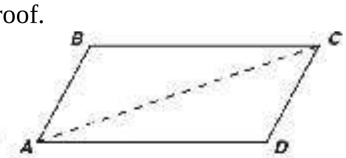
9. Thomas needs to prove the following theorem.

If one pair of opposite sides of a quadrilateral is congruent and parallel, then the quadrilateral is a parallelogram.

He draws the figure below and begins his proof.

Given: $AB \cong DC$
$\overline{AB} \parallel \overline{DC}$

Prove: $ABCD$ is a parallelogram



Statements	Reasons
1. $\overline{AB} \cong \overline{DC}$ $\overline{AB} \parallel \overline{DC}$	1. Given
2. $\angle BAC \cong \angle DCA$	2. ?

What should be Thomas's reason for Step 2?

A. Vertical angles are congruent.

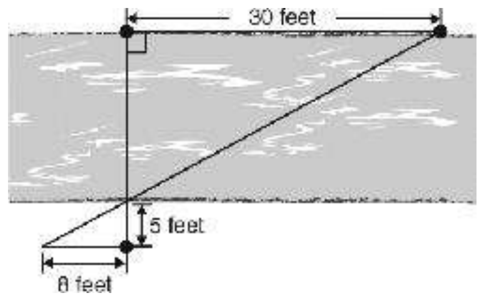
B. Congruent parts of congruent triangles are congruent.

C. If parallel lines are cut by a transversal, corresponding angles are congruent.

D. If parallel lines are cut by a transversal, alternate interior angles are congruent.

Geometry Proficiency 3

1. A surveyor needs to measure the distance across a river. He used a photograph of the river where there are two poles 30 feet apart on one side of the river. He drew a line across the river to another pole to make two similar right triangles, as shown in the drawing.



According to the surveyor's drawing, what is the distance across the river?

A. 18.75 feet

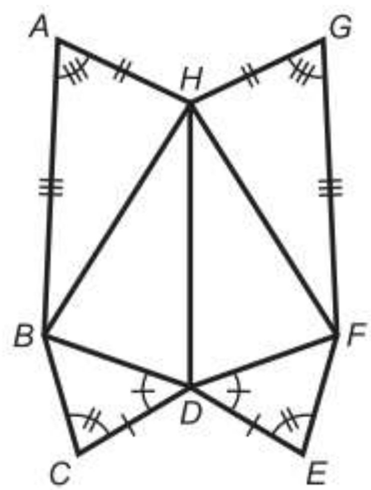
B. 23.75 feet

C. 25.00 feet

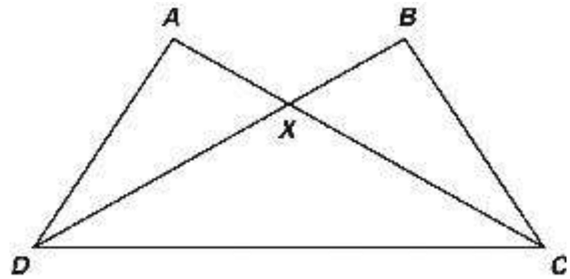
D. 29.58 feet

2. Which congruence theorem proves the final statement in a proof that $\Delta HBD \cong \Delta HFD$?

A. ASA
B. AAS
C. SAS
D. SSS



2. In the figure below, $\angle A$ is congruent to $\angle B$. Which relationship is necessary to prove $\Delta ACD \cong \Delta BDC$?



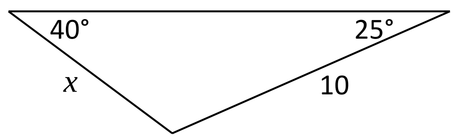
A. $\angle ADC \cong \angle CBD$

B. $\angle ADB \cong \angle BCA$

C. $\angle ACD \cong \angle BDC$

D. $\angle AXD \cong \angle BXC$

4. Which equation could be used to find the value of x?



A. $\frac{\sin 25^\circ}{10} = \frac{\sin 40^\circ}{x}$

B. $\frac{\sin 25^\circ}{x} = \frac{\sin 40^\circ}{10}$

C. $\frac{\sin 10^\circ}{25} = \frac{\sin x^\circ}{40}$

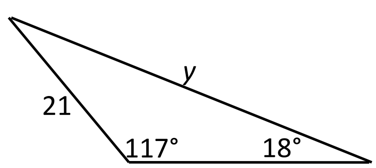
D. $\frac{\sin 10^\circ}{40} = \frac{\sin x^\circ}{25}$

5. In ΔABC, $m\angle ACB = 48°$, $AC = 17$ ft, and $CB = 10$ ft. To the nearest tenth of a foot, what is AB ?

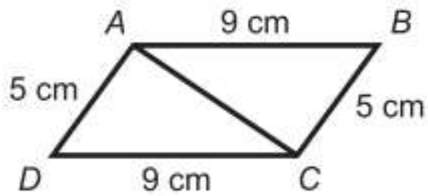
A. 12.7
B. 13.7
C. 19.7
D. 25.1

6. Solve for the variable. Round to the nearest tenth.

A. 7.3
B. 10.0
C. 60.6
D. 100.9



7. In this figure, which triangle is congruent to ΔABC ?



A. ΔADC
B. ΔACD
C. ΔCAD
D. ΔCDA

8. Given the following information about ΔABC:

Point D is located on $\overline{BC}$

$m\angle C = 40°$

$m\angle B = 30°$

$\overline{AD}$ is perpendicular to $\overline{BC}$

What is $m\angle CAD$?

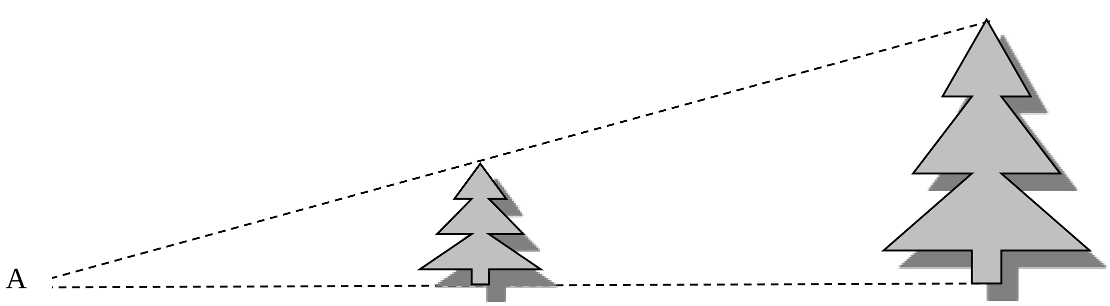
A. 50°
B. 55°
C. 60°
D. 110°

9. What is the solution to this system of equations?

$$\begin{cases} 3x + 3y = 6 \\ y = x - 2 \end{cases}$$

A. $x = 0, y = -2$
B. $x = 0, y = 2$
C. $x = -2, y = -2$
D. $x = 2, y = 0$

10. A man (point A) wants to find the height of the tallest tree in his farm. When he stood 40 feet in front of the small tree, he noticed the tallest tree was in his direct line of sight. If he knows the smallest tree is 7 feet tall and the distance between the two trees is 50 feet, what is the height of the tallest tree? Round to the nearest foot.



A. 17 feet
B. 16 feet
C. 14 feet
D. 9 feet

11. Raphael has programmed his robot to walk the perimeter of a triangle with side lengths 6 feet, 11 feet with a 35° angle between them. If the robot walks the entire perimeter of the triangle, how far will the robot walk?

A. 6.99 feet
B. 23.99 feet
C. 81.57 feet
D. 98.29 feet

12. A consumer protection magazine published a study that determined that 1 out of every 3 computers produced by the YBC company has a motherboard that fails within 4 months. The same study determined that 1 out of 20 Kinobo computers has a motherboard that fails within 4 months. Based on this information, what should a consumer do?

A. Buy a Kinobo computer instead of a YBC computer.
B. Buy a YBC computer instead of a Kinobo computer.
C. Buy both computers right now.
D. Buy a YBC computer now and buy a Kinobo computer in 4 months.

Algebra I Diagnostic 3

1. Mary solved this system of equations:

$$\begin{cases} \frac{1}{2}x + \frac{1}{4} \qquad = 6 \\ \frac{1}{5}x + \frac{1}{3} \qquad = 1 \end{cases}$$

What is the solution, (x, y) ?

A. (8, 8)
B. (-15, 12)
C. (-5, 6)
D. (15, -6)

2. What is the solution to this system of equations?
$y + x = 5x + 3$
$12 – y = x + 2y$

3. Joe's towing company charges a base rate of $90 plus $4.50 per mile. Mac's towing company charges a base rate of $70 plus $5 per mile. For what total mileage will both companies charge the same amount?

A. 38 B. 40 C. 42 D. 44

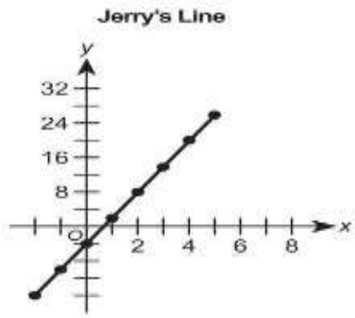
4. Kelly drew a sketch of a square garden, on a coordinate grid. Three corners of the garden are points *P*(-6, 2), *Q*(-2, -2), and *R*(-2, 6), and point *S* is the 4th corner. What is the equation, in slope-intercept form, of the line containing *R* and *S* ?

A. $y = -3x + 6$
B. $y = x + 8$
C. $y = 2x + 6$
D. D. $y = -x + 4$

5. At Lynn's T-shirt Store, each t-shirt that is sold earns the company $7 in profit. If Lynn's T-shirt Store earns $400 in profit when 60 t-shirts are sold, then what is the equation, in standard form, that models the profit of Lynn's T-shirt Store? Let the amount of profit be represented by *p*, and let t-shirts be represented by *t*.

A. $-7t + p = -20$
B. $7t – p = -20$
C. $7t + \text{p} = -820$
D. $-7t – p = -820$

6. Jerry plotted this line segment.



Tim plotted another line that passed through (8, -8) and whose *y*-intercept was the same as the line Jerry plotted. What is the equation, in standard form, of Tim's line?

A. x – y = 16 B. x + 2y = –8 C. 3x + 2y = 4 D. 7x + 4y = 6

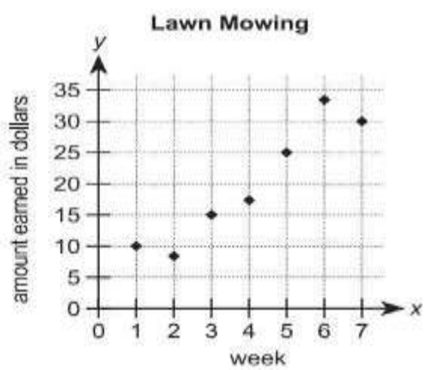
7. Jose earned money mowing lawns. The graph shows the amount he earned each week for 7 weeks. Which equation most closely approximates the line of best fit?

A. $y = 5x - 5$

B. $y = -x + 15$

C. $y = -5x$

D. $y = 5x$



8. A teacher collected the heights and weights of 13 students in the following table.

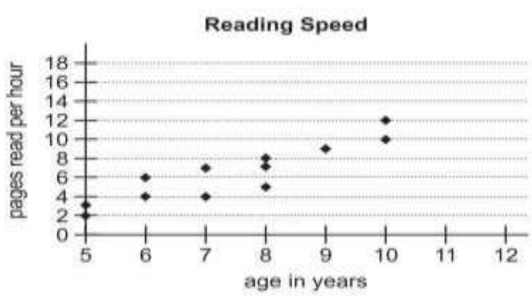
Height (cm)	Weight (kg)
135	26
136	26
137	30

138	40
140	30
142	39
143	35
145	40
147	38
148	49
150	47
155	53
157	50

Based on the line of best fit for the data in the table, what is a reasonable estimate of the weight of a student, in kilograms, whose height is 160 cm?

A.70 B. 48 C. 41 D. 40

9. Rosa plotted the ages of 12 children against the number of pages they can read in an hour.



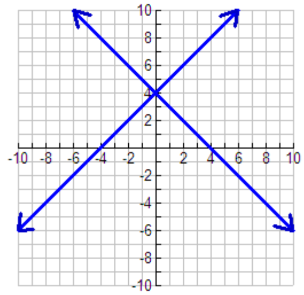
Based on the line of best fit, what is the best estimate of the number of pages an 11-yearold can read in an hour?

A.8 B. 10 C. 13. D. 18

Algebra I Proficiency 3

1. What is the solution to the systems of equations represented in the graph?

A. (-4, 0)
B. (0, -4)
C. (0, 4)
D. (4, 0)



2. What is the solution, (x, y), to this system of equations?

$$\begin{cases} 4y - 5x = 20 \\ x - 2y = 2 \end{cases}$$

A. (8, –3)

B. (–6, –4)

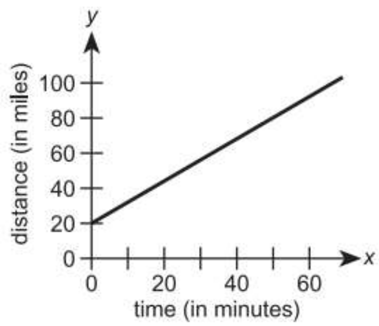
C. $\left(-\frac{16}{7}, -\frac{15}{7}\right)$

D. (–8, –5)

3. Gabriella knows that she can burn 12 calories per minute cycling and 8 calories per minute walking. How long will she need to perform each sport to burn 480 calories during her 50 minute workout session?

A. 40 minutes cycling and 10 minutes walking
B. 30 minutes cycling and 20 minutes walking
C. 25 minutes cycling and 25 minutes walking
D. 20 minutes cycling and 30 minutes walking

4. Juan is 20 miles from home. This graph shows the distance he traveled.



If y is the distance in miles and x is the time in minutes, what is the equation, in slope-intercept form, of the line that represents Juan's travel?

A. $y = 3x + 20$

B. $y = \frac{6}{5}x + 20$

C. $y = 3x + 50$

D. $y = \frac{5}{6}x + \frac{10}{3}$

5. What is the equation, in slope-intercept form, of the line that passes through the point (–3,11) and has a slope of –4?

A. $y = -4x - 1$
B. $y = 12x + 11$
C. $y = 4x + 1$
D. $y = -4x + 21$

6. Hugh's Rental Car Company charges a flat fee and $.30 per mile travelled. If the total cost is $220 when a person travels 400 miles, what is the equation, in standard form, which models the total cost for Hugh's Rental Car Company? Let the total cost be represented by c, and let miles travelled be represented by m.

A. $0.30m + c = 100$
B. $0.30m - c = -100$
C. $0.30m + c = 340$
D. $0.30m - c = -340$

7. Leah operates the local pizzeria. She uses the chart below to determine what to charge her customers based on how many toppings they want on their large pizza. If you were to plot the data from the chart on a graph what would be the y-intercept and what is its meaning?

Number of Toppings	Cost of Large Pizza
3	$6.50

4	\$7.00
5	\$7.50
6	\$8.00

A. \$0.50; cost of each additional topping
B. \$0.50; cost of a large pizza with no toppings
C. \$5.00; cost of a large pizza with no toppings
D. \$5.00; cost of each additional topping

8. The cost for a taxi ride can be represented by the equation $y = 2.00x + 4.00$, where x is the number of miles the taxi drives and y is the total cost for the ride. What is the rate of change and its meaning?

A. \$4.00; extra charge (surcharge) for additional passengers
B. \$2.00; extra charge (surcharge) for additional passengers
C. \$4.00; cost charged per mile the taxi travels
D. \$2.00; cost charged per mile the taxi travels

9. Identify the x-coordinate of the solution of the system of equations.

$$\begin{cases} y = -x + 4 \\ y = 2x + 1 \end{cases}$$

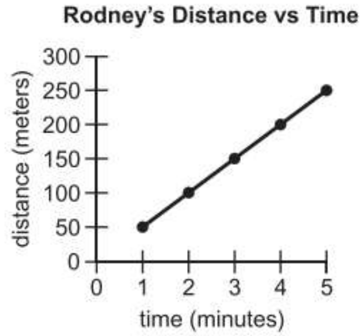
A. $x = -1$
B. $x = 3$
C. $x = 1$
D. $x = -3$

10. Which of the following statements best describe the solutions to the system of equations?

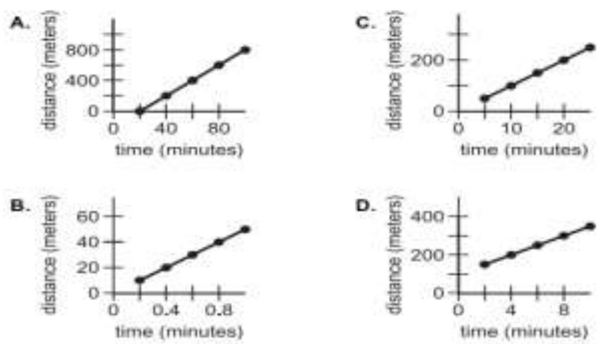
$$\begin{cases} 4y = 3x + 20 \\ -6x + 8y = 40 \end{cases}$$

A. There are no solutions.
B. There are infinitely many solutions.
C. $x = -\frac{20}{3}$ and $y = 0$
D. $x = 0$ and $y = 5$

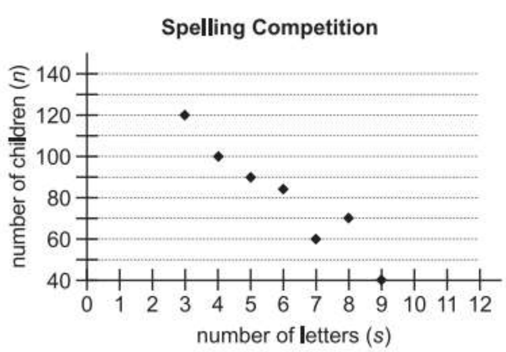
11. This graph shows Rodney's distance from the starting point in a race after 1-minute intervals.



Which graph has the same rate of change as Rodney's graph?



12. A total of 140 children participated in a spelling competition. This graph shows the relation between the number of children, n, who spelled words correctly and the number of letters, s, in the word spelled.



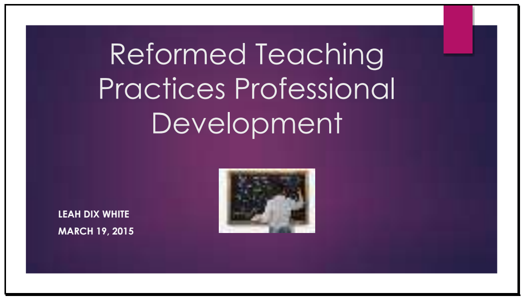
13. Which equation most closely approximates the line of best fit?

A. $n = -11s + 150$
B. $n = -20s + 165$
C. $n = 11s + 150$
D. $n = 20s + 165$

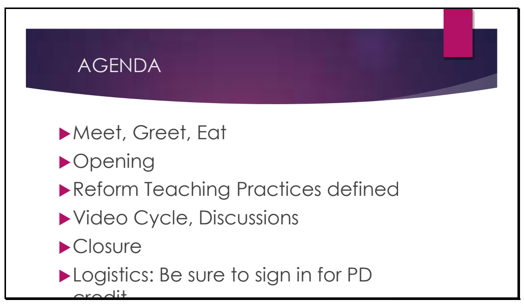
APPENDIX F: PD1, PD2, PD3

PD1

Slide 1



Slide 2



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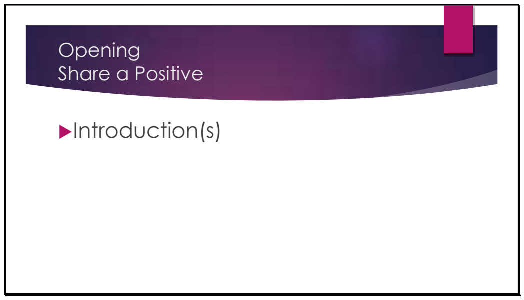

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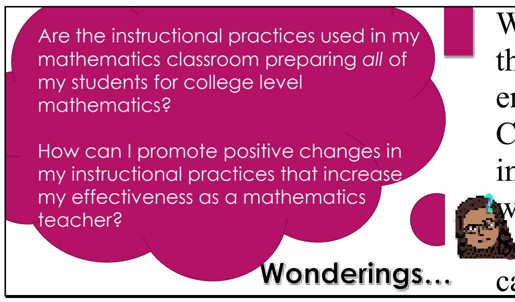
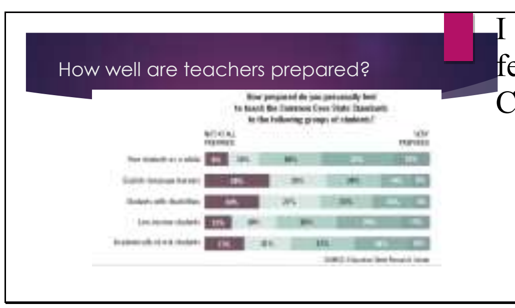


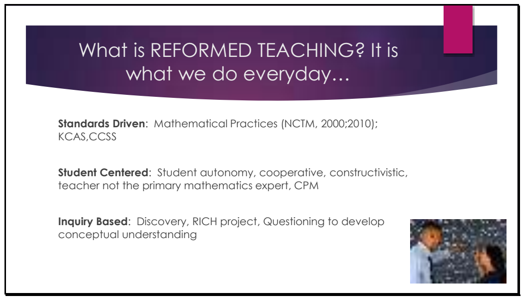
Wonderings that have led to this proposal. How can I engage my students in learning CCSS. The students who live in the same neighborhood where I grew up in West and South areas in Louisville. How can a prepare them for the mathematics they will need to know in the near future. How can I prepare myself through PD?

Slide 5



I am not the only teacher who feels unprepared for teaching CCSS.

Slide 6



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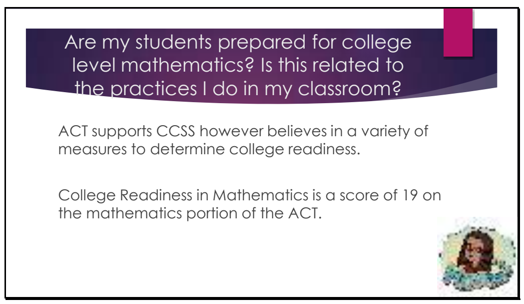

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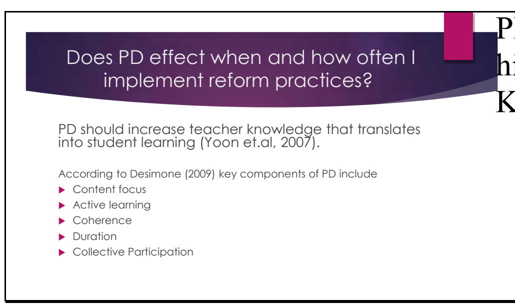
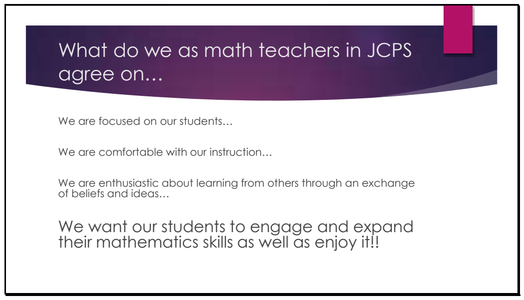


PD adheres to expectation of high quality PD according to KDE and JCPS expectations.

Slide 9



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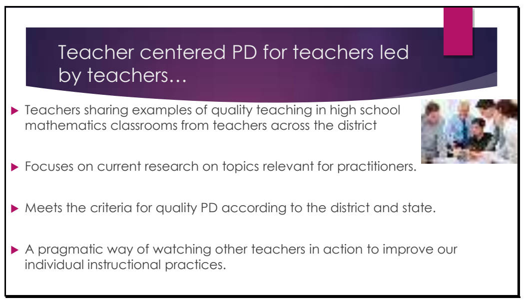

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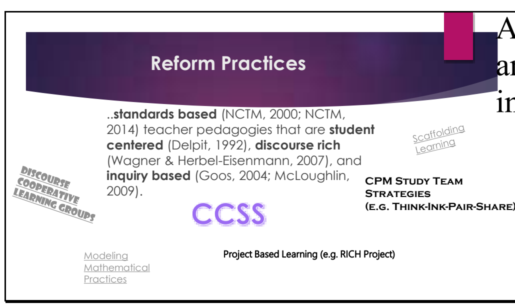
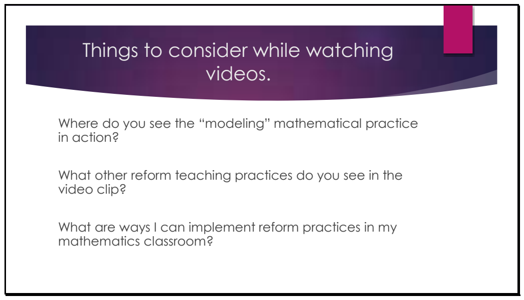


Add citation to the definition and each example will be used in the PD

Slide 12



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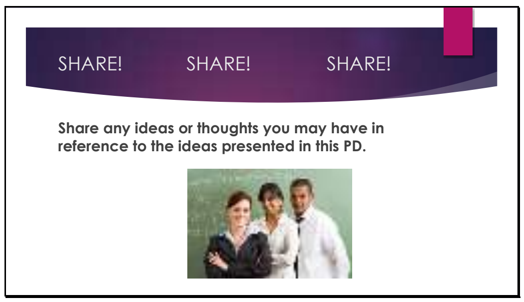
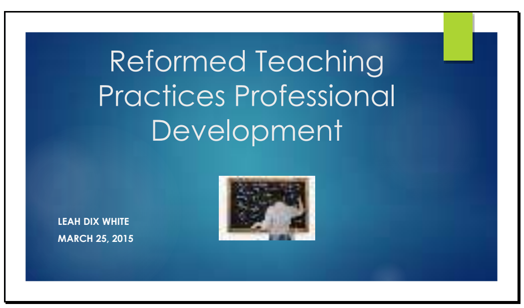
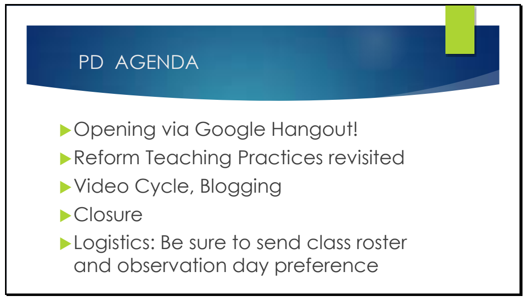


PD 2

Slide 1



Slide 2



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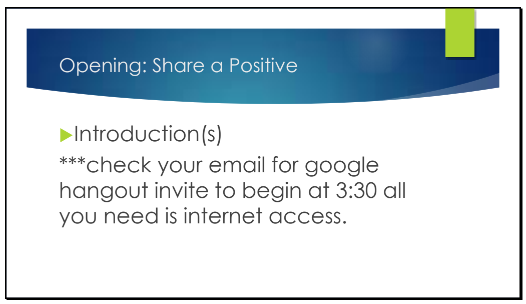
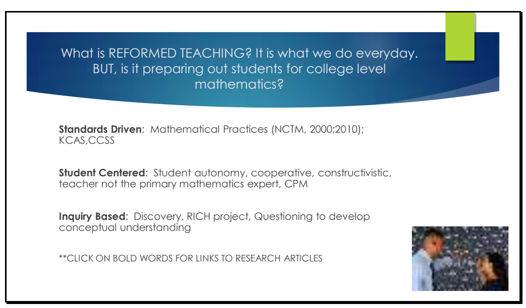


You do not have to participant in the google hangout to earn PD credit and or participate in the PD. You may view video and PD at your leisure; just respond to essential questions via blog post within the next week.

Slide 4



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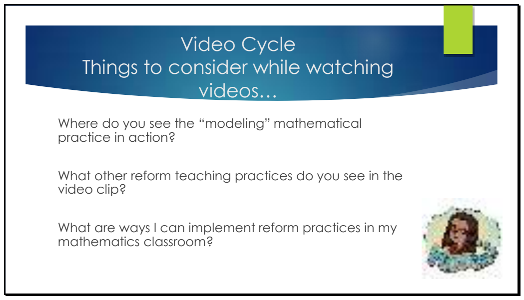

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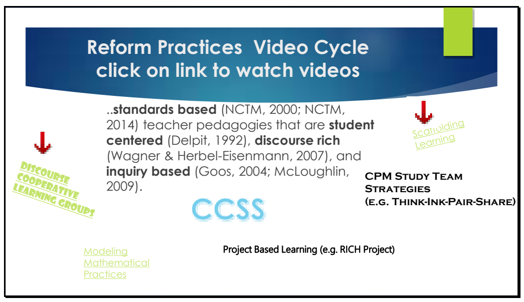
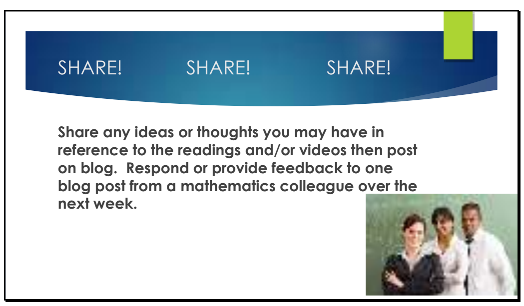


Add citation to the definition and each example will be used in the PD

Slide 7



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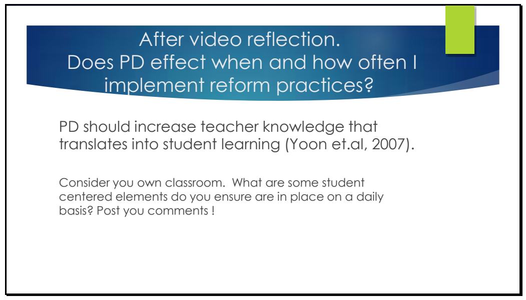
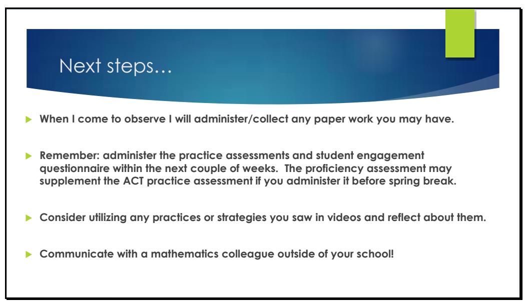


PD adheres to expectation of high quality PD according to KDE and JCPS expectations.

Slide 9



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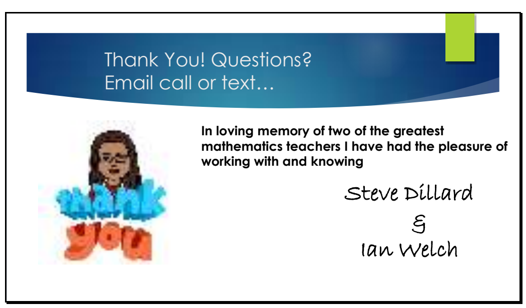
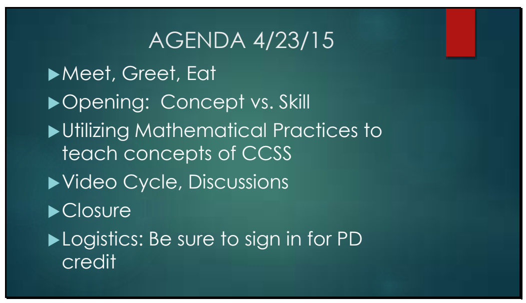


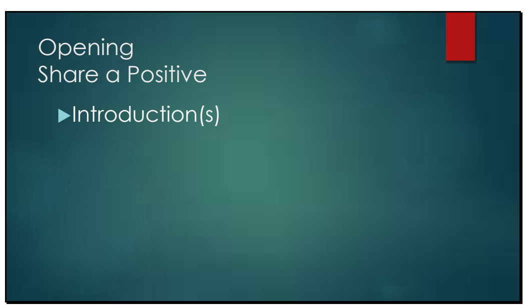
PD3

Slide 1

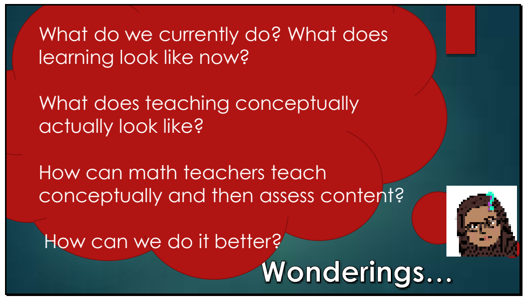
Slide 2



Slide 3

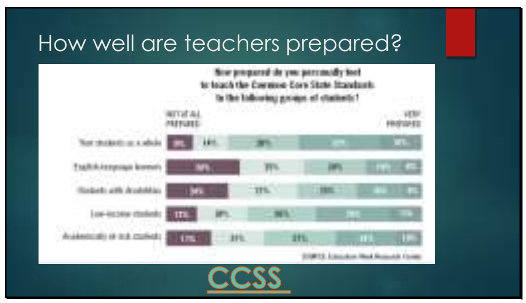


Slide 4



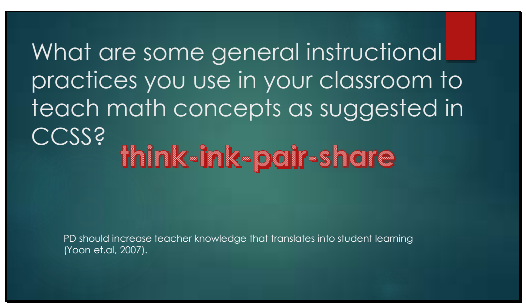
Wonderings that have led to this proposal. How can I engage my students in learning CCSS. The students who live in the same neighborhood where I grew up in West and South areas in Louisville. How can a prepare them for the mathematics they will need to know in the near future. How can I prepare myself through PD?

Slide 5



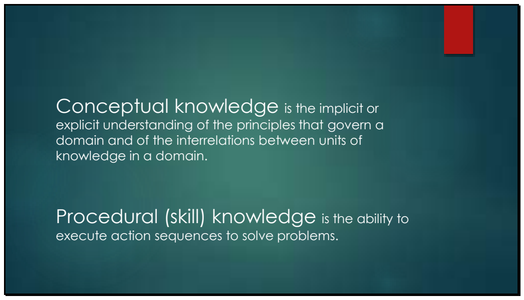
After this slide play click on link to 14 min video about CCSS.

Slide 6

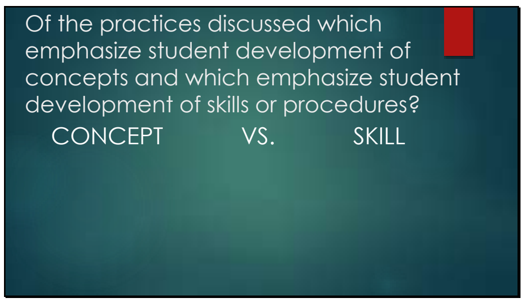


Have participants share their responses and facilitator when write them on chart paper titled, “What we currently do”?

Slide 7

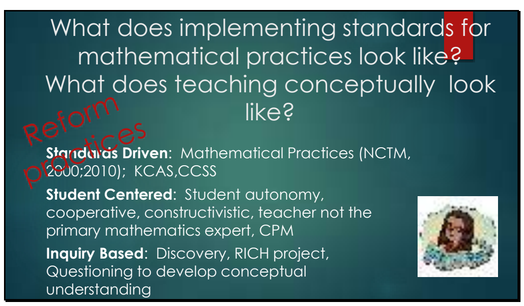


Slide 8



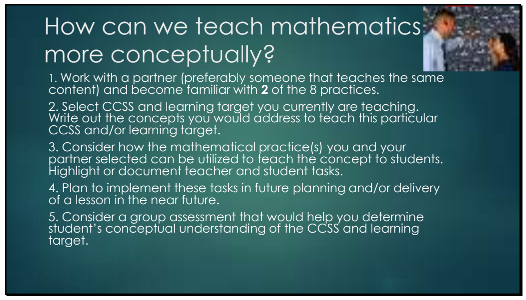
Have large post-it paper concept vs. skill in the middle. Participants will share out responses and facilitator will list them in the appropriate category.

Slide 9



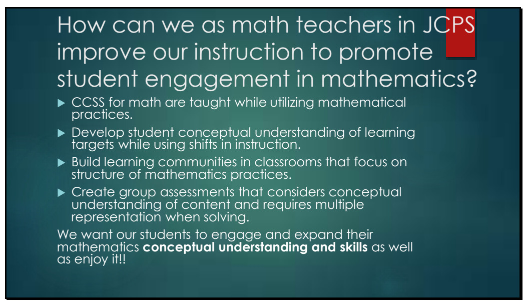
Teachers will get copy of mathematical practices.Click on picture for hyper link to conceptual understanding development in classroom.

Slide 10



Provide participants with handout of implementing practices. Each groups will have highlighter and post its. Allow 15 minutes for this discussion/exploration.

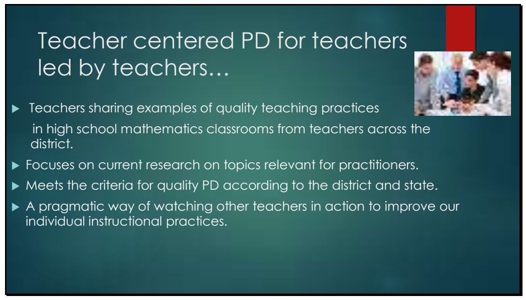
Slide 11



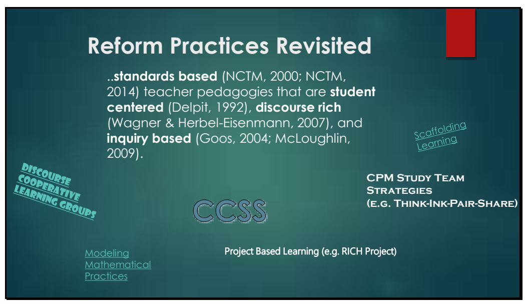
Provide shifts handout.

Slide 12

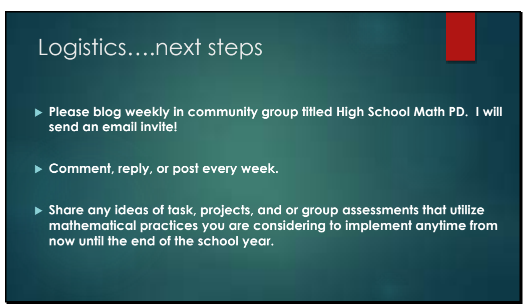
Slide 13



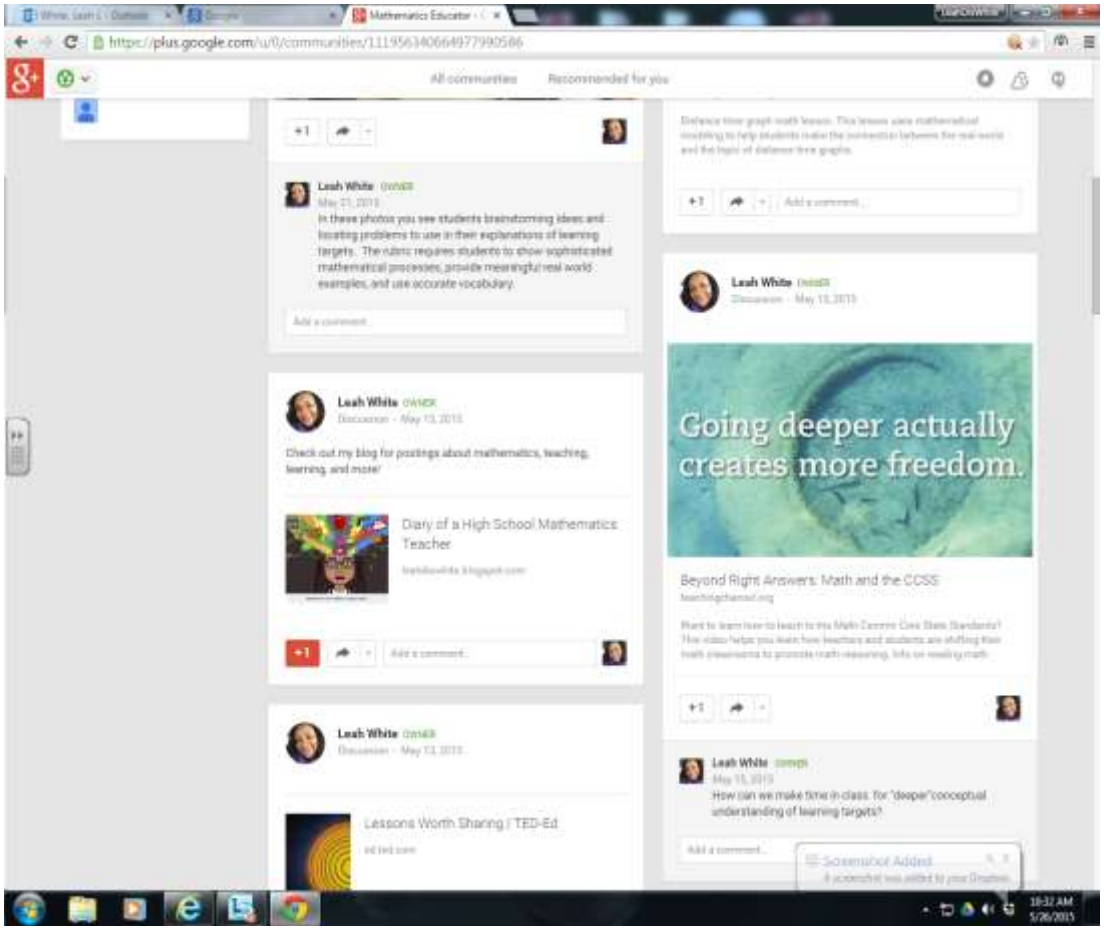
Slide 14

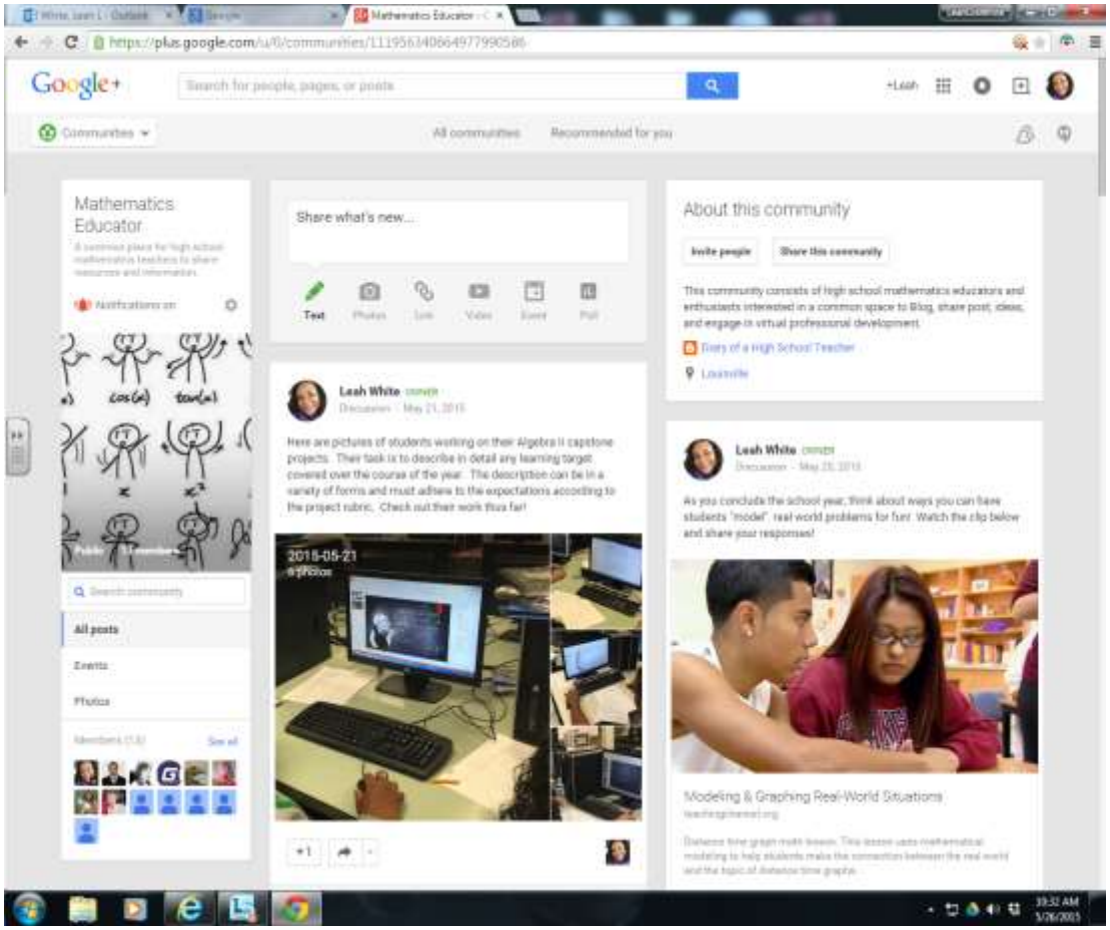


Slide 15



APPENDIX G: BLOG





Mathematics Educator
Share what's new...
About this community
Invite people
Share this community
Leah White
Here are pictures of students working on their Algebra II capstone projects. Their task is to describe in detail any learning target covered over the course of the year. The description can be in a variety of forms and must adhere to the expectations according to the project rubric. Check out their work thus far!
2015-05-21
As you conclude the school year, think about ways you can have students "model" real world problems for fun. Watch the clip below and share your responses!
Modeling & Graphing Real-World Situations

APPENDIX H: IRB

UNIVERSITY OF LOUISVILLE

DATE: October 01, 2014
TO: Karen Karp

Human Subjects Protection Program Office
MedCenter One – Suite 200
501 E. Broadway
Louisville, KY 40202-1798
Office: 502.852.5188 Fax: 502.852.2164

FROM: The University of Louisville Institutional Review Board
IRB#: 14.0735
STUDY TITLE: Preparing High School Students for College Mathematics: A Study of Engagement and College Readiness in Mathematics
REFERENCE #: 358777
DATE OF REVIEW: 09/30/2014
IRB STAFF CONTACT: Name: Jacqueline S. Powell
Phone: 852-4101
Email: jspowe01@Louisville.edu

This study was reviewed on 09/30/2014 and determined by the Chair of the Institutional Review Board that the study is exempt according to 45 CFR 46.101(b) under category Category 1: Instructional strategies in established educational settings . This study was approved for children under category 1. 45 CFR 46.404 - Research not involving greater than minimal risk. No greater than minimal risk to children is presented, only if the IRB finds that adequate provisions are made for soliciting the assent of the children and the permission of their parents or guardians, as set forth in Sec. 46.408. This category requires the assent of child (7 years and older) and at least one parent signature.

Documents/Attachments reviewed and approved:

Submission Components			
Student Survey Instrument	Version 1.0	09/24/2014	Approved
Research Request Document	Version 1.0	09/08/2014	Approved
Professional Development Proposal	Version 1.0	09/08/2014	Approved
Teacher Survey	Version 1.0	09/07/2014	Approved
RTOP user manual	Version 1.0	09/07/2014	Approved
PhotoVideoReleaseFrm04	Version 1.0	09/07/2014	Approved
Student Consent Form	Version 1.1	09/24/2014	Approved
Informed Consent Main 09-26-13	Version 1.3	09/07/2014	Approved

1099 Information (If Applicable)

As a reminder, in compliance with University policies and Internal Revenue Service code, all payments (including checks, gift cards and gift certificates) to research subjects must be reported to the University Controller's Office. Petty Cash payments must also be monitored by the issuing department and reported to the Controller's Office. Before issuing compensation, each research subject must complete a W-9 form. For additional information, please contact the Controller's Office at 852-8237 or controll@louisville.edu

Please be advised that any study documents submitted with this protocol should be used in the form in which they were approved. Since this study is Exempt the study documents do not contain the IRB approval stamp

Since this study has been approved under the exempt category indicated above, no additional reporting, such as submission of Progress Reports for continuation reviews, is needed. If your research focus or activities change, please submit an Amendment to the IRB for review to ensure that the indicated exempt category still applies. Best wishes for a successful study. Please send all inquiries to our office email address at hsppofc@louisville.edu

Thank you for your submission.

Sincerely,

Peter M. Quesada, Ph.D., Chair
Social/Behavioral/Educational Institutional Review Board
PMQ/jsp

APPENDIX I: Kentucky's Definition and Standards for High Quality Professional Development
(June 24, 2005)

Professional development is considered high quality when it meets the definition of professional development in 704 KAR 3:035 – Section 1(1) and Section 4(2) and all of the Kentucky Department of Education Professional Development Standards which are consistent with the federal criteria in Section 9101 of No Child Left Behind. Schools and districts will determine if the professional development for teachers, administrators and other school staff meets the following definition and standards for high quality professional development.

All standards need to be applied in the context of the audience for professional development (PD) to qualify as high quality PD. The Department of Education recognizes that the extent to which professional development meets each standard may vary.

<u>Definition</u>

704 KAR 3:035 – Section 1(1) "High-quality professional development" means those experiences that systematically, over a sustained period of time, enable educators to facilitate the learning of students by acquiring and applying knowledge, understanding, skills, and abilities that address the instructional improvement goals of the school district, the individual school, or the individual professional growth needs of the educator. **Section 4(2)** High-quality professional development experiences shall be related to teachers' instructional assignments and administrators' professional responsibilities. Experiences shall support the local school's instructional improvement goals and be aligned with the school or district improvement plan or individual professional growth plans of teachers.

Kentucky Department of Education Professional Development Standards
Standard 1: Professional Development is aligned with: • local school and district goals and priorities as reflected in the school or district improvement plan or individual professional growth plans; • Kentucky's Standards and Indicators for School Improvement; <u>and</u> • **Kentucky New or Experienced Teacher Standards or Interstate School Leaders Licensure Consortium Standards, or other professional/job standards.**
Standard 2: Professional Development is a continuous process of learning through consciously constructed relevant job-embedded experiences so that professional development experiences and professional learning are integrated in the day-to day work of teachers, administrators, and others to support improved practices, effectiveness and the application of skills, processes, and

Kentucky Department of Education Professional Development Standards
content. *(e.g., action research, study groups, online learning, collegial professional learning networks, peer collaboration, peer coaching, mentoring, formal and informal peer observations, coaching, instructional demonstrations, collegial feedback, personal reflection, team planning, collaborative-problem solving, analysis of student work, self directed learning).* • *PD is sustained, intensive, classroom-focused and is on in order to have a positive and lasting impact on classroom instruction, the teacher's performance in the classroom, and increased student performance; and* • *PD is not one-day or short-term workshops or conferences unless they are a component of an intentionally designed comprehensive professional development plan based on teacher needs and student needs.*

	Standard 3: Professional Development focuses on the knowledge and skills teachers, principals, administrators, and other school and district staff are to know and to do in support of student learning and students' well being. Professional development is based on what students need to know and be able to do in order to meet Kentucky's challenging content standards and student performance standards. Student content, performance and opportunity to learn standards are the core of professional development. ❑ **National standards *(e.g., content, leadership, teacher, safety, transportation, nutrition, health)*** ❑ Kentucky Learning Goals ❑ Academic Expectations ❑ Program of Studies ❑ Core Content for Assessment ❑ Performance Standards/ Student Performance Level Descriptions (PLD) ❑ Kentucky Early Childhood Standards ❑ Technology Standards ❑ Character Education ❑ **District/school aligned curriculum**
	Standard 4: Professional Development actively engages teachers, principals, administrators, and others in learning experiences that advance their understanding and application of research based instructional practices and skills that reduce barriers to learning, close achievement gaps, and improve student performance ***(e.g., inquiry-based learning, investigation, work backwards, act out the problem, make a drawing or diagram, employ guess and check, make a model, jigsaw, self monitoring strategy, simulations, formulating a model, invention, questioning, wait time, restate in own words, break into smaller steps, goal setting, experimentation, debate, reciprocal teaching, writing process, story maps, structured note taking, think aloud, round robin, pairs check, inside-outside circle, manipulatives, data collection tools, time lines, picture clues, sequence chains, compare/contract matrix, concept mapping, Venn diagrams, advanced organizers, checklists, community based instruction, bus safety, and safe physical management)*****.**
	Standard 5: Professional Development prepares teachers, administrators, school council members and others in the school community as instructional leaders and collaborative partners

in improving student performance (e.g., *instructional leadership, organizational direction, collaborative decision making, analysis and use of data, planning, community partnerships, and creating a learning culture).*
Standard 6: Professional Development is data and results driven focused on increasing teachers, administrators, and others' effectiveness in improving student performance and is continuously evaluated to improve the quality and impact of professional development.
Standard 7: Professional Development fosters an effective ongoing learning community that supports a culture and climate conducive to performance excellence.
Standard 8: Professional Development is culturally responsive and facilitates removing barriers to learning in an effort to meet each student's needs *(e.g., intellectual, social, career, cultural, and developmental).*
Standard 9: Professional Development is planned collaboratively (e.g., teachers and principals) and organized to maximize the collaborative use of all available resources to support high student and staff performance *(e.g., planning, time, release time, staff, technology, funding sources)***.**
Standard 10: Professional Development fosters a comprehensive, long-range change process that communicates clear purpose, direction, and strategies to support teaching and learning.
Standard 11: Professional development is grounded in the critical attributes of adult pedagogy (*e.g., connections to work, reflective practice, guided practice, feedback, multiple intelligences, learning styles, choice, time for processing and integrating and applying information, implementation in job setting, analysis and follow-up of results, brain research, peer interaction, peer review, peer observations, mentoring, personal and active inquiry, investigations, self-reflection, and collegial networks).*

JCPS Standards for High Quality Professional Development

Data-driven: Professional development sessions are focused on addressing needs indicated by an analysis of data, particularly data resulting from CATS.

Long-term and sustained: Professional development builds on the strengths and skills of participants. It is sustained through coaching, mentoring, teamwork, and leadership.

Results-oriented: The focus of all professional development is improving students achievement through improved instructional practice.

Job-embedded: Professional learning is a seamless part of the school day. Teachers use the classroom for building professional knowledge and identifying areas in which they need to grow.

Collegial: Colleagues learn from each other in formal professional development sessions as well as through conversations focused on improving student achievement.

CURRICULUM VITAE
Leah Dix White

EDUCATION

2010-Current University of Louisville, Louisville, Kentucky
Ph.D. in Curriculum and Instruction (ABD)
Concentration: Secondary Mathematics Education
Doctoral Chair: Dr. Karen Karp

2008-2010 University of Louisville, Louisville, Kentucky
Masters of Education
Focus: Teacher Leader

2000-2002 University of Louisville, Louisville, Kentucky
Master of Arts in Teaching
Focus: Secondary Mathematics

1999-2000 University of Louisville, Louisville, Kentucky
Bachelor of Arts in Mathematics

PROFESSIONAL CERTIFICATION

Mathematics 8-12
Teacher Leader Endorsed

PROFESSIONAL EXPERIENCE

August 2002-Current **Mathematics Teacher, Western Early College, Louisville, Kentucky**

Instruct Mathematics utilizing KCAS/Common Core State Standards, design and develop programs to meet the academic, intellectual, and social needs of students. Instruct Algebra I/II, Geometry, Probability/Statistics, and Applied Mathematics courses implementing College Preparatory Mathematics Curriculum. Assess student performance formatively to drive instruction. Prepare students for End of Course Exam(s) and ACT assessments. Maintain accurate intervention records. Collaborate with mathematics teachers to design and plan curriculum pacing for Algebra II.

UNIVERSITY COURSES

EDAP 611 Calculator Specialists and Teacher Leader, Summer Portfolio Institute

EDAP 605 Teacher Assistant, Elementary Mathematics Methods

PRESENTATIONS

Dix, L. (July, 2010). *Relevance and Rigor in the Classroom.* Jefferson County Public Schools. Western Early College, Faculty Retreat, Louisville, Kentucky

White Dix, L. (October, 2013). *Interactive Mathematics*. National Council of Teachers of Mathematics. Regional Conference, Las Vegas, Nevada.

White Dix, L. (November, 2013). *Technology in the Classroom*. National Council of Teachers of Mathematics. Regional Conference, Louisville, Kentucky.

White, L. (November, 2014). *Teaching with Technology*. Kentucky Center for Mathematics. Regional Conference, Lexington, Kentucky.

White, L. (July, 2014). *Motivating Unmotivated Learners*. Jefferson County Public Schools. Western Early College, Faculty Retreat, Louisville, Kentucky.

White, L. (March 2015). *Student Engagement and College Readiness for High School Students: Dissertation Study*. Spring Research Conference. University of Louisville, Louisville, Kentucky.

LEADERSHIP EXPERIENCE

2015 – Current	Greater Louisville Council of Mathematics, President Elect
2013 – Current	Greater Louisville Council of Mathematics, Board Member-Communications
2013 – 2014	National Council of Teachers of Mathematics, Program Committee, Richmond, Virginia
2005 – Current	National Council of Teachers of Mathematics, Member

2014 – Current	Instructional Leadership Team, Western Early College High School
2007 – Current	Kentucky Teacher Internship Program (KTIP), Resource Teacher
2011 – Current	Professional Learning Community Facilitator
2010 – Current	Professional Representative Jefferson County Teachers Association
2011 – 2012	Mathematics Department Co-Chair
2010 – 2012	School-wide Instructional Leadership Team, Member