IMPROVING SCIENCE TEACHERS' SELF-EFFICACY FOR SCIENCE PRACTICES WITH DIVERSE STUDENTS

by
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Abstract

This quasi-experimental study explored the effects of professional development utilizing virtual cross-group contact on teachers' self-efficacy for teaching science practices with underrepresented minorities. Participants (*N* = 29) were science teachers of grades 6 – 8 from a diverse, sub urban school district. Teachers completed surveys of self-efficacy, content knowledge, and measures of attitudes and beliefs of various student groups. Results indicated that participants' self-efficacy for teaching diverse student groups increased as a result of the treatment, however linear regression did not identify attitudes or beliefs as predictive factors. Survey responses suggest that more direct conversations are needed within the framework of multicultural education in order to equip teachers with the cultural competencies needed to influence teachers' practice in diverse classrooms.

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Preface

First, I want to sincerely thank my wife, Shanna Romanillos for her endless support and love throughout this program. She was instrumental in my ability to successfully complete this dissertation!

I also want to thank the educators and administrators of the District who so willingly gave of themselves in order for this study to take place. The level of coordination and cooperation displayed throughout this intervention were humbling for me. At so many points I thought it would all fall apart, but at every turn there was another teacher willing to say yes to helping. I'm truly grateful! Also, many thanks to Dr. Mary Urquhart for her help in materially supporting this intervention.

Finally, many thanks to my committee for their kind words and support. The many revisions helped make this project evolve to its final state. I enjoyed our many conversations on this topic! A special thanks to Carolyn Parker for her guidance throughout the project, I really appreciate all the help you provided.

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Executive Summary

The study district ("District") is a learning organization struggling to respond to the demographic changes happening within its neighborhoods and schools. African American, Hispanic, economically disadvantaged, and limited English proficient (LEP) students increasingly represent the majority of students in the District, yet academic outcomes (e.g., graduation rates, academic achievement rates, academic self-efficacy, and course enrollment patterns) remain lower than White or economically advantaged students. As a result of these differential outcomes, these student groups risk being unprepared to join a knowledge-based economy that increasingly requires students to have the content and skills associated with a postsecondary education in science, technology, engineering, and mathematics (STEM) (Olson & Riordan, 2012; National Science Foundation [NSF], 2014).

Science Practices

In order to improve academic outcomes and increase the number of underrepresented minority (URM) students prepared to pursue STEM in university, practices within the classroom must be reformed. Teachers play a pivotal role within schools in improving academic achievement for students (Rivkin, Hanushek, & Kain, 2005). Studies have shown that teachers' use of engaging reform-oriented practices (e.g., inquiry, practices of scientists and engineers, hands-on) within the science classroom significantly increases academic achievement and engagement, and improves identification with science (Kanter & Konstantopoulos, 2010; Maltese & Tai, 2011; Swarat, Ortony, & Revelle, 2012). Experiencing positive academic exchanges and realizing success are directly related to students' decisions to pursue STEM as a major and career (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Moreover, Maltese & Tai

(2011) found that the junior high science classroom is a particularly important time that primarily influences students' career decisions in science.

In spite of a long-running national effort to reform the science classroom (National Research Council [NRC], 2000; 2012), researchers have found varied understandings of inquiry and little implementation, even among interested teachers (Capps & Crawford, 2013; Kind, 2013). Returning to teachers as a critical site of reform, research into the characteristics of effective teachers has shown that low content knowledge, a lack of experience, or negative experiences with science reduce teachers' self-efficacy and effectiveness in the classroom (Avery & Meyer, 2012; Goldhaber, 2002; Kanter & Konstantopoulos, 2010; Leonard, Barnes-Johnson, Dantley, & Kimber, 2011; Tosun, 2000). Furthermore, teacher biases and beliefs of URM and struggling students (e.g., Special Education, LEP) have been shown to significantly reduce teacher self-efficacy (Pang & Sablan, 1998; Ross, 2014; Soodak & Podell, 1994) and reduce academic expectations (Bolshakova, Johnson, & Czerniak, 2011; Campbell, 2012; Gilbert & Yerrick, 2001; Riegle-Crumb & Humphries, 2012).

Professional Development

Professional development (PD) is a common, yet inconsistent intervention strategy to improve teacher practice (Borko, 2004). Empirical work on the specific attributes of effective PD in science has resulted in a concise conceptual framework that delineates several key characteristics shown to influence practice (Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; National Academies of Sciences, Engineering, and Medicine, 2015; Penuel, Fishman, Yamaguchi, & Gallagher, 2007). Teacher beliefs have been identified as a powerful constraint influencing teachers' implementation of inquiry following well-constructed PD (Lotter, Rushton, & Singer, 2013; Luft, 2001). In spite of this understanding Capps, Crawford, and

Constas (2012) note that few studies on PD assess teacher beliefs. Furthermore, while Supovitz and Turner (2000) found that low school socioeconomic status negatively influenced inquiry practice, the intersection of equity, teacher beliefs, and science PD has not received much attention (Bianchini, Dwyer, Brenner, & Wearly, 2015). Battey and Franke (2015) also note the paucity of research into changing teachers' beliefs relating to URM within the context of mathematics PD.

Interventions with the express goal of reducing individuals' biases or prejudice for out-group members are well established (Devine, Forscher, Austin, & Cox, 2012; Lai et al., 2014). Direct, cross-group interaction is one such methodology that has been studied extensively and is shown consistently to reduce stereotypical beliefs and more importantly, improve affective aspects such as anxiety (Pettigrew & Tropp, 2011). An extension of this theory includes extended cross-group contact wherein direct contact between people of different races or cultures is not possible. The use of videos to simulate positive contact has resulted in significantly improved attitudes, reducing anxiety, and increasing self-efficacy for participants (Joyce & Harwood, 2014; Mazziotta, Mummendey, & Wright, 2011).

Intervention

A common desire expressed by many of the District's JH science teachers when discussing instruction is the wish to "do more science". Data suggest, however, that a majority of these JH science teachers do not have an extensive content background (only 40.8% have a degree in science or engineering), nor do their students report utilizing science practices very frequently in the classroom (1-2 times per month). Moreover, limited professional development opportunities within the District struggle to engage this majority in opportunities that meet their personal or professional needs. In an interview with one JH teacher, the veteran reported that it was difficult to find PD that matched their schedule, and that truly met their needs.

In order to respond to these factors and subsequently increase URM outcomes in JH, this intervention engaged JH science teachers in a five-day institute on physics instruction utilizing the WestEd *Making Sense of SCIENCE*: *Force & Motion for Teachers of Grades 6-8 (*Daehler, Shinohara, & Folsom, 2011) materials. The WestEd program was identified and delivered in partnership with a local university PD program. This PD develops teachers' content knowledge and pedagogical content knowledge for physics instruction (see Figure 1 for the logic model). Teachers were engaged in investigations, collaborative learning, case studies, and time to reflect on and integrate learning within their classroom practice. Participants in the treatment group received virtual cross-group contact in the form of three videos showing a model teacher engaged in science practices with URM students.

A quasi-experimental approach is utilized, with one treatment and one control group. Two research questions explored the effect of the intervention on teachers' content knowledge, self-efficacy, and attitudes of diverse student groups.

1. Did virtual cross-group contact increase subjects' science teaching efficacy with underrepresented minority students?
2. Did teachers' affect and attitudes of URM mediate participants' science teaching efficacy with underrepresented minority students?

Quantitative data were collected through surveys to measure content knowledge, teachers' self-efficacy for science, teachers' self-efficacy for teaching URM, and intergroup attitudes. Surveys were administered at three points, as pre-, post-, and delayed-posttests. Observations were conducted following the training to determine implementation in the classroom. Finally, a written survey with constructed response items was collected to characterize teachers' experiences through the training, and the influence of the intervention on their learning and practice. Figure 2 illustrates the theory of change supporting this intervention.

Findings

Data analyses of the quantitative and qualitative results yielded significant and relevant findings pertaining to both professional development for science teachers, and for administrators developing professional learning for their organizations.

Research Question 1

Participants in both groups experienced significant gains in physics content knowledge and self-efficacy by the end of the training. Results from the constructed response items provided further data illustrating the impact of various PD components on teachers' improvement. Teachers cited the importance of active learning, collective participation, a focus on content, and coherence through time spent with lesson materials. These four components are evident in the best practices of PD identified in the research on professional development (National Academies of Sciences, Engineering, and Medicine, 2015).

Looking at science self-efficacy for URM students, teachers within the treatment group experienced gains while the control group experienced a decline. Data analyses found a significant impact for the treatment between the two groups. Background variables and initial measures of content knowledge and self-efficacy were similar for both groups, and were not predictive of the measured changes. These results suggest that virtual cross-group contact as a part of science professional development can positively impact teachers' self-efficacy to teach diverse student groups.

Data analyses looking at the change in self-efficacy across the three time points showed a lasting effect of the treatment on teachers' self-efficacy. Data from the delayed post-test showed that following the training, personal self-efficacy for both groups decreased after three months in the classroom. Teachers' final personal self-efficacy levels remained greater than where they started for the treatment group, while control group participants experienced an overall decrease over the entire intervention. Similarly, treatment group participants experienced an overall increase in science self-efficacy for URM, while control group members experienced an overall decrease. Although statistical analyses are non-significant for these changes for phase and group, the results suggest that the addition of virtual cross-group contact provided teachers an added source efficacy information that lasted through their experiences in the classroom. Conversely and importantly, the generalized PD for science practices received by the control group that did nothing to address the needs of a diverse classroom had a detrimental and lasting effect on teachers' science self-efficacy.

Research Question 2

Measures of teachers' attitudes and emotions of various student groups showed strong inter-relationships. Teachers' attitudes and emotions of a specific group were each significant and positively related. Moreover, in agreement with contact theory, positive and frequent contact with English Language Learners (ELL) was positively related with intergroup attitudes for ELLs, Hispanics, and African Americans.

Correlational analyses illustrated some support for the hypothesized link between teacher self-efficacy, and teachers' beliefs. Teachers' attitudes and emotions about English Language Learners were both significant and positively related to personal teaching self-efficacy and science self-efficacy for URM students. Intergroup attitudes of Hispanic students was the only other factor related to either self-efficacy score; the remainder of measures were not related to teachers' self-efficacy. Finally, linear regression did not find any measure of attitudes or emotions to be predictive of teachers' change in science self-efficacy for URM students.

These mixed results provide some support to the idea that teachers' beliefs of their students impact their self-efficacy to teach them in the classroom. One background measure collected of all participants was an indicator of the diversity of their friend network. Both the treatment and control group exhibited very diverse friend networks. This measure has been shown to influence individuals' cross-group beliefs in previous research. The varied experiences participants have with such a diverse group of friends may be impacting the various measures of anxiety, attitudes, and emotions. Moreover, the small sample size of both groups reduces the power of this study, therein limiting the ability of this investigation to delineate significant interactions.

Implementation

The proximal outcome of this intervention was to influence teachers' physic content knowledge, their personal teaching self-efficacy, and science self-efficacy for URM students. The larger outcome of this and other research on professional development is to impact classroom practice. Classroom observations, although limited, and survey results indicated that teachers implemented knowledge and material aspects of the training in their classroom. Low scores on the Reformed Teaching Observation Protocol and teacher-centered survey responses illustrated that classroom changes were centered on teachers' behaviors, and less so on students' roles in the classroom. Taken together, although this intervention had significant impacts on teacher outcomes, the translation to classroom changes were diminished and require further effort.

Recommendations

The results of this study provide learning organizations hoping to improve science education some important guidance. First, professional development efforts much focus on providing teachers with experiences that include multiple attributes of high-quality PD. Second, videos of cross-group contact seem to be an effective way to target teachers' work with diverse students. Generic PD offerings that do not address the specific needs of teaching URM students may have a negative impact on teachers in the long run. Finally, true reform to classroom practice that changes students' and teachers' roles are indeed long-term outcomes that take more than one professional development session. Furthermore, improving teachers' practice with diverse student groups would best be situated within larger and long-term initiatives at the district level involving multicultural education that build teachers' cultural competency.

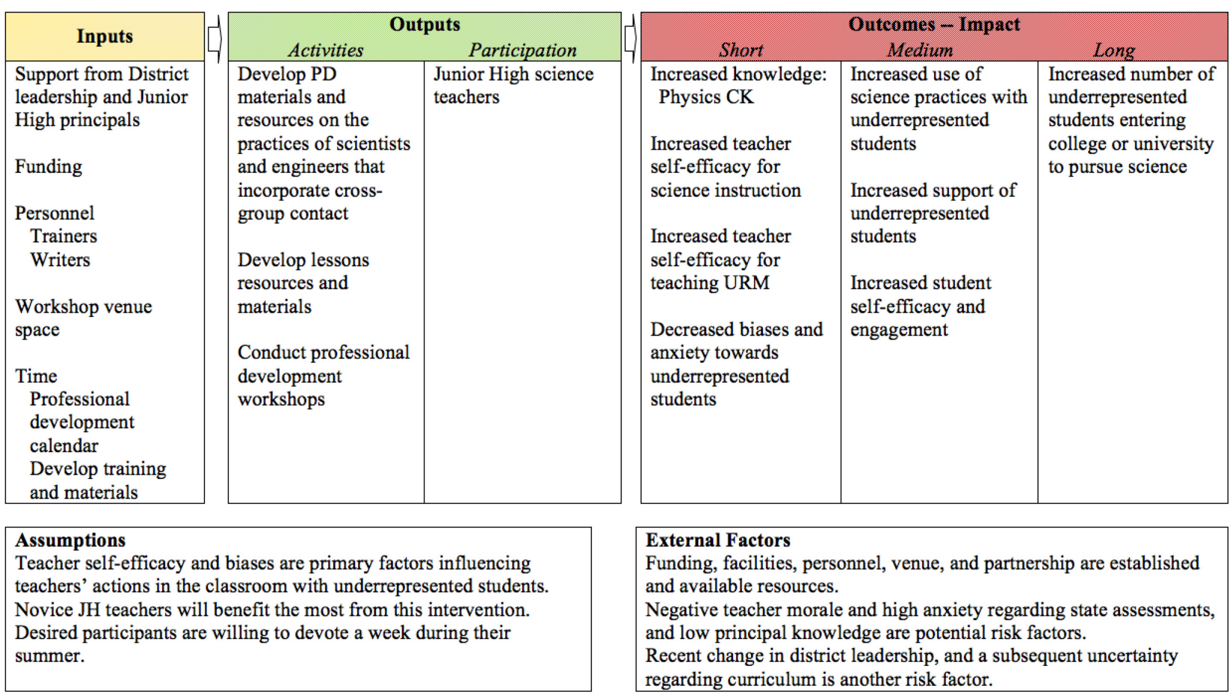

Figure 1. Logic model for an intervention to improve outcomes for underrepresented students.

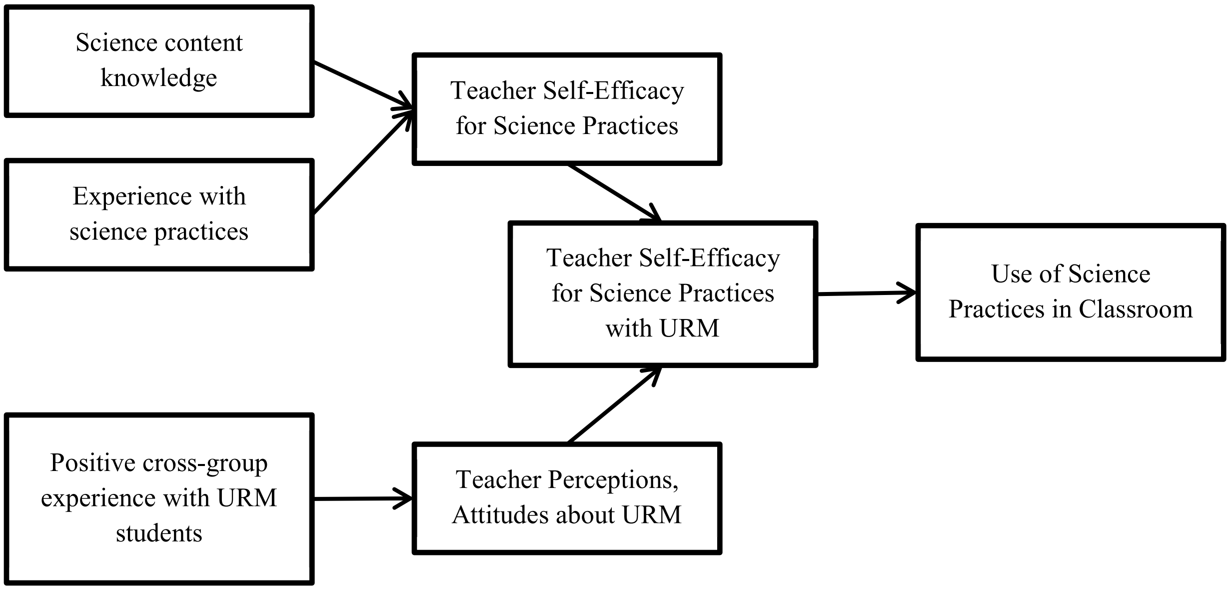

Figure 2. A causal diagram illustrating the theory of treatment supporting the intervention.

Chapter 1

The Barriers to Science for Underrepresented Minorities

The President's Council of Advisors on Science and Technology (2012) reported that one million more science, technology, engineering, and mathematics workers would be needed over the next decade to meet the economic demands of a knowledge-based economy. In order to meet this demand our nation's universities will need to increase the number of STEM graduates by 34% (President's Council of Advisors on Science and Technology, 2012). Current demographic trends in STEM education indicate the need to draw upon currently underrepresented populations (African Americans, Hispanics, Native Americans, and females) to meet this unprecedented call (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011; NSF, 2014; U.S. Census Bureau, 2013).

Evidence on the factors associated with a student's decision to pursue science as a major point to the importance of experiences within the middle and high school classroom (Maltese & Tai, 2011). The opportunity for students to experience engaging instruction from effective teachers within a positive classroom climate have been shown to build self-efficacy and an interest in STEM (Bolshakova et al., 2011; Bouchey & Harter, 2005; Maltese & Tai, 2011; Rice, Barth, Guadagno, Smith, & McCallum, 2013; Swarat et al., 2012). Conversely, evidence of teacher biases, patterns of tracking that place minority students within negative classroom environments, and ineffective teachers that utilize primarily didactic strategies result in low levels of self-efficacy in the area of STEM (Bolshakova et al., 2011; Campbell, 2012; Gilbert & Yerrick, 2001; Riegle-Crumb & Humphries, 2012; Woodcock, Hernandez, Estrada, & Schultz, 2012).

Social cognitive theory indicates that career goals are dependent upon student self-efficacy (Bandura et al., 2001). As such, the junior high science classroom is an important locus of influence wherein experiences that affect student self-efficacy result in either persistence to employment or attrition from STEM (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010).

Theoretical Framework

Bandura's (1986) social cognitive theory utilizes a model of "triadic reciprocality" (p. 12) to explain learning and human functioning as the result of the differential interactions that occur between behavioral, environmental, and personal variables (e.g., cognition, affect, self-efficacy). Central to Bandura's work is the construct of self-efficacy, which is an individual's judgment of ability to accomplish a given task, situated in a future context. Within the classroom the generalized results of behaviors over time form beliefs within students and teachers about causal relationships of action and outcome (Bandura, 1986). Bandura theorizes that beliefs mediate actions within future situations, where then the outcome either positively or negatively reinforces the accuracy of the perceived capability. Learners receive many such messages about their ability within the science classroom; the nature of a teacher's feedback influences a student's perception of self-efficacy as it relates to academic tasks. Upon encountering future scenarios that mirror known contexts, the student will adjust their behavior based on their perceived self-efficacy. These mutual interactions between behavior, cognition, and environment result in a self-reinforcing process, resulting in the large influence self-efficacy has over behavior, goals, effort, and perseverance during learning (Bandura, 2006; Schunk, 2008).

The sociocultural perspective views learning as an inextricably social process (Cobb & Bowers, 1999). Thinking and action are situated, mediated by the material aspects (tools, objects, people) of the environment, and informed by social and cultural constructs of the individuals involved (Brown, Collins, & Duguid, 1989; Cobb & Bowers, 1999; Gee, 2008) Learning within science is understood as a result of value-laden experiences within a greater science community (Brown et al., 1989; Cobb & Bowers, 1999; Gee, 2008). The mind processes events and experiences to yield context-specific models that inform action in future interactions (Gee, 2008). Brown et al. (1989) further refer to “indexicalized representations” (p. 36), in which the social norms, tools, and language, and the actor’s perception, feelings, and attitudes all contribute to create a context-dependent model that points to a specific situation or activity. Learning, therefore, reflects not only a student’s cognitive processes but importantly an evolution of the ways in which students and teachers interact socially within the larger system of the science classroom and lab (Cobb & Bowers, 1999; Gee, 2008).

Vygotsky’s (1978) view on the social development of speech and its corresponding effect on internal mental processes within individuals are central to the sociocultural perspective. The primary culture in which a student develops forms the basis upon which all subsequent action, perception, and cognition occur (Gee, 2008). The science classroom represents a novel culture defined by language and patterns of cognition unique to the science community. As such, learning requires students to resolve the incongruities present in the new environment, and ostensibly enculturate to “foreign” ways of action, perception, and thought (Brown et al., 1989; Gee, 2008).

Statement of the Problem

Student decisions to pursue science as a career have been linked to formative experiences within the junior high science classroom (Maltese & Tai, 2011). The opportunity to engage in the practices of science and engineering (PSE) from effective teachers builds science-related self-efficacy and identification (Bolshakova et al., 2011; Bouchey & Harter, 2005; Maltese & Tai, 2011; Rice et al., 2013; Swarat et al., 2012). Unfortunately, evidence indicates that negative and disengaging classroom environments lower student self-efficacy, and engender a disidentification with the culture of science (Bolshakova et al., 2011; Campbell, 2012; Gilbert & Yerrick, 2001; Riegle-Crumb & Humphries, 2012; Woodcock et al., 2012).

Researchers have also uncovered the powerful effects of self-efficacy on the behaviors and instructional practices of teachers (Bolshakova et al., 2011; Heneman, Kimball, & Milanowski, 2006; Tschannen-Moran & Hoy, 2001). Recent work in this area suggests that targeted professional development can improve teacher self-efficacy (Ross, 2014). Although early work on teacher self-efficacy (TSE) by Riggs and Enochs (1990) spurred a focus on science, the majority of research on TSE focuses on general constructs of teaching (Tschannen-Moran & Hoy, 2001). A lack of specificity to the context of science instruction fails to accurately reflect self-efficacy, especially when teaching within the unique context of the laboratory environment commensurate with instruction in the practices of scientists and engineers. At present, some work has been done on the interaction between teacher content knowledge and TSE in science, while little has been done on the effect of self-efficacy on the integration of science and engineering practices into a diverse classroom with underrepresented minorities.

Project Objective

The objective of this study was to increase the use of science and engineering practices within the junior high science classroom in order to increase student engagement, identification, and academic self-efficacy in underrepresented students. This investigation analyzes the ways in which teacher self-efficacy and content knowledge interact to result in reform-oriented teacher behaviors within the diverse science classroom.

Review of Literature

Teacher self-efficacy is a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran & Hoy, 2001, p. 783). Social cognitive theory holds that self-efficacy directly affects behavior, and influences outcome expectations, goals, commitment, effort, and emotional qualities such as stress and depression (Bandura, 2006). Similarly, teacher self-efficacy affects expectations, effort, and teacher behaviors within the classroom (Tschannen-Moran & Hoy, 2001). Given the primary importance of teacher behaviors on student achievement (Rivkin et al., 2005), TSE has enjoyed a prominent position in empirical research. Since the inception of studies on TSE, investigators have studied the effects of teacher efficacy on student achievement, teacher behaviors, the instrumentation of TSE, and the factors and sources influencing self-efficacy in teachers at all levels, and within various subjects.

Teacher Self-Efficacy Instrumentation

In the 40 years since the Rand Corporation first measured teacher self-efficacy, researchers have developed various instruments to measure TSE (Armor et al., 1976; Tschannen-Moran & Hoy, 2001). Gibson and Dembo (1984) were one of the first to incorporate the items from the Rand study with Bandura's (1986) conceptualization of self-efficacy (Tschannen-Moran & Hoy, 2001). The *Teacher Efficacy Scale* provided the groundwork for many studies on teacher efficacy that followed (Gibson & Dembo; 1984). Klassen, Tze, Betts, and Gordon (2011) found that a third of all research on TSE utilized the *Teacher Efficacy Scale*, or a subject-specific variant such as the *Science Teaching Efficacy Belief Instrument* (Riggs & Enochs, 1990).

Tschannen-Moran and Hoy (2001) investigated the framework of the *Teacher Efficacy Scale* in their development of a teacher efficacy measure. Tschannen-Moran and Hoy expressed theoretical inconsistencies with the instrument. In response, the *Teacher Sense of Efficacy Scale* (TSES) was created to more accurately measure self-efficacy. Items reflect Bandura's (2006) guidance on self-efficacy measurement through wording that asks respondents "can do rather than will do" (p. 308) statements.

Bandura (2006) noted that perceived self-efficacy is context specific. Self-efficacy instruments must be constructed to include activities that reflect the challenges and level of demand common within that context. Bandura argued that surveys including items too general in construction will have "limited explanatory and predictive value" (p. 307). Tschannen-Moran and Johnson (2011) developed an instrument to measure TSE in literacy instruction. The authors found literacy self-efficacy to be unique from a non-specific measure of TSE. They concluded that teacher self-efficacy and self-efficacy for literacy instruction are related but independent. In other words, teachers may feel capable of utilizing instructional strategies but not specifically while teaching literacy. The use of conceptually accurate and subject-specific measures is critical to empirical investigations meant to accurately correlate teacher self-efficacy with effective classroom behaviors.

Teacher Self-Efficacy and Teacher Behaviors

Teachers are critical to the success of students; reform efforts meant to improve teacher practices are supported by scholarship eliciting the connection between positive teacher self-efficacy, teacher behaviors, the classroom environment, and academic achievement (Reyes, Brackett, Rivers, White, & Salovey, 2012; Tschannen-Moran & Hoy, 2001). At a personal level, Caprara, Barbaranelli, Steca, and Malone (2006) determined that a teacher's satisfaction with school is positively related to self-efficacy. The study surveyed 2000 Italian junior high teachers utilizing a self-efficacy survey developed from the TSES. Achievement and job satisfaction data were collected at the end of two successive years. Caprara et al. (2006) developed a statistical model connecting the various data points that determined that: (a) teacher self-efficacy had a strong, and positive influence on job satisfaction; (b) student achievement at the end of year one had a significant influence on teacher self-efficacy; and, (c) teacher self-efficacy had a moderate, but significant effect on student achievement at the end of the second year. This study confirms Bandura's (2006) assertion of the influence of self-efficacy on satisfaction. Furthermore, Bandura's (1986) model of triadic reciprocality is evident in the mutually reinforcing interaction measured between teacher self-efficacy and student achievement. Caprara et al. conclude that this study identifies the importance of TSE on the effectiveness of the learning environment.

Further investigations have focused on specific variables leading to the conclusion evidenced by Caprara et al. (2006). Van Uden, Ritzen, and Pieters (2013) utilized Bandura's (2006) teacher self-efficacy scale as part of an investigation to determine the influence of teacher beliefs on perceptions of student engagement. Data from a sample of pre-vocational and vocational teachers in the Netherlands revealed that those with high self-efficacy perceived their students to be more highly engaged, both emotionally and behaviorally. The authors argued that efficacious teachers' increased perceptions of engagement could be indicative of a positive classroom environment, and a positive relationship between teacher and student. Conversely, other studies have documented the negative effects of low teacher expectations on underrepresented students (Gilbert & Yerrick, 2001).

The evidence presented above is ultimately the result of specific teacher behaviors. Efficacious teachers have been shown to utilize time in the classroom more effectively, and be less critical of students during questioning (Gibson & Dembo, 1984). Teachers with high self-efficacy are also more inclined to engage with students when they are not able to answer verbal questions accurately (Gibson & Dembo, 1984). Tschannen-Moran & Hoy (2001) reference extensive scholarship documenting the impact of TSE on specific teacher behaviors, including a teacher's willingness to adopt new instructional techniques.

In a mixed-methods study on the effects of an extensive professional development program on the pedagogical practice of drama teachers, Lee, Cawthon, and Dawson (2013) determined that implementation was related to TSE. The goal of the professional development program was to increase the use of drama-based instruction by elementary and secondary teachers. Lesson plans were analyzed by Lee et al. (2013) to determine the degree of implementation for a small sample of 14 teachers. Implementation scores were analyzed against teacher self-efficacy scores collected with the TSES. Data analyses indicated that while TSE scores were not related to implementation for elementary teachers, self-efficacy for instructional strategies and student engagement were significant predictors for secondary teachers. This suggests that teachers with higher self-efficacy in the area of instructional practices are more likely to implement new methods as the result of professional development.

Factors Influencing Teacher Self-Efficacy

As the work of Lee et al. (2013) suggests, the factors influencing teacher self-efficacy are important components to consider in any reform approach hoping to influence the environment and practices of the classroom. Bandura (1986) proposed four sources of information influencing self-efficacy: mastery experiences, vicarious experiences, verbal persuasion, and physiological arousal. The strongest of these sources are mastery experiences in which an attempt at a task is successful. The nature of these four sources must influence the structure of professional development models if teacher self-efficacy is to be improved.

Ross (2014) studied the relationship between professional development and math teachers' self-efficacy in dealing with English Language Learners. Ross surveyed 181 preK-12 math teachers utilizing a math-specific version of the *Teacher Sense of Efficacy Scale*. The teachers were also asked questions to determine teachers' awareness and attendance at various types of professional development for ELLs. Initial measures indicated that teachers exhibited lower self-efficacy with ELLs as compared to non-ELL students. This initial result, along with the work of Tschannen-Moran and Johnson (2011) represent the only investigations delineating a significant difference in teacher self-efficacy for a specific student population. Regression analyses did not indicate that professional development, or the frequency of attendance significantly accounted for the variation in self-efficacy measures. A post-hoc power analysis did indicate that professional development was positively correlated with higher self-efficacy in dealing with ELLs. Ross's study was not able to determine the specific type of experience responsible for teacher's heightened sense of self-efficacy; this limits the ability to determine which source of efficacy best influenced these math teachers.

Tschannen-Moran and Johnson (2011) were more specific in their work determining which factors most influenced teacher self-efficacy in literacy instruction for a sample of 648 teachers. The authors surveyed the teachers utilizing a literacy-specific version of the TSES, along with items meant to assess two sources of self-efficacy: verbal persuasion and vicarious experiences. These items were determined by measuring the highest degree obtained by the teacher, the quality of university education in literacy instruction, and the quality of professional development. Correlational analyses indicated that the quality of a teacher's university education or professional development experiences contributed to a teachers' self-efficacy in literacy instruction. The authors note that while this result indicates the ability to influence teacher self-efficacy through vicarious experience and verbal persuasion as posited by Bandura (1986), this study was also limited in its lack of detail in determining program components most responsible for self-efficacy growth.

The context of preservice teaching courses has been a primary site for investigations into the specific factors influencing teacher self-efficacy (Fives & Buehl, 2010; Tschannen-Moran & Hoy, 2007). The studies have determined that preservice teachers have significantly lower and more fluid TSE than experienced teachers; as a result, investigations aimed at determining the specific sources responsible for considerable growth in preservice teachers' self-efficacy are vital to producing effective teachers (Fives & Buehl, 2010; Tschannen-Moran & Hoy, 2007). The work of Palmer (2006) with preservice elementary science teachers in New Zealand represents a focused effort to delineate specific programmatic attributes responsible for building TSE. Working with individuals in their third year of undergraduate studies, Palmer administered Riggs and Enochs's (1990) *Science Teaching Efficacy Belief Instrument Form B* as a pre- and post-test to determine the growth in self-efficacy following a methods course in science. The course was designed to provide mastery experiences through student teaching experiences, vicarious experience and verbal persuasion through content lectures and group workshops, and three additional categories theorized as influential in the field of science education: cognitive content mastery, cognitive pedagogical mastery, and simulated modeling. Surveys throughout the course provided data as to which experiences were the most important to the students. Final analyses showed a significant increase in teacher self-efficacy in science as a result of the methods course, with student survey responses indicating that experiences in which students learned pedagogical content knowledge were the most influential. This result leads me to conclude that other sources are responsible for building self-efficacy in teachers besides the four delineated in social cognitive theory. Palmer importantly argues that content knowledge and pedagogical content knowledge are critical sources of teacher self-efficacy in science.

Practices of Scientists and Engineers

The National Research Council's (2012) publication *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* represents the most recent reform-oriented publication meant to transform the nature of science education. The Framework employs a sociocultural perspective in its calls for students to engage in learning experiences that mirror the actual practices of professional scientists and engineers. These practices update and extend the National Research Council's previous focus on inquiry education published in *Inquiry and the National Secondary Science Standards* (NRC, 2000). The authors of the framework are clear to distinguish inquiry from PSE, with the former comprising only one factor of the later. Noting both the inconsistent manner in which inquiry is defined in the literature, and the narrowing effect inquiry has had on the common perception of science as just the scientific method, the NRC developed a three-part model (investigating, evaluating, and developing explanations and solutions) that more accurately characterizes the work of scientists and engineers.

Given the recent transition from inquiry to PSE within educational literature, the frequency of inquiry within science educational practices still remains prominent. As this review is concerned with the critical factor teacher self-efficacy plays in determining a teacher's practice in the classroom, it will now transition to the practices of scientists and engineers, and its power to influence student success and identity within underrepresented student groups.

Swarat et al. (2012) surveyed 533 junior high students to determine student interest during science instruction as determined by the content topic, activity, and learning goal of described instructional episodes. Data analyses of the students' responses revealed that the activity of the instructional episode uniquely affected the students' self-reported level of interest, while content topic and learning goal showed no affect. Analyses by activity types showed a positive and significant relationship for hands-on and technology related instructional activities involving experiments, lab work, or projects. This study indicates that student interest and engagement in science can be achieved through instruction that utilizes the practices of scientists and engineers.

Although the importance of inquiry and PSE to science education has been established, Capps and Crawford's (2013) sought to determine the actual frequency with which 26 self-selected science teachers utilized inquiry practices in the classroom. Lesson observations, lesson plans, and survey responses showed a wide range of views and implementation of inquiry into instructional practice, with the majority showing little evidence. Follow-up questioning indicated that teachers had an overinflated view of their practice. The authors concluded that even in a set of motivated teachers, the understanding of and use of inquiry practices were very limited. The dearth of inquiry in the science classroom and lack of understanding by teachers as shown here indicates that teachers are not prepared to reform science instruction as envisioned by the NRC.

Understanding the difficulty inherent in utilizing PSE or inquiry in the classroom, Leonard et al. (2011) set about determining the role teachers' beliefs played in implementing inquiry-based practices in the classroom. A mixed methods approach was utilized that determined pre- and post measurements on the *Science Teacher Inquiry Rubric* and the *Science Teaching Efficacy and Belief Instrument,* as well as data on lesson implementation obtained through observations and lesson plans. The survey data indicated that TSE increased as a result of a methods course, while observations indicated that only a minority was able to consistently implement high inquiry-based practices. The authors suggest that two cases showed that the content knowledge of the preservice teachers might have been a factor resulting in decreased implementation of inquiry-based practices.

Conclusion

Research has shown that the classroom environment and practices employed by teachers directly impact engagement and interest in science for underrepresented students (Maltese & Tai, 2011; Swarat et al., 2012). When students are engaged in inquiry or PSE, students identify with science and build positive self-efficacy that results in increased decisions to pursue science as a major. While this connection is clearly indicated in the research, studies into the practices of science teachers show that low content knowledge and low teacher self-efficacy may be responsible for the dearth in actual practice. As work with preservice and practicing teachers has shown that professional development and methods courses can build teacher self-efficacy and content knowledge, the goal of increased utilization of science and engineering practices can seemingly be achieved through authentic professional learning for teachers that employs mastery experiences and vicarious learning to grow both content knowledge and self-efficacy.

Chapter 2

Empirical Examination of the Factor and Underlying Causes

The national economic demand to provide for the expanding presence of knowledge and technology-intensive industries is experienced locally for the District as an imperative to produce an educated labor force. The District is situated within a suburb of a major city and is itself a major employment center, hosting a large number of international telecommunication companies. Serving the families and businesses of the area, the District is fully aware of the need to educate students in preparation for the demands of a highly skilled workplace. At the same time District data show that it educates a diverse population, with Hispanic (40.0%) and African American (22.3%) students making up the majority, and economically disadvantaged students (57.7%) outnumbering their peers. The tensions inherent in serving a high-needs population are evidenced in district data showing disproportionate educational outcomes for these groups. The realities facing educators in the District necessitate an in-depth examination of the factors within its science classrooms that are influencing underrepresented students.

In the previous section I noted that students' career goals are influenced by their self-efficacy; consequently, characterizing the experiences of students within secondary science classrooms is an important line of research and assessment (Bandura et al., 2001; Byars-Winston et al., 2010). This needs assessment focused primarily on measuring the self-efficacy and engagement of underrepresented students within District science classes, specifically for African American, Hispanic, female, and low socioeconomic (SES) students. Equally, as teacher self-efficacy and content knowledge are directly related to teacher effectiveness and student outcomes, secondary science teachers within the District are also included as participants (Coleman et al., 1966; Tshannen-Moran & Hoy, 2001).

The research conducted here is in partnership with the District and its Department of Accountability. Existing district data for students is utilized in agreement with conditions for research included in Appendix A, as set out by the District. Data collected from students and teachers is done under the approval of the Johns Hopkins University Institutional Review Board (Appendix B). Information letters and consent forms for students and teachers are included in Appendices C and D, respectively.

Student Self-Efficacy

The self-efficacy of underrepresented students in the STEM classroom is an important factor determining persistence to a STEM degree (Byars-Winston et al., 2010; Rice et al., 2013). Bandura's (1986) concept of self-efficacy holds that the generalized results of behaviors over time form beliefs within an individual about the casual relationship of action and outcome. These internalized beliefs mediate the actions and choices of the individual in future situations (Bandura, 1986). Within students, Bandura posits that academic beliefs determine effort and persistence on classroom assignments, therein determining academic achievement and reinforcing self-beliefs associated with the classroom.

Through a reciprocal interaction of beliefs and results, academic self-efficacy, achievement, and academic choices mutually reinforce each other and direct the occupational pathway of the student (Bandura, 1986; Bandura et al., 2001). Maltese & Tai (2011) have empirically illustrated that the interaction of experience, academic achievement, and course selection strongly determine a student's decision to enter a STEM major. Positive academic self-efficacy is particularly important as academic success within upper-level Advanced Placement courses in high school have been shown to be the strongest predictor of completion in science and engineering majors (Ackerman, Kanfer, & Calderwood, 2013).

Research on self-efficacy operationalizes the concept through surveys in which students utilize a scale to identify their perceived ability to complete a presented task (Bandura et al., 2001). Various surveys reflected in the literature are constructed to measure general self-efficacy (Bandura et al., 2001; Bolshakova et al., 2011), while others focus on STEM self-efficacy utilizing statements specific to science or math (Britner & Pajares, 2001; Byars-Winston et al., 2010; Rice et al., 2013). Data results for self-efficacy are correlated here with grade achievement. Both measures are utilized to compare results for underrepresented students versus other student groups.

Student Engagement

According to Lovelace, Reschly, Appleton, and Lutz (2014) student engagement is the degree to which a student is connected to and invested in the learning and goals of school. School reform efforts have focused on student engagement as empirical work has indicated a strong positive relationship with graduation rates and student achievement (Lovelace et al., 2014; Reyes et al., 2012). Boutakidis, Rodriguez, Miller, and Barnett (2014) found student engagement to be significantly related to grade point average in a sample of junior high students.

Engagement is the result of interactions between the student and the social context of the learning environment (Appleton, Christenson, Kim, & Reschly, 2006). As this is essentially concerned with the sociocultural context of the classroom, the environment of the science classroom is integral to engendering engagement and maintaining motivation in students (Appleton & Lawrenz, 2011). Maltese and Tai (2011) again find that a student's decision to enter a STEM major in university is predicted by interest levels in junior high science. Studies on specific attributes of the junior high classroom find that student engagement increased through the context of hands-on, inquiry style instruction (Swarat et al., 2012).

Conceptualizations of student engagement vary, however Appleton et al. (2006) find that most models include behavioral (e.g., participation, conduct), affective (e.g., happiness, identification), and cognitive (e.g., investment, self-regulation, metacognition, learning goals) subtypes. These components identify important factors that are utilized to operationalize engagement. In a review of 21 engagement instruments, Fredricks et al. (2011) detailed the various survey methodologies, objectives, and statistical power of each instrument.

Teacher Effectiveness

Extensive scholarship on the factors influencing student achievement identify teacher effectiveness as the single most important factor within schools (Goldhaber, 2002; Rivkin et al., 2005). Student attributes identified so far are linked in the literature to teachers' effectiveness at employing instructional strategies and behaviors (Rice et al., 2013; Swarat et al, 2012). Quantifiable variables associated with overall teacher effectiveness include two key factors: teacher self-efficacy and content knowledge (Bolshakova, et al., 2011; Goldhaber, 2002).

Teacher Self-Efficacy

Teacher self-efficacy is a teacher's self-perceived belief in their ability to engage students through instruction that results in student achievement (Gibson & Dembo, 1984; Tschannen-Moran & Hoy, 2001). Teachers with high self-efficacy exhibit student-centered behaviors in the classroom and are more likely to utilize reform-oriented pedagogy (Bolshakova et al., 2011; Gibson & Dembo, 1984; Tschannen-Moran, Hoy, & Hoy, 1998).

Empirical investigations into TSE utilize various methodologies and instruments, including interviews (Bolshakova et al., 2011) and scale response surveys (Tschannen-Moran & Hoy, 2001). Bandura (2006) warns that self-efficacy is a context-specific trait, and that scale items must match the tasks and difficulty of the desired domain. Teacher self-efficacy instruments include scales that measure personal teaching efficacy for teaching (Tschannen-Moran & Hoy, 2001), and scales unique to the teaching of science (Riggs & Enochs, 1990) and math (McGee & Wang, 2014). Participant characteristics including school context (elementary, secondary) and years of experience are often included as co-variables, although correlations with such variables are often inconsistent (Fives & Buehl, 2010; Tschannen-Moran & Hoy, 2007).

Content Knowledge

Teacher content knowledge (CK) is both an antecedent to teacher efficacy, and a characteristic associated with overall effectiveness within the science or math classroom (Goldhaber, 2002; Tschannen-Moran & Hoy, 2001). The National Research Council's (2012) publication *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* calls for students to engage in learning experiences that mirror the actual practices of professional scientists and engineers. This recent call for instructional change builds upon the NRC's (2000) push for inquiry education. In spite of the awareness of instruction in science that utilizes nature of science and inquiry-based instruction, research indicates that science teachers retain incomplete or inaccurate understandings (Capps & Crawford, 2013). Leonard et al. (2011) importantly indicated that a lack of science content knowledge hindered teachers' use of these techniques in the classroom.

Bolyard and Moyer-Packenham's (2008) review of teacher effectiveness studies in science and mathematics identified both subject-specific degrees and coursework as indirect measures of content knowledge. Kanter and Konstantopoulos (2010) directly measured content knowledge through an assessment associated with a specific unit of instruction.

Goals and Objectives

The purpose of this needs assessment was to further characterize the educational experiences within secondary science classrooms for underrepresented[1] students (African American, Hispanic, low-SES, and female). The objective of this needs assessment was to determine the need for instructional changes within the science classroom, and professional development needs for secondary science teachers in order to prepare underrepresented students to major in science. Therefore, this study addressed the following goals:

1. Assess the academic attributes of underrepresented students.
2. Assess the academic pathways through science for underrepresented students.
3. Assess the use of science practices within secondary science.
4. Assess the attributes of current secondary science teachers that are shown to impact teacher effectiveness.

The District serves a diverse and economically disadvantaged population. Table 1 includes 2013-14 student demographic information for the District, and for the state of Texas. In order to respond to this need the District places a great deal of emphasis on educating all students, and ensuring students succeed at graduation-determining accountability exams. In spite of this focus, district data show unequal graduation rates for Hispanic (86.3%) and White (95.1%) students. Equally, while the District is guided by a strong focus on preparing students for postsecondary education, testing data for Advanced Placement exams show Hispanic students completed only 20.1% of administered Advanced Placement (AP) exams in 2014. This exam rate compares to 58.3% of exams being completed by White students. These two student data points indicate that minority students are experiencing factors that fail to bring equitable outcomes to all

[1] Underrepresented groups here reference national trends in STEM education and employment (NSF, 2014).

student groups. Given the importance of academic achievement and AP exam rates in preparing for a major in science, data indicate a clear need to conduct further investigation.

Table 1

2013-14 District Student Demographics (Texas Data in Parentheses)

Student Group	*n*	%
Ethnicity		
African American	8,498	22.3 (12.7)
American Indian	142	0.3 (0.4)
Asian	2,627	6.9 (3.7)
Hispanic	15,283	40.0 (51.8)
White	10,625	28.0 (29.4)
Two or more	956	2.5 (1.9)
Economically Disadvantaged	22,129	57.7 (60.2)
Limited English Proficient	9,831	24.9 (17.5)
Total Enrollment	38,283	

Methodology

Setting and Study Respondents

Through this needs assessment I drew on three sources of data, including a student survey, extant student enrollment data, and a survey administered to secondary science teachers. The participants for each survey are explained in detail in the following section.

Student survey. Participants included 347 students in Grade 7 from two junior high campuses within the District. The two campuses reflected the racial/ethnic, socioeconomic, and geographic diversity of the District. Table 2 presents demographic information for the student sample as compared to the overall population of Grade 7 students in the District.

Table 2

Demographic Characteristics for Grade 7 Students

Characteristics	Sample		District	
	n	%	*n*	%
Race/Ethnicity				
African American	56	16.1	585	21.4
Hispanic	150	43.2	1125	41.1
Asian	22	6.3	188	6.9
White	109	31.4	745	27.2
Gender				
Male	157	45.2	1402	51.2
Female	190	54.8	1335	48.8
Socioeconomic Status				
Low-SES	171	49.3	1582	57.8
High-SES	176	50.7	1155	42.2
Course				
Grade 7 Science	130	37.5	1226	44.8
Pre-AP 7 Science	200	57.6	1439	52.6
ELL 7 Science	15	4.3	29	1.1
SPED 7 Science	2	0.6	43	1.6
Total	347	100	2737	100

Longitudinal course analysis. Data represents course selections for all students at grade levels 7, 9, 11, and 12. Demographic characteristics are presented in Table 3.

Table 3

Demographic Characteristics for Students from 2009-10 through 2014-15

Characteristics	Grade 7 (2009-10) *n*	%	Grade 9 (2011-12) *n*	%	Grade 11 (2013-14) *n*	%	Grade 12 (2014-15) *n*	%
Race/Ethnicity								
African American	612	23.5	636	23.3	462	22.8	396	20.2
Hispanic	867	33.2	828	30.4	697	34.5	582	29.7
Asian	185	7.1	235	8.6	154	7.6	191	9.7
White	887	34.0	887	32.5	633	31.3	732	37.3
Gender								
Male	1313	50.3	1359	49.8	977	48.3	940	47.9
Female	1295	49.6	1292	47.4	1012	50.0	1009	51.4
Socioeconomic Status								
Low-SES	1497	57.4	1331	48.8	936	46.3	771	60.7
High-SES	1112	42.6	1397	51.2	1087	53.7	1191	39.3
Total	2609		2737		2023		1962	

Teacher survey. Participants were 85 science teachers, comprised of 35 junior high and 50 high school. Teachers represent all grade levels (7-12) and all course designations (General, Academic, Career and Technical Education (CTE), and 4th Year). The average years of experience is 8.29, *SD* = 7.40, with a range of 1 to 38 years.

Variables

Student survey. A 14-item survey was administered to students that included three variables meant to operationalize student self-efficacy and engagement (see Appendix E). Available grades for the 2014-15 fall semester of grade 7 science were also collected for each student.

Five items from the Science Self-Efficacy instrument assessed student self-efficacy (SSE) (Britner & Pajares, 2001). Five items measured a student's self-reported perception of their ability to earn an A, B, C, or D in their 7th grade science class: "How confident are you that you will pass science class at the end of this semester?". Values range from 1 (*not confident at all*) to

6 (*completely confident*). The reported SSE reflects the average value for the items, with a higher value reflecting a higher level of self-efficacy.

Science engagement (ENG) measures a student's behavioral engagement in their science classroom. Four items from the University of Chicago Consortium on Chicago School Research (UCCCSR) (2014) My Voice, My School Student Survey asked students questions such as "I usually look forward to this class." Values range from 1 (*strongly disagree*) to 4 (*strongly agree*). A student's ENG score reflects an average score across the four items. A higher value reflects a higher level of student engagement.

The final section of the student survey included five items from the My Voice, My School Survey assessing science practices (UCCCSR, 2014). These items reflect a student's observation of the frequency with which hands-on practices are utilized in their science classroom. One item has students measure the frequency they "write lab reports". Items are averaged to produce a value for science practices that reflects frequency, ranging from 1 (*never*) to 5 (*almost every day*).

Longitudinal course analysis. Course pathway was measured by sorting course selections into four categories: General, Academic, CTE, and 4th Year. These designations match those utilized in the National Education Longitudinal Study (Institute of Education Sciences, 1988). General courses include those required by Texas in junior high, and within graduation requirements from grades 9-11. General courses are on-level science courses, including special education inclusion settings, and English as a second language (ESL) sheltered courses. Academic courses include college preparatory courses, including AP courses at grades 9-12, and Pre-AP courses at grades 7-9. Career and Technical Education courses include those courses at grades 10-12 that meet the federal designation for CTE. The 4th Year courses are elective science courses at grades 11-12 that are selected as the final credit in high school for graduation. They include Aquatic, Astronomy, Earth & Space Science, and Environmental Systems.

Teacher Survey. A 32-item teacher survey included two instruments measuring five variables associated with teacher effectiveness in science (see Appendix F). The first instrument assessed teachers' backgrounds through four variables: experience, undergraduate major, certification, and highest degree.

Experience was collected as the number of years in the classroom. Participants were classified into two groups, novice (1-3 years) and veteran (4 or more years). Bandura (1997) holds that once an individual establishes a perception of their ability to accomplish a task through repeated experience, self-efficacy becomes relatively resistant to change. The designations I utilize reflect the variable nature of self-efficacy early on in learning a new skill (Bandura, 1997). For novice teachers, the first few years in the classroom are a time of learning where the realities of the classroom are finally encountered. In their study comparing novice and experienced teachers, Tschannen-Moran and Hoy (2007) found 3 years to be a significant point. The lowest TSE scores reported by teachers jumped after the third year, either because scores improved with experience, or because teachers left the field.

Undergraduate major and highest degree are utilized to measure a teachers' level of content knowledge. Undergraduate major was measured by categorizing reported majors into three categories: education, science & engineering, or other. Education included degree programs at local universities that have the express goal of preparing students for work in education (e.g., interdisciplinary studies, special education, elementary education). Science and engineering included all majors within the colleges of science (e.g., physics, biochemistry, earth science, geoscience) and engineering (e.g., chemical engineering, engineering). All other majors (e.g., psychology, kinesiology, communications, management) were grouped into a separate category. Highest degree reflected four levels: bachelors, masters, doctorate, and professional degree (e.g., M.D., D.D.S., J.D.).

The final variable, teacher telf-efficacy, was assessed using the long form of the Teachers' Sense of Efficacy Scale (Tschannen-Moran & Hoy, 2001). Twenty-four items measured a teacher's self-reported perception of their ability within the classroom to respond to various teaching situations. Teachers utilized a 9-point scale (*None at all, A Great Deal*) to answer items that assess teachers' self-efficacy with respect to three areas:

- Efficacy for Student Engagement – "How much can you do to motivate students who show low interest in school work?"
- Efficacy for Instructional Strategies - "How much can you use a variety of assessment strategies?"
- Efficacy for Classroom Management - "How much you do to control disruptive behavior in the classroom?"

All items were averaged to produce a final TSE score, with a higher value reflecting a stronger measure of self-efficacy. Scores for each of the three sub-factors (Classroom Management, Instructional Strategies, and Student Engagement) are also obtained, each as a mean of eight items.

Data Collection Methods

The student survey instrument was administered to all (N = 774) grade 7 students at two participating junior high campuses. Science teachers administered paper surveys within one class period to their students. Spanish versions were provided for LEP students as determined by their teacher (see Appendix E). Teachers read aloud the directions for the survey and allowed students as much time as necessary to complete the survey. The option to read each question aloud to the students was available as necessary to meet student needs.

Student identification numbers were provided for students on their surveys. Surveys were collected and answers transcribed into SPSS for 347 students that submitted signed consent forms. Student IDs were utilized to match district provided demographic data and fall semester grades with survey responses. District demographic data was collected from the student information data system, which reflects a family's self-reported values at the time of enrollment. Once data was completely entered and missing demographic values corrected, students were coded and their ID subsequently removed from the data set.

Course data was collected from the student information data system and provided by the District's Assessment and Accountability Department.

All secondary science teachers ($N = 142$) were e-mailed information concerning the purpose and scope of the study. Upon submission of a signed consent form, participants were emailed a link to the survey, which was administered anonymously using Google Forms. Teachers were allowed two weeks to complete the survey at their convenience; slightly more than one-half ($N = 85$) of all teachers completed the survey.

Results

Student Results

Means and standard deviations for student science measures are provided in Table 4. Correlation analyses of science measures are provided in Table 5. An analysis of variance with SSE as the dependent variable, and student race/ethnicity, gender, SES, and course as independent variables indicated that main effects were not significant. The results revealed significant interactions between the effects of science course and race/ethnicity, $F(4,312) = 3.26$,

p = .01. African American (AA), Hispanic (HISP), and White students reported weaker SSE when enrolled in general science as compared to those same student groups who were enrolled in academic science.

An analysis of variance with science grade as the dependent variable, and student race/ethnicity, gender, SES, and course as independent variables indicated significant main effects for SES, $F(1,303) = 3.96$, $p = .05$, and science course, $F(1,303) = 58.99$, $p < .001$. The main effect of gender and race/ethnicity were not significant. No interaction effects were significant.

Results also indicated that students across all groups reported similar levels of engagement. Lastly, students in general science reported utilizing science practices significantly more frequently than students in academic science, $t(344) = 3.82$, $p < .001$.

Table 4

Means and Standard Deviations for Science Measures by Student Group

	Measures							
	Science Grade		Science Efficacy		Engagement		Science Practice	
Student Groups	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Race								
African American	85.6	1.15	4.99	1.12	3.00	0.65		
Hispanic	85.4	0.58	4.66	1.14	3.08	0.51		
Asian	88.4	1.65	4.72	1.21	3.14	0.71		
White	83.2	1.39	5.41	0.88	3.00	0.53		
Gender								
Male	86.4	8.99	5.02	1.04	3.09	0.52		
Female	86.8	8.25	4.77	1.14	3.00	0.58		
Socioeconomic Status								
Low SES	84.0*	0.82	4.70**	1.15	3.09	0.56		
Non-SES	90.5*	0.89	5.25**	0.97	2.98	0.54		
Course								
General Science	80.6***	7.92	4.48	1.09	3.01	0.53	3.28*	0.69
Academic Science	92.1***	5.20	5.33	0.96	3.06	0.57	2.96*	0.81

Note. *$p < .05$, **$p < .01$., ***$p < .001$

Table 5

Correlations of Science Measures

Measure	1	2	3	4
1. Science Grade	-	.501***	.024	-.106*
2. Science Efficacy		-	.283***	-.004
3. Science Engagement			-	.232***
4. Science Practices				-

Note. *$p < .05$, ***$p < .001$.

Analyses of variance for student course enrollment showed significant main effects at

- 7th grade for race/ethnicity, $F(5,2596) = 17.03$, $p < .001$, and SES, $F(1,2596) = 23.68$, $p < .001$;
- 9th grade for race/ethnicity, $F(5,2627) = 25.14$, $p < .001$, and SES, $F(1,2627) = 7.53$, $p = .006$; and

- 11th grade for race/ethnicity, $F(5,2325) = 8.683$, $p < .001$, and SES $F(1, 2325) = 3.91$, $p = .048$.

Post hoc analyses using Turkey HSD criterion showed that AA and HISP differed from White and Asian groups at $p < .05$. No significant effect for gender was determined.

A primary aim of this needs assessment was to determine if underrepresented students in the District exhibited differential outcomes as a result of their placement within secondary science classrooms. The results presented here show that African American, Hispanic, and economically disadvantaged students are following a course trajectory within science dominated by the general science track. The importance of enrollment within the academic science classroom has been shown to be a significant predictor of both persistence in STEM, and success in university (Ackerman et al., 2013; Maltese & Tai, 2011).

Results show that students utilized science practices more frequently in the general classroom. Conversely, they also show that those students in general 7th grade science have lower levels of self-efficacy and lower grades. While the data cannot indicate a causal relationship between enrollment and outcomes, other aspects of the general classroom not measured here may account for these important results. The literature indicates that the classroom environment and teachers' behaviors within general classrooms can result in the negative impacts on student outcomes collected here (Campbell, 2012; Gilbert & Yerrick, 2001; Reyes et al., 2012). In agreement with Social Cognitive Theory, the low perceptions of ability measured early in these student's secondary career may account for the subsequent enrollment choices in general science also measured here. These data point to the importance of addressing factors within the general science classroom.

The importance of engagement in the classroom utilizing science practices is evident in the literature (Swarat et al., 2012). Students in the District reported utilizing science practices at a rate of *once or twice a month* in both general and academic 7th grade science. Understanding the similar level of engagement reported for students across all groups and in both courses, the evidence clearly shows that a great opportunity exists to increase the prevalence of science practices in instruction. Although the data only indicated a weak relationship between science practices and engagement, an increase in the use of these practices could result in an increase in engagement, and subsequently a greater feeling of success and self-efficacy in critical student groups. The frequency of hands-on practices is dependent upon the science teacher, however. This discussion will now turn to the results obtained for the District's teachers.

Teacher Results

Teacher background characteristics are presented in Table 6. Means and standard deviations for teacher self-efficacy variables for junior high and high school teachers are presented in Table 7. Results from an analysis of variance with the total TSES score as the dependent variable, and five teacher characteristics as independent variables identified a significant main effect for school level, $F(1, 85) = 4.645$, $p = .04$. No main effect was significant for any other teacher variable.

A multivariate analysis of variance with the three TSES subscales (*Classroom Management, Instructional Strategies, Student Engagement*) as dependent variables and the same teacher variables showed a significant main effect for school level, $F = 3.32$, $df = (3, 50)$, $p = .03$. Interaction effects between school level and other variables were not significant. Univariate F tests indicated a significant difference between JH and HS teachers for *Classroom Management*,

$F = 7.16$, $df = (1, 52)$, $p = .01$. The data was not significant for the *Instructional Strategy* or *Student Engagement* scales.

Table 6

Characteristics for Secondary Science Teachers

Characteristics	Sample *n*	Sample %
Experience		
1-3 years	28	32.9
4+ years	57	67.1
Degree Area		
Education	17	20.0
Science & Engineering	46	54.1
Other	22	25.9
Degree Level		
Bachelors	52	61.2
Masters	31	36.5
Doctorate	2	2.4
Certification		
Traditional (University-based)	47	55.3
Alternative	38	44.7
Total	85	100

Table 7

Means and Standard Deviations of Teacher Self-Efficacy Variables by School Level

	School Level			
	Junior High (*n = 35*)		High School (*n = 50*)	
	M	*SD*	*M*	*SD*
Teacher sense of efficacy	7.09*	0.99	6.95*	0.93
Classroom management	7.44**	1.23	7.34**	1.00
Instructional strategies	7.23	0.96	7.21	1.10
Student engagement	6.61	1.24	6.30	1.10

Note. $^{*}p < .05$, $^{**}p < .01$.

A secondary aim of this study was to determine the effectiveness of science teachers in the District through the measures of teacher self-efficacy, and background characteristics purported to increase effectiveness in the science classroom. A marked difference in content knowledge exists between JH and HS teachers; a higher percentage of HS teachers earned an undergraduate major in science and engineering (74% to 25.7%) than JH teachers. Also, a greater percentage of HS teachers have earned a graduate degree (40% to 31.4%) than JH teachers. Goldhaber (2002) notes the importance of content knowledge for teacher effectiveness in science. These data indicated a clear difference that may then impact effectiveness in the classroom, and a teacher's confidence and ability to implement science practices (Leonard et al., 2011).

Teacher self-efficacy is also associated with effectiveness (Tshannen-Moran & Hoy, 2001). Results obtained here for TSE match published results showing:

- no effect for experience on TSE (Tschannen-Moran & Hoy, 2007);
- a significant effect for school level (Fives & Buehl, 2010; Heneman et al., 2006; Lee et al., 2013); and,
- *Classroom Management (M* = 7.38, *SD* = 1.10) and *Student Engagement (M* = 6.43, *SD* = 1.16) as the strongest and weakest TSE sub-scale, respectively (Fives & Buehl, 2010; Ross, 2014; Tschannen-Moran & Hoy, 2007).

The results obtained showing a lack of a main effect for CK, either through undergraduate major or graduate degree, possibly call into question the context match of the TSES. The relative strength of efficacy for Instructional Strategies does not match the infrequent use of science practices as reported by the students. This disconnect may be a result of other factors limiting their use in the classroom by teachers, or the inability of the TSES to measure self-efficacy for science practices as an instructional strategy. Bandura (2006) stressed that valid self-efficacy scales must utilize items that mirror the context of the desired area of study. The measure of teacher self-efficacy by the TSES here, though it mirrors published research, does not match the context of instruction utilizing science practices. The development of a TSES variant specific to this context could be developed in order to more accurately measure science teachers' abilities (McGee & Wang, 2014).

Conclusion

While this needs assessment is concerned with the use of certain practices within the science classroom, its primary goal was to characterize factors influencing URM within the science classroom. Teachers reported weaker self-efficacy with respect to student engagement. Items for this subscale assess teachers' perception of their ability to motivate and get students to believe they can do well (see Appendix E). Although these data did not indicate a significant difference in engagement for URM, experiences in the classroom are contributing to weaker science self-efficacy, lower academic achievement, and the decision to forgo academic-level science courses as they move through high school in the Distrct. As such, these results confirm the need to implement an intervention aimed at improving teacher self-efficacy with the express aim of improving classroom practice through the use of science practices. Drawing upon the connection between the use of hands-on practices and engagement (Swarat et al., 2012), I suggest that an increase in the prevalence of such pedagogy throughout the District could dramatically increase engagement at all levels, and ultimately science self-efficacy in African American, Hispanic, and economically disadvantaged students.

Chapter 3

Intervention Literature Review

The United States must draw upon populations underrepresented in the STEM labor force if it is to meet the growing needs of the knowledge-based economy (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2011; President's Council of Advisors on Science and Technology, 2012). Educators play a pivotal role in realizing this result by engaging and teaching students so that they excitedly enter the STEM pipeline, bound for a post-secondary career in science or engineering. Given the low numbers of underrepresented minority students who are currently following this pathway, more needs to be done to target factors within the classroom. In the previous chapter, a needs assessment study collected strong evidence in-line with national trends that identified the presence of persistent factors within the junior high science classroom that are leaving students disengaged and disempowered to pursue a STEM career.

Science teachers are instrumental in developing students’ interests and consequently students’ decisions to pursue a STEM major. Maltese and Tai (2011) have shown that students’ experiences within the junior high science classroom are positively associated with later decisions to major in science. Understanding the importance of teachers’ behaviors and instructional methodologies on student outcomes, research into teacher factors associated with the science classroom are a key focus area. Three primary areas are specifically addressed through this intervention: (a) STEM content knowledge, (b) teacher self-efficacy, and (c) teachers’ biases of diverse students.

A teacher’s level of content knowledge in science has been associated with their effectiveness in the classroom (Diamond, Maerten-Rivera, Rohrer, & Lee, 2014; Goldhaber, 2002; Supovitz & Turner, 2000). Kanter and Konstantopoulos (2010) found an increase in student achievement occurred with an increase in teacher content knowledge. Moreover, studies within the science classroom have related CK with teachers' implementation of inquiry-based practices (Leonard et al., 2011; Supovitz & Turner, 2000).

Teacher self-efficacy is a critical cognitive factor affecting teachers' behaviors and dispositions (Tschannen-Moran & Hoy, 2001). Teachers with high self-efficacy more frequently utilize student-centered behaviors and are more likely to implement reform-oriented pedagogy, including science and inquiry practices (Cakiroglu, Capa-Aydin, & Hoy, 2012; Fisler & Firestone, 2006; Gibson & Dembo, 1984; Tschannen-Moran & Hoy, 2001). As a result of learning from highly efficacious teachers, students enjoy increased engagement, academic achievement, and self-efficacy in STEM (Bolshakova et al., 2011; Caprara et al., 2006; Reyes et al., 2012).

Lastly, teachers' pedagogical choices are linked to their beliefs and perceptions of students within the classroom (Pajares, 1992). The negative academic impacts of teachers' biases towards diverse student groups have been well documented in STEM (Bolshakova et al., 2011; Campbell, 2012; Gilbert & Yerrick, 2001; Riegle-Crumb & Humphries, 2012). The effects and consequences of biases are also associated with teachers' self-efficacy. Studies have found that teachers reported lower self-efficacy when working specifically with diverse and struggling students (Pang & Sablan, 1998; Ross, 2014; Soodak & Podell, 1994).

As I briefly outlined above, content knowledge, self-efficacy, and biases each play important roles in determining teachers' practices in the classroom. Figure 2 presents a causal diagram illustrating the interactions of these factors, and how they are theorized to influence classroom practice.

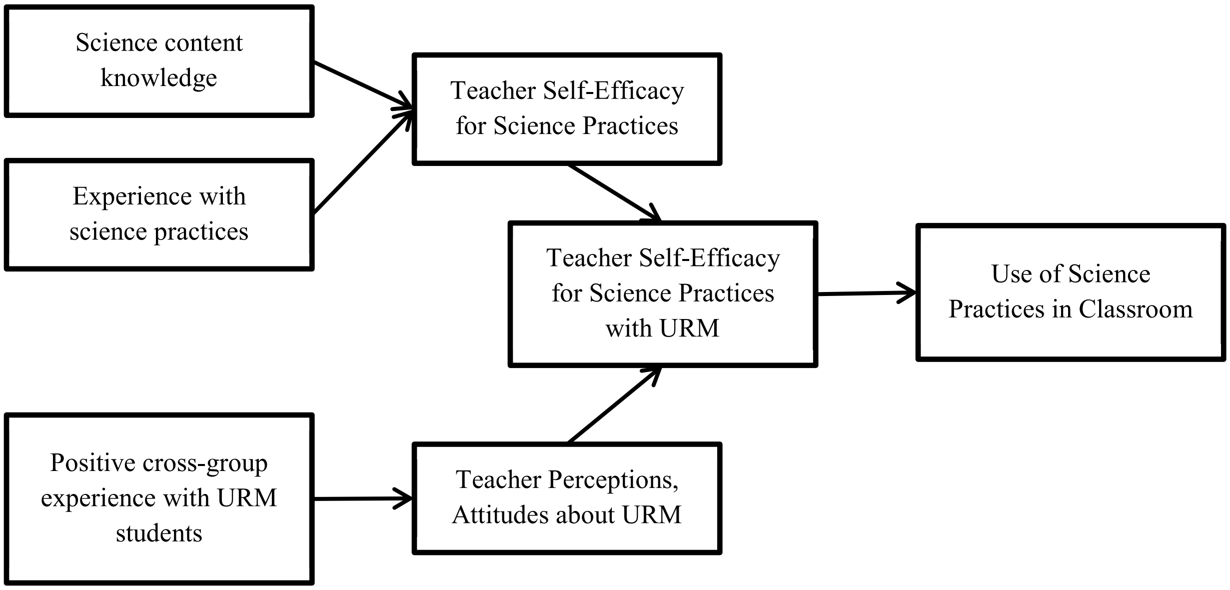

Figure 2. A causal diagram illustrating the theory of treatment supporting the intervention.

This study centered on an intervention utilizing professional development to realize two teacher outcomes:

1. Increase content knowledge and self-efficacy for using science practices.
2. Improve teachers' biases and increase self-efficacy concerning the use of science practices with underrepresented minorities.

It is suggested that these teacher outcomes will lead to the longer-term goal of improving academic outcomes for underrepresented minorities.

This literature review will first draw on social cognitive theory in order to guide efforts to improve teachers' self-efficacy. The review will then transition to a discussion of professional development and the attributes of effective programs known to improve content knowledge and teacher practice. Finally, contact theory will be utilized to reframe the conversation on science professional development to bring it into focus on the context of diverse classrooms. Empirical studies will be utilized throughout in order to substantiate the use of professional development incorporating virtual cross-group contact.

Theoretical Framework

Cognitive theory is focused on understanding the active manner in which individuals process and mediate stimuli from the environment (Bruning, Schraw, & Norby, 2011). Learning is understood to occur when information from the environment is perceived, processed, organized in relation to existing frameworks, and encoded within memory (Etmer & Newby, 1993; Schunk, 2008). This understanding of learning has important implications for the design of learning experiences for students and teachers. Active learning environments allow individuals to interact with phenomena in important and relevant contexts, allowing learners to activate prior knowledge and construct knew understandings (Bransford, Brown, & Cocking, 1999; Bruning, Schraw, & Norby, 2011; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003).

Bandura's (1986) social cognitive theory explains the differential interactions that occur between behavior, the environment, and personal cognition and factors. Central to Bandura's work is the construct of self-efficacy, which is an individual's judgment of their ability to accomplish a given task situated in a future context. The generalized results of behaviors over time form beliefs within individuals about the causal relationship of action and outcome (Bandura, 1986). Bandura theorizes that these beliefs mediate future actions, where the outcome then either positively or negatively reinforces the accuracy of the perceived capability. These mutual interactions between behavior, cognition, and environment result in a self-reinforcing process, resulting in the large influence self-efficacy has over behavior, goals, effort, and perseverance (Bandura, 2006; Schunk, 2008).

The sociocultural perspective views learning as an inextricably social process (Cobb & Bowers, 1999). Thinking and action are situated, mediated by the material aspects (tools, objects, people) of the environment, and informed by social and cultural constructs of the individuals involved (Brown et al., 1989; Cobb & Bowers, 1999; Gee, 2008). Learning within science is understood as a result of value-laden experiences within a greater science community (Brown et al., 1989; Cobb & Powers, 1999; Gee, 2008). The mind processes all aspects of events and experiences, including cultural norms and language to yield context specific models that inform future actions (Brown et al., 1989; Gee, 2008). Learning therefore reflects not only cognitive processes, but also importantly an evolution of the ways in which teachers interact socially (Cobb & Bowers, 1999; Gee, 2008).

Finally, intergroup contact theory seeks to reduce prejudice in individuals. Research into biases and prejudice has indicated that stereotypes are automatically and subconsciously activated when in the presence of an individual from a specific group, and that these notions may result in anxiety or prejudiced behavior (Allport, 1954; Devine, 1989; Glock & Krolak-Schwerdt, 2014). Fortunately, while stereotypes are automatic and often go unnoticed, they are malleable and can be influenced through conscious mental effort (Blair, 2002; Glock & Krolak-Schwerdt, 2014; Lai et al., 2014). Allport's (1954) theory stems from the essential notion that: "if we wish to reduce prejudice in our society attacks on segregation … are scientifically sound and of high priority" (p. 480). Through positive intergroup contact between individuals of different races, prejudice can be improved within in-group individuals (Allport, 1954; Pettigrew, Tropp, Wagner, & Christ, 2011).

Literature Review

Teacher Self-Efficacy

Teacher self-efficacy is a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran & Hoy, 2001, p. 783). Self-efficacy is known to affect teachers' expectations, effort, and instructional behaviors within the classroom (Gibson & Dembo, 1984; Tschannen-Moran & Hoy, 2001). Because of the measured impact of TSE on teacher behavior, this area has received a great deal of attention. A myriad of studies have investigated different conceptualizations of teacher efficacy, the instrumentation of TSE, the effects of teacher efficacy on student achievement and teacher behaviors, and the factors and sources influencing self-efficacy in teachers at all levels and within various subjects (Bandura, 2006; Caprara et al., 2006; Ross, 2014; Tschannen-Moran et al., 1998; Tschannen-Moran & Johnson, 2011). The factor most important to this review is the effect self-efficacy has on teachers' ability to change their practice and implement new strategies within the classroom.

Previous work in this area has found self-efficacy to be an important factor influencing teachers' receptiveness to instructional change (Tschannen-Moran & McMaster, 2009). Moreover, teacher self-efficacy has also been an important variable shown to fluctuate as teachers progress through professional development designed to bring about change (McKinney, Sexton, & Meyerson, 1999). McKinney et al. (1999) utilized the Efficacy-Based Change Model to elucidate the internal changes taking place as teachers engaged in coursework on whole language theory and practice.

McKinney et al.'s (1999) data showed a strong link existed between self-efficacy and teachers' progression through the stages of change related to instructional implementation. This result has important consequences here as instructional change is the ultimate goal. The researchers found that teachers with low TSE exhibited the self-centered concerns characteristic of individuals at an early stage of change. Conversely, teachers at latter stages of change reported high self-efficacy. The researchers found that this efficacious group were outwardly focused, concerned with how whole language instruction would influence their students, and how best to utilize the innovation in the classroom. Interestingly, McKinney et al. (1999) found that participants' self-efficacy was the *only* construct of those measured that was significantly predictive for teachers with the highest level of implementation.

The work by McKinney et al. (1999) established self-efficacy as an important internal construct related to pedagogical change. The results they obtained are further mirrored in the beliefs of teachers in an urban school district following a three-year long professional development program (Fisler & Firestone, 2006). Fisler and Firestone (2009) found that a change in TSE realized from completing the program matched the change evident in teachers' classroom practice. Moreover, the data showed that those teachers with low self-efficacy did not change, and that they shared limited beliefs in the ability of instructional approaches to influence their students' learning. Conversely, teachers that experienced an increase in TSE shared positive beliefs in the ability of instruction to influence students.

The association between teacher self-efficacy, beliefs in innovation, and the implementation of educational change illustrates the importance of increasing teachers' self-efficacy. Interventions hoping to do this have confirmed that professional development as a general construct can positively impact teachers (Cakiroglu et al., 2012; Lakshmanan, Heath, Perlmutter, & Elder, 2011; Lee et al., 2013; Powell-Moman & Brown-Schild, 2011; Ross, 2014; Tschannen-Moran & McMaster, 2009). Before specifically addressing professional development in science and the wide variety of factors exhibited in the literature, a short discussion on the sources of information directly influencing self-efficacy is warranted.

Efficacy sources. Bandura (1977) held that individuals gained information that formed their sense of efficacy through four sources: mastery experiences, verbal persuasion, vicarious experiences, and emotional arousal. Mastery experiences are situations in which an individual is successful at completing a desired task. Verbal persuasion comes in the form of information and suggestions from others about a task's nature and ease of success. Vicarious experiences occur when individuals are able to observe credible models completing tasks. Finally, emotional arousal refers to the various positive and negative emotions elicited during a task that provide the actor information on the possibility of success. Bandura explains that the various sources of efficacy information have differing strengths and subsequent impacts on the individual's self-efficacy. Empirical work comparing the four indicates that mastery experiences are the most powerful (Bandura, 1977). That said, understanding the strengths of each source within the context of educational interventions has important consequences for professional development.

Tschannen-Moran and McMaster (2009) worked with 93 primary teachers to measure the effects of various professional development formats on teacher self-efficacy. Four trials were constructed, each developed to provide content knowledge for literacy instruction through one of the four sources of self-efficacy. The simplest format was a traditional workshop on literacy instruction depending solely on verbal persuasion. On the opposite end, the most complex format provided the same workshop along with modeling (vicarious experience), practice in the classroom (mastery experience), and instructional coaching (verbal persuasion). Consistent with the findings of Bandura (1977), the data indicated that mastery experiences in the classroom alongside mentor teachers resulted in significantly greater increases in TSE. Although to a lesser degree, the results from Tschannen-Moran and McMaster (2009) and others also indicate that workshops relying primarily on verbal persuasion were also effective at improving self-efficacy (Fisler & Firestone, 2006; Lakshmanan et al., 2011).

On top of the four sources discussed thus far, Bandura (1977) also holds that self-efficacy is a context-specific judgment. This means that details of the situation or aspects of the environment also influence self-efficacy. Within the research this aspect was illustrated in work developing a subject/context-specific self-efficacy instrument for English teachers (Tschannen-Moran & Johnson, 2011). Tschannen-Moran and Johnson (2011) showed that measures of personal teaching self-efficacy were significantly different from a specialized instrument for literacy instruction. This indicates that the ecology of science education (e.g., the lab, science classroom) is also an important factor if teachers are expected to receive any source of information meant to buoy their sense of self-efficacy to specifically teach science practices. The practice of science is dependent upon the development of knowledge through shared language, behaviors, and tools. Sociocultural theory importantly shifts this discussion of efficacy work with science teachers, to ensure that an intervention engages participants in efficacy-building experiences while in an environment that enculturates teachers to science (Gee, 2008).

Thus far the literature has supported the focus on teacher self-efficacy as an important factor influencing pedagogical change. As a source of efficacy-building information, professional development offers teachers an effective and context-specific environment. The next section will transition specifically to science professional development. Utilizing a framework for effective professional development in science, we'll further elucidate the specific factors necessary to both improve teachers' content knowledge and self-efficacy to teach using science practices.

Professional Development

Reform efforts in science education are largely dependent upon teacher professional development designed to improve teachers' knowledge and skills (Loucks-Horsley et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2015). A great deal of empirical and theoretical work has been devoted to characterizing the key aspects of effective PD known to improve both student and teacher outcomes (Akerson & Hanuscin, 2007; Desimone, 2009; Garet et al., 2001; National Academies of Sciences, Engineering, and Medicine, 2015). Yet in spite of these efforts, teachers continue to experience professional learning bearing little resemblance to the effective PD illustrated in the literature (Borko, 2004; Loucks-Horsley et al., 2003).

One factor complicating efforts is the multitude of considerations and options facing leaders hoping to implement effective PD. As Loucks-Horsley et al. (2003) bluntly note, “there is no prescription for which designs are right for which situations – no “paint by numbers kit” for professional development” (p. 7). As a result, while teachers may encounter a wide variety of learning experiences throughout the school year (e.g., workshop, lecture, professional learning community, lesson studies), the simple context or structure of learning experiences do not necessarily ensure high-quality learning (Desimone, 2009). To ameliorate this situation, Loucks-Horsley et al. (2003) developed the widely referenced Professional Development Design Framework to help guide PD development for science and mathematics teachers. The authors elucidate the critical decisions and constructs that must be considered, including the development of learning experiences that match the evolving research base of cognitive science. While the framework raises important questions and offers sound guidance, it ultimately falls to educators to answer these questions for their professional context. Where Loucks-Horsley et al. (2003) remind us that change takes time (p. 48), the exact dosage of an effective PD remains unknown.

Quantifying critical features that result in documented improvements for teachers and students has been taken up in large, national studies of PD for mathematics and science teachers. Garet et al. (2001) utilized a nationally representative sample of 1,027 mathematics and science teachers to evaluate the effectiveness of various high-quality PD components as a part of the Eisenhower Professional Development Program. Three structural features of the learning experience and three aspects of the PD activities were analyzed. Although teacher self-reports were the only data utilized, the authors concluded that increases in teacher knowledge and improvements in practice were attainable when specific components were present, irrespective of the type of learning experience (i.e., traditional v. reform). Garet et al. concluded that effective PD must include: (a) extended time and duration for learning to take place over many hours and days; (b) a focus on content knowledge and pedagogical content knowledge; (c) active learning related to the work of teaching; (d) the collective participation of teachers in teams; and (e) coherence with teachers' PD experiences, and aligned to standards.

The work of Garet et al. (2001) advanced the literature on effective PD by utilizing a large data set to confirm attributes long proffered by other researchers (Loucks-Horsley et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2015). Drawing on this work and various others, Desimone (2009) developed a representative framework that identifies the various features essential to any reform-oriented PD developed for science teachers, including: (a) content focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation (Desimone, 2009). This framework was recently adopted by the National Academies of Sciences, Engineering, and Medicine (2015) for their report *Science Teachers' Learning*, and is reflected in recent reviews of science professional development (Capps, Crawford, & Constas, 2012; van Driel, Meirink, Van Veen, & Zwart, 2012). Consequently, this framework is also adopted here to provide direction to the construction of a PD intervention that will address the outcomes detailed earlier. The next sections will expound on these five features, drawing on empirical results with teachers and students, in order to clarify the picture of a PD that can realize change in teacher self-efficacy and pedagogy.

Content focus. Effective PD for science teachers focuses on increasing teachers' knowledge and skills related to the implementation of science practices (Garet et al., 2001; Jeanpierre, Oberhauser, & Freeman, 2005; Penuel et al., 2007; Supovitz & Turner, 2000). Included in this overarching goal is the development of various forms of knowledge, including:

- specific science content knowledge,
- pedagogical content knowledge,
- knowledge of how students learn science content (e.g., misconceptions),
- procedural knowledge and skills associated with carrying out science investigations, and
- knowledge related to the implementation of new curricula (Borko, 2004; Garet et al., 2001).

The importance of increasing teachers' knowledge is foundational - teachers are unable to lead students through learning that they have never experienced. Utilizing a nationally representative sample of elementary science teachers, Supovitz and Turner (2000) determined that irrespective of PD attributes, teachers' feeling of content preparation was the most significant individual factor influencing their development of a culture and practice of inquiry following professional development.

Numerous studies on PD in science have focused on the various forms of content knowledge and their effects on teachers and students (Capps et al., 2012; van Driel et al., 2012). In their early study of the Eisenhower program, Garet et al. (2001) determined a significant and positive relationship between a focus on content and teachers' subsequent knowledge and skills, and their reported change in practice. The data also indicated a negative impact on teacher change when content led to no increase in teachers' knowledge or skills. While these data again support the importance of a content focus as I suggest, the generalized results lack the specificity for PD designed to target science practices. An international PD experience called the GLOBE Project provides some further detail.

The GLOBE Project is focused on utilizing science practices to teach students the topic of earth science. Penuel et al. (2007) surveyed a representative sample of 454 participants to identify the various factors that influenced teachers' use of program materials. To support implementation of the program, the PD focused both on teachers' content knowledge in earth-science, and strategies and activities to support student inquiry. The team gathered a mix of data that included teacher surveys and data submissions, providing the researchers a more accurate picture of implementation by teachers. Results from hierarchical linear modeling showed a clear connection between content focus and implementation. An increase in time on content during PD was significantly correlated with an increase in teacher preparedness for student inquiry, while an increase in emphases on student inquiry practices led to increased reporting of data by teachers. These results both emphasize the need to increase teachers' subject-specific CK, and their knowledge related to student practice.

The results presented here on content focus clearly identify the importance of various forms of knowledge to science teacher practice, and that improving teachers' knowledge results in documented changes in teacher practice and student work. These studies draw out the need to construct PD that has a strong content focus; the manner or strategies utilized to realize these significant changes is the second component of effective PD.

Active learning. Creating a learner-centered environment is as important for teachers as it is for students (Bransford et al., 1999). Carefully crafted professional learning experiences allow teachers the space to engage in both the practice of science, and the teaching of science (Loucks-Horsley et al., 2003). Irrespective of the practices highlighted below, these contexts allow teachers to chance to reflect, refine, and construct the vital knowledge described above (Borko, 2004; Loucks-Horsley et al., 2003).

Active learning is considered to occur when teachers participate in "meaningful discussion, planning, and practice" (Garet et al., 2001, p. 925). Loucks-Horsley et al. (2003, p. 113) referred to three clusters of strategies that situated PD activities within teachers' professional context: aligning and implementing curriculum, examining teaching and learning, and practicing teaching. Results from the GLOBE project showed significant increases in teacher participation and feelings of preparedness as a result of active learning. The PD providers allocated time within the training to localize GLOBE activities to teachers' curriculum and classroom (Penuel et al., 2007).

Others have extended this construct of active learning to include authentic science experiences in which teachers carry out scientific investigations (Capps et al., 2012; Loucks-Horsley et al., 2003). One participant of such a PD for science teachers shared: "Instead of being told how to use inquiry learning, we were taught by inquiry learning" (Jeanpierre et al., 2005, p. 683). A mixed-methods approach utilized by Jeanpierre et al. (2005) identified the power of authentic field experiences to effect change in twenty teachers. Observations, surveys, and assessments of knowledge revealed both a significant increase in CK, and most importantly an increase in teachers' utilization of inquiry in the classroom.

Until this point in this review reported data has centered on changes in teacher practice without evidence of student change. In a departure from this trend, another PD experience that focused on immersing elementary teachers in authentic inquiry reported results for both teachers and students (Akerson & Hanuscin, 2007). Situated within monthly half-day workshops, Akerson and Hanuscin (2007) immersed six teachers in investigations that utilized the science practices they would then lead with students. Reflective group discussions on the nature of science followed investigations. Data including questionnaires, observations, and lesson plans identified a marked change in teacher views of science practice. Most importantly, student responses about the nature of science also showed an improvement in understanding at all grades.

Duration. The third attribute common to effective professional development is an extended time devoted to teacher learning. Duration identifies both the hours scheduled at one session, and a sustained focus stretched out over several sessions within the school year (Desimone, 2009; Garet et al., 2001). The latter is particularly emphasized in the literature; Loucks-Horsley et al. (2003) stress that PD in science must be sustained in order to allow teachers the time needed to change their practice. Data support this as an increase in content knowledge was only determined to be significant once teachers attended additional sessions following an initial PD for the GLOBE project (Penuel et al., 2007). Similarly, Akerson and Hanuscin (2007) noted the importance of monthly workshops sustained throughout three years to the development of teachers' practice of inquiry. Sustained PD stands in stark contrast to the short, fragmented workshops that remain a consistent feature of professional learning (Borko, 2004).

While duration is a factor reported in every study here, and those reviewed by Capps et al. (2012) and van Driel et al. (2012), the exact dosage required to effect teacher change is not agreed upon in the literature (National Academies of Sciences, Engineering, and Medicine, 2015). A wide range of contact times have been suggested by several researchers, from a minimum requirement of 20 hour of contact time by Desimone (2009), to 80 hours by Supovitz and Turner (2006). Still yet, Johnson (2006) reported an absence of change in teachers following over 140 hours of professional development.

Although duration remains an inexact construct, time appears to be an important factor in so far as it allows for teachers to engage in active learning that promotes change (Garet et al., 2001; Loucks-Horsley et al., 2003). Akerson and Hanuscin (2007) allude to this notion as they reflect on the importance of their sustained monthly workshops: “This program allowed teachers to develop ideas over time, and then change their practice over time” (p. 674).

Collective participation. The fourth attribute of highly effective PD is the ability for teachers to grow together as teams. Whether teams span grade levels, subjects, or across a building, participating in professional learning communities supports teachers’ change in practice (Borko, 2004). Once again looking to the GLOBE project, teachers who experienced collective participation in their PD reported greater changes versus those without (Penuel et al., 2007).

In the same manner that time provides teachers the ability to engage with reform practices over time, collective participation allows for the discourse and collective problem solving that are highlights of an “intellectual community” (Bransford et al., 1999, p. 25). Teachers are able to raise pressing issues and questions from the classroom and receive immediate feedback from colleagues that are engaged in the same learning (Akerson & Hanuscin, 2007). Consequently, the inability to collaborate with ones peers has been shown to have a negative impact on the effectiveness of science PD. A lack of scheduled time for team collaboration was reported by teachers to be a significant political barrier impeding their incorporation of inquiry (Johnson, 2006).

Coherence. The final attribute of a PD session that influences its effectiveness is the degree to which the learning aligns with a teachers’ context. This is an inclusive idea that spans a teacher’s personal professional learning goals, their district’s activities and target goals, and the educational standards of the area (Capps et al., 2012; Garet et al., 2001; Loucks-Horsley et al., 2003; van Driel et al., 2012). A common example of coherence is time devoted within PD sessions aligning content to science standards (Capps et al., 2012). A more instructive example of coherence was evident in Penuel et al.'s (2007) work with the GLOBE project. Teachers specifically worked to integrate program materials and lessons into their local curriculum. Discussions of alignment between those materials and state standards provided participants a chance to bring coherence to their work.

Coherence has also been expanded to also include alignment between the focus of learning within a PD, and a teacher's goals and beliefs about their practice(Desimone, 2009). Beliefs are an important construct within this investigation - they are powerful mediators of teacher learning and behavior (Gibson & Dembo, 1984; Lotter et al., 2013; Pajares, 1992; Tschannen-Moran et al., 1998; Yerrick, Parke, & Nugent, 1997). A 2013 study with 36 high school science teachers sought to determine just how much teachers' beliefs about inquiry influenced their practice following PD (Lotter et al., 2013). Participants received many of the attributes discussed thus far, and the added opportunity to practice inquiry lessons with students in a summer program. Three interviews throughout the program were combined with observations of lesson implementation to determine participants' cultural and pedagogical beliefs regarding inquiry. The authors found that participants' belief in the ability of inquiry to result in student learning was an important attribute influencing enactment. This finding is mirrored in the results of a case study with junior high teachers (Johnson, 2006). Teachers held a shared belief that there was an inherent conflict between inquiry and state testing that limited use.

The results concerning teacher beliefs following science professional development are mixed and not widely assessed by researchers (Capps et al., 2012). Yerrick et al. (1997)

ultimately concluded that teachers' initial beliefs regarding the merit of inquiry in the science classroom remained unchanged, in spite of a two-week summer institute. Results were decidedly more mixed following another study employing a summer institute (Luft, 2001). Veteran teachers exhibited changes in their practice without changes in their beliefs, while novice teachers showed no change in practice and a decrease in their beliefs regarding inquiry.

These findings reviewed here shouldn't suggest that change in teacher beliefs cannot occur. Rather, they serve to highlight that checklist attributes are not solely predictive of the effectiveness of professional development. As Lotter et al. (2013) conclude, in order to best consider teachers' beliefs and prompt change, effective PD should align with teacher goals and expectations, and provide differentiated material supports (Lotter et al., 2013).

Returning to the intent of this literature review, the primary outcome listed for this intervention is to increase the content knowledge and self-efficacy of junior high teachers. The five attributes discussed thus far provide an essential framework necessary to develop an effective intervention. The various studies presented above illustrate that well-crafted learning experiences employing the factors above can affect significant change in teacher beliefs, knowledge, and practices.

As a final note, interviews with teachers have identified the presence of contextual barriers (e.g., time for collaboration) that pose significant impediments to change in spite of well-designed professional learning (Johnson, 2006). Supovitz and Turner (2000) identified three variables through hierarchical linear modeling that accounted for teacher practice and classroom culture following PD. While two have been discussed thus far in detail (duration, content knowledge), the local school context as measured by school socioeconomic status was a significant factor outside the design of the PD. Schools with high numbers of low-SES students seemed to utilize reform-oriented practices less than schools with a high-SES population (Supovitz & Turner, 2000).

The impact of contextual barriers affirms the importance of the local environment when designing effective PD, and also returns us to the larger goal of this study (Borko, 2004; Loucks-Horsley et al., 2003) If outcomes for URM students are to change, PD for science will need to address the contextual realities of education in diverse, low-SES schools. The last section of this literature review leaves traditional teacher professional development, and takes up a discussion of intergroup contact. Contact theory may provide the means necessary to respond to the hurdles of high student diversity.

Intergroup Contact

Thus far this review has focused on improving teachers' sense of self-efficacy through professional development, and the requisite attributes of effective PD design. The diverse student body that forms an important sociocultural aspect of the classroom context however has been neglected until this point.

Researchers working with STEM education have documented the existence and deleterious effects of teachers' biases towards various groups of students (Bolshakova et al., 2011; Campbell, 2012; Riegle-Crumb & Humphries, 2012). Gilbert and Yerrick (2001) uncovered teacher biases and diminished expectations within a tracked high school science classroom, and illustrated how this resulted in disempowering sociocultural boundaries for minority students. The results of tracking in schools leads to the dearth of URM students that complete the academically rigorous coursework requisite for success in university science courses (Ackerman et al., 2013). Given the segregated nature of advanced science classrooms versus on-level classrooms, addressing science teacher self-efficacy through professional development requires an understanding of the markedly different context this creates for teachers.

Diversity and teacher self-efficacy. Diverse student populations have been shown to have significant effects on teachers' self-efficacy and behaviors. Pang and Sablan (1998) determined that preservice and in-service teachers alike held a lower perceived ability to educate African American students. This decrease in self-efficacy was similarly illustrated in a study with preservice teachers and special education students (Crowson & Brandes, 2014), and secondary mathematics teachers and English Language Learners (Ross, 2014). Importantly for this study, Crowson & Brandes (2014) were further able to determine a link between this reported decrease in TSE and the presence of anxiety and the use of stereotypes by teachers.

A teacher's diminished sense of their ability to teach results in different, and often more teacher-centered, didactic pedagogical choices (Tschannen-Moran et al., 1998). This observed interaction is of critical importance if teachers' efficacy is diminished with particular groups of students. In two separate investigations looking at this link, case studies showed that teachers with lower self-efficacy exhibited differential responses when considering scenarios with difficult-to-teach students. A negative bias towards low-SES students was evident in special education referral suggestions by low-efficacy teachers, while SES was not a significant factor for effective teachers (Podell & Soodak, 1993). In the second study, low-efficacy teachers showed a greater reliance on support systems outside the classroom to assist with a struggling third grade student, as compared to high-efficacy teachers that made more teacher-based recommendations (Soodak & Podell, 1994).

The studies included here clearly implicate student diversity as a factor that negatively influences teacher practice, and furthermore that this link may be explained by teachers' prejudices and consequently their self-efficacy. Before turning to contact theory to construct a possible pathway to remedy teachers' prejudices and self-efficacy, this review turns to a short discussion on multicultural education in order to situate this intervention within the larger body of scholarship on diversity and education.

Multicultural education. Improving educators' ability to work with students of diverse backgrounds has been the focus of a great deal of study in the area of multicultural education (Banks, 2016). The express goal of multicultural education, as it is here, is to reform institutions so that diverse students can be successful (Banks, 2016). In order for schools to realize this goal, Banks (2016) identifies five dimensions that must be addressed: (a) content integration, (b) the knowledge construction process, (c) prejudice reduction in students, (d) an equity pedagogy, and (e) an empowering school culture and social structure. The fourth dimension, equity pedagogy is directly relevant to this study – "an equity pedagogy exists when teachers modify their teaching in ways that will facilitate the academic achievement of students from diverse racial, cultural, and social-class groups" (Banks, 2016, p. 5). For this, teachers must develop the knowledge, beliefs/attitudes, and skills (referred to cross-cultural competencies) necessary to interact successfully with students from diverse groups (Banks, 2016; Sue et al., 1982).

Cross-cultural competency has been studied extensively within the field of counseling as the profession adapted to better serve its diverse patients (Sue et al., 1982; Sue, 2001). An individual's growth towards increased competency requires an increase in their knowledge and skills in dealing with a wide variety of cultures and peoples, and most importantly an evolution in their personal and most likely unrealized biases and prejudice towards out-groups (Sue, 2001). The difficulty in accomplishing this task is compounded by the unrealized ethnocentric view permeating Western culture wherein the egalitarian expectation is one of color-blindness and an aversion to racism (Pearson, Dovidio, & Gaertner, 2009; Sue, 2001; Sue, 2004). Growing in one's cultural competency then begins with the requirement that the individual willingly confront and accept their own prejudice; a task that Sue (2004) admits is difficult for many.

Banks (2016) references the difficulty in changing teachers' attitudes and cites the paucity of work identifying effective interventions to improve the situation. On the short list of suggestions however, is the use of "cross-cultural interactions" (Banks, 2016, p. 289), or cross-group contact. Rodenborg and Boisen (2013) cite the ability of cross-group contact to reduce prejudice, and thus conclude that it provides a theoretical pathway to begin individuals' growth towards improved cultural competency. It is with the understanding addressed thus far regarding the difficulties of improving cultural competencies, and also the organizational need to explore an intervention that is feasible with a majority of teachers that this study focuses on the use of cross-group contact.

Contact theory and self-efficacy. The combination of social cognitive theory and intergroup contact theory to explicate and improve behavior has recently been explored in the literature. Plant and Butz (2006) identified an important link between self-efficacy and intergroup contact through two studies. The authors showed that a diminished self-efficacy for interacting socially with Black people resulted in anxiety and avoidance behaviors in non-Black study participants (Plant & Butz, 2006). This link is further explicated in a study with 229 preservice teachers. Crowson and Brandes (2014) developed a model indicating that increased stereotype use and intergroup anxiety towards students with disabilities significantly predicted decreased self-efficacy in preservice teachers. These results suggest that in order for teachers' self-efficacy in a diverse classroom with URM to improve, teachers' prejudices and anxiety towards diverse student groups must be ameliorated.

Studies on reducing prejudice have identified various successful intervention strategies built around various theories (Devine et al., 2012; Lai et al., 2014). Direct, cross-group interaction is one that has been studied extensively and is shown consistently to reduce stereotypical beliefs and improve affective aspects of prejudice such as anxiety (Pettigrew & Tropp, 2011). This theory holds promise for education due in large part to the social and institutional segregation evident in the United States (Allport, 1954; Coleman et al., 1966; Smith, McPherson, & Smith-Lovin, 2014). In one example of the effects of this segregation, a survey of preservice teachers revealed that 70% had not attended a school with African American students, and only 47% expressed that they has a strong understanding of African American culture (Pang & Sablan, 1998). When teachers, however, have had prior cross-group contact through previous experiences or travel abroad, their attitudes are more positive towards out-group students such as English Language Learners (Youngs & Youngs, 2001).

More recently researchers have extended contact theory to include examples of indirect contact. While Allport's (1954) work began with direct physical contact between individuals of varying groups, recent research in the field has extended contact theory to included indirect forms of contact that don't involve physical interactions (Mazziotta et al., 2011). This push towards indirect contact began with the extended contact hypothesis, wherein knowledge that an in-group member has a close relationship with an out-group member leads to more positive attitudes (Wright, Aron, McLaughlin-Volpe, & Ropp, 1997). Since that hypothesis the literature on contact theory has expanded with empirical work illustrating the positive effects of extended cross-group contact and vicarious intergroup contact (Joyce & Harwood, 2014; Mazziotta et al., 2011; Mazziotta, Rohmann, Wright, De Tezanos-Pinto, & Lutterbach, 2015; Pettigrew et al., 2011). It’s with the latter that an application towards professional development with science teachers holds promise to improve teachers’ beliefs.

Vicarious contact. Mazziotta et al. (2011) applied social cognitive theory to contact theory in order to conceptualize vicarious intergroup contact as an example of vicarious learning. Their proposal holds that the observation of an in-group member successfully engaged with an out-group member provides positive vicarious learning information. This method of contact offers the observer behavioral knowledge that could provide them the ability to build more positive interpersonal relationships. This methodology also allows researchers the ability through videos to ensure the observation of a positive interaction, whereas direct contact always has the ability to provide negative information and reinforce prejudice (Mazziotta et al., 2015).

In two separate studies verifying the potential of vicarious intergroup contact, German university students and German visitors respectively watched videos depicting positive German-Chinese interactions (Mazziotta et al., 2011). The data indicated significantly more positive feelings towards the out-group and more willingness to have contact as a result of the contact. This same result was confirmed in work with university students in Arizona, where a 10-minute video resulted in significantly improved attitudes towards illegal immigrants (Joyce & Harwood, 2014).

Most important to this review, Mazziotta et al. (2011) determined that self-efficacy mediated the results of intergroup contact. Vicarious contact increased participants’ self-efficacy, resulting in reduced anxiety and uncertainty in the participants. This pathway provides a viable methodology wherein as a part of the professional development intervention proposed here, teachers watch videos depicting a science teacher successfully interacting with underrepresented minority students. These videos could serve as an important source of vicarious self-efficacy information for both implementing scientific practices, and for positive interactions with URM students.

Important considerations for the development of any video depicting vicarious intergroup contact exist. First, vicarious learning is most successful when the model reflects similar characteristics as the observer, including age, expertise, or gender (Bandura, 1977). Secondly, contact must occur between the model and out-group member; Mazziotta et al. (2011) verified that a control condition in which an out-group member participated solely without interacting had no effect on in-group observers' attitudes. Lastly, a successful event must occur within the video if behavioral knowledge is to be developed. In total, these three considerations indicate that a video utilized within science PD must utilize a credible, in-group peer engaged with URM students, illustrating successful interactions between teacher and student, and successful use of science practices in the classroom.

Conclusion

This review has drawn upon a varied body of work to develop a theoretical framework that supports the development of science teachers' self-efficacy for both innovative instruction, and for the diverse students they find in their classrooms. If education systems are to respond effectively to the growing diversity evident nationally and locally within the District, professional development must be constructed thoughtfully to target both teachers' knowledge of science and their biases. I proposed a five-day professional development in the summer wherein grades 6-8 science teachers would engage in active and collaborative learning that employed virtual intergroup contact through short videos depicting URM students positively engaged in the same conceptual material. Further professional development in the fall would supplement the summer and support teacher teams as they prepare to enact curricula designed for this intervention.

This review holds out the notion that the novel framework presented above would lead to an effective intervention that equips and emboldens District teachers to engage their African American, Hispanic, and low-SES students in reform-oriented science practices. This would hopefully lead in-turn to markedly improved academic outcomes, and wider career aspirations than currently exist for these students. The next section further elucidates the intervention procedures and the program evaluation plan designed to measure its impact.

Chapter 4

Intervention and Program Evaluation

This chapter details the structure of my intervention designed to address the overarching question: How can professional development be utilized with science teachers to increase their use of science practices with underrepresented minority students?

I drew upon the best practices of science professional development and cross-group contact described in the previous section to construct an intervention situated within the context of summer and fall professional development (Desimone, 2009; Loucks-Horsley et al., 2003; Mazziotta et al., 2011; Wright et al., 1997). The purpose of this study was to explore the viability of virtual cross-group contact as a possible means to improve general science professional development, and therein specifically target limiting factors influencing teachers' practice within a diverse science classroom. The ability of a teacher to change their practice is operationalized through a participant's sense of teaching efficacy, a construct well established in the literature (Gibson & Dembo, 1984; Tschannen-Moran et al., 1998).

The methodology and outcome evaluation plan that will be described below serve to address two evaluation questions:

1. Did virtual cross-group contact increase subjects' science teaching efficacy with underrepresented minority students?
2. Did teachers' affect and beliefs of URM mediate participants' science teaching efficacy with underrepresented minority students?

In the sections that follow the research design will be detailed, study participants will be identified, and variables and instruments are described. Finally, a thorough discussion of the study procedure is presented that includes intervention details and proposed statistical analysis techniques.

This research was conducted in partnership with the District and its Department of Accountability as set out in their agreement for research included in Appendix G. Data collected from teachers is done under the approval of the Johns Hopkins University Institutional Review Board (Appendix H).

Research Design

This intervention utilized a five-day professional development in which participants engaged in physics-based scientific investigations, teaching case studies, and collaborative work on integrating student lesson materials into their curriculum. Short videos depicting URM students positively engaged in the same conceptual material complemented the investigations. These experiences were hypothesized to result in four short-term outcomes: (a) increased teacher content knowledge in Physics, (b) increased teacher self-efficacy, (c) improved attitudes of URM, and (d) increased teacher self-efficacy for teaching URM. Over the medium-term, these outcomes are projected to increase the use of science practices with URM students, resulting in increased student self-efficacy and engagement. Improved instruction by teachers would ultimately result in the desired long-term goal - an increased number of URM students choosing STEM as a post-secondary pursuit. Figure 1 illustrates the logic model for this intervention.

Inputs	Outputs		Outcomes – Impact		
	Activities	*Participation*	*Short*	*Medium*	*Long*
Support from District leadership and Junior High principals Funding Personnel Trainers Writers Workshop venue space Time Professional development calendar Develop training and materials	Develop PD materials and resources on the practices of scientists and engineers that incorporate cross-group contact Develop lessons resources and materials Conduct professional development workshops	Junior High science teachers	Increased knowledge: Physics CK Increased teacher self-efficacy for science instruction Increased teacher self-efficacy for teaching URM Decreased biases and anxiety towards underrepresented students	Increased use of science practices with underrepresented students Increased support of underrepresented students Increased student self-efficacy and engagement	Increased number of underrepresented students entering college or university to pursue science

Assumptions	External Factors
Teacher self-efficacy and biases are primary factors influencing teachers' actions in the classroom with underrepresented students. Novice JH teachers will benefit the most from this intervention. Desired participants are willing to devote a week during their summer.	Funding, facilities, personnel, venue, and partnership are established and available resources. Negative teacher morale and high anxiety regarding state assessments, and low principal knowledge are potential risk factors. Recent change in district leadership, and a subsequent uncertainty regarding curriculum is another risk factor.

Figure 1. Logic model for an intervention to improve outcomes for underrepresented students.

Process Evaluation

O'Donnell (2008) contrasts two conceptualizations of fidelity of implementation (FOI) in the literature that depend on the stage of development for an intervention program. As this study primarily constituted a new and untested approach, fidelity of implementation is conceptualized as an efficacy study (O'Donnell, 2008). Fidelity measures ensure that the professional development is constructed, delivered, and received by participants at an acceptable level in alignment with the logic model and theory of change (Saunders, Evans, & Joshi, 2005). Results from FOI evaluation efforts are utilized to ensure that measured effects on teachers' self-efficacy and attitudes can be attributed to participation in the intervention (O'Donnell, 2008). Consistent with this conceptualization of FOI, three areas are evaluated: materials, implementation, and receipt by participants.

The first area of evaluation determined whether PD materials (e.g., teacher workbook, inquiry activities, and classroom vignettes) were constructed with fidelity to the theory of treatment, and contained quality components necessary to increase teachers' self-efficacy and affect their perceptions and attitudes of URM. The level of fidelity was determined by comparing PD materials against best practices and attributes of professional development (National Academies of Sciences, Engineering, and Medicine, 2015), and studies in virtual cross-group contact (Joyce & Harwood, 2014). High fidelity materials would mirror published attributes known to increase content knowledge and change practice, while low fidelity materials would be absent many of these aspects.

The second area of evaluation involved tracking the day-to-day implementation of the program components by presenters (Saunders et al., 2005). High fidelity implementation would occur when the program was completed in its totality, and that presenters delivered the most important components of the intervention in an effective manner. The cancellation of days or vital components being delivered poorly or not at all would constitute a low level of fidelity.

The final focus for FOI focused on measuring the extent to which teachers received the intervention materials (Saunders et al., 2005). Teachers' attendance, participation, and response to program materials was assessed. Complete attendance and a high level of participation during the program would constitute a high degree of fidelity, while absences and a low level of participation would lower the fidelity of the intervention. The primary goal of the classroom videos was to affect teachers' attitudes towards URM, thus teachers' responses to the videos are very important. High fidelity videos would be well received by participants as positive depictions of a diverse classroom with which they could identify (Bandura, 1977; Mazziotta et al., 2011). Videos that are not well received would mark a low level of fidelity to the theory of change.

Outcome Evaluation

This study utilized a novel approach to improve TSE for diverse students. Obtaining data that best returned an accurate determination of impact is the primary factor driving evaluation design (Shadish, Cook, & Campbell, 2002). A secondary consideration however was the availability of participants. Current contextual factors within the organization, as well as the timing of the intervention during the summer limited the number of individuals available to participate. The limited available sample and propensity for teachers to attend in teams negated randomized assignment. In order, then to best balance these competing concerns, this evaluation utilized a quasi-experimental approach with a nonequivalent comparison group design (Shadish et al., 2002). One control group and one treatment group were assessed using one dependent pretest and posttest for TSE for science equity. Control and mediating variables were also assessed, as well as a nonequivalent dependent variable (see Appendix I) (Shadish et al., 2002).

Outcome modeling was conducted through a value-added design adjusted for additional covariates (Henry, 2010). As recommended by Henry (2010), the selection of control variables was informed by self-efficacy theory and contact theory (Allport, 1954; Bandura, 1977). Consistent with other studies in TSE, teacher characteristics were measured, including years of experience, race/ethnicity, prior content knowledge as measured by university degree, and campus socioeconomic status (Lee et al., 2013; Tschannen-Moran & Johnson, 2011). Participants' experience with cross-group individuals is a critical factor informing one's level of anxiety, attitudes, and prejudice (Allport, 1954). As such, teachers' previous experience and level of involvement with cross-group individuals (e.g., friendship, confidant) was also included as a control variable (Mazziotta et al., 2015; Stephan & Stephan, 1985). The addition of control variables to the regression analysis served to bolster weaknesses in the outcome model.

Participants

Participants were 32 teachers that taught Grades 6-8 science as their primary assignment (at least three of five sections) during the 2015-16 school year for the District. Teacher leaders, instructional coaches, or science specialists that are defined as science teachers within the organization, but that have primary duties outside the instruction of students were excluded from the sample. Of the 32 teachers that began the intervention, one teacher could not complete the intervention. Thus, the final participant group included 31 teachers that completed the intervention and returned full questionnaires following the intervention. At the end of the study, three participants were no longer full-time teachers.

Non-random volunteer sampling was utilized to obtain participants for one control group and one treatment group (O'Leary, 2014; Shadish et al., 2002). Demographics for these two groups are included in Table 8. This methodology calls into question the representativeness of the treatment and control groups, and introduces selection bias to the sample (O'Leary, 2014). The participants who willingly would make themselves available during the summer for training may already be more efficacious than those in the control, and moreover than those who decline to participate. As such evaluation of several control variables was utilized to determine the variation between groups prior to outcomes analyses (Henry, 2010; O'Leary, 2014; Shadish et al., 2002).

Table 8

Participant Demographic Characteristics

Characteristics	Control *n*	Control %	Treatment *n*	Treatment %
Race/Ethnicity				
African American	2	15.4	2	11.8
Asian	3	23.1	0	0
Hispanic	1	7.7	1	5.9
White	7	53.8	14	82.4
Gender				
Male	5	38.5	3	17.6
Female	8	61.5	14	82.4
Certification				
Traditional	7	53.8	11	64.7
Alternative	6	46.2	6	35.3
Experience				
Novice	6	46.2	6	35.3
Veteran	7	53.8	11	64.7
Level				
Elementary	1	7.7	4	23.5
Junior High	12	92.3	13	76.5
Total	13	100	17	100

Measures

I drew on four sources of data to determine the impact of the intervention: (a) extant data, (b) survey responses, (c) content assessment, and (d) classroom observations. In addition, measures were included to determine fidelity of implementation throughout the course of the training. Appendix I details the various variables and instruments utilized during the course of this investigation; however, Table 9 lists them for quick reference.

Table 9

Study Variables and Instruments

Indicator	Role of Indicator	Instrument
Teacher background Years of experience Undergraduate degree Race/ethnicity Campus % low-SES Prior cross-group contact Cross-group friends	Control	Survey
Content knowledge	Mediating variable	Local assessment (Urquhart, n.d.)
Intergroup attitude	Mediating variable	General evaluation scale (Wright et al., 1997)
Intergroup anxiety	Mediating variable	Intergroup anxiety (Stephan & Stephan, 1985)
Subtle prejudice	Mediating variable	Subtle prejudice scale (Pettigrew & Meertens, 1995)
Teacher efficacy	Nonequivalent dependent variable	Teacher Sense of Equity Scale (Tschannen-Moran & Hoy, 2001)
Science teaching efficacy	Outcome variable	Survey adapted from Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990)
Reflection survey	Outcome variable	Constructed response

Background. Several background variables were collected through surveys and extant demographic data to provide control variables for the participants (see Appendix J). Campus demographic information in the form of socioeconomic level is available from the District through the percentage of students on free and reduced lunch. A locally developed background survey provided the remainder of the control variables. To gauge factors impacting teachers' initial level of self-efficacy they were asked to report their school level (elementary, junior high), years of experience, undergraduate degree (science/engineering, non-science/engineering), and certification route (traditional university-based, alternative) (Tschannen-Moran et al., 1998).

Items were included to control for teachers' biases, including measures of the quality and quantity of teachers' prior contact with out-group members at work, and the diversity of their network of friends (Pettigrew & Meertens, 1995; Stephan & Stephan, 1985; Voci & Hewstone, 2003; Wright et al., 1997). Two items measured quantity of contact: "How much of your day do you spend teaching on-level, inclusion, and/or ESL classes?" (*None – All*); "How much of your day do you spend teaching Pre-AP, Gifted & Talented classes, and/or accelerated classes?" (*None – All*). Quality of contact was measured following both contact items: "When you teach this/these class(es), in general how do you find it?". Teachers were given three sets of adjective pairs to answer on a 5-point scale: unpleasant/pleasant, natural/forced, and disengaging/engaging (Voci & Hewstone, 2003). Diversity of the participant's friends-network is assessed through one stem item: "In your network of friends, how many friends of ____ do you have?" (Pettigrew & Meertens, 1995). They were asked to answer this question for five examples: another nationality, a different religion, a different race, a different sexual orientation, and a different economic level (*None, A Few, Many*). Finally, participants were asked to share their race/ethnicity.

Teacher self-efficacy. Two survey instruments were employed to measure teacher self-efficacy. The first operationalized as Science Teaching Efficacy was measured through a survey adapted from Riggs and Enochs's (1990) Science Teaching Efficacy Belief Instrument (STEBI) (see Appendix K). This widely utilized 25-item instrument was developed from Gibson and Dembo's (1984) Teacher Efficacy Scale to specifically measure teachers' beliefs within the specific context of teaching elementary science. Items from the STEBI are commonly reported to measure two factors:

- *Science Teaching Outcome Expectancy* (STOE) - “When a student does better than usual in science, it is often because the teacher exerted a little extra effort.”
- *Personal Science Teaching Efficacy* (PSTE) - “I understand science concepts well enough to be effective in teaching elementary science.”

Teachers respond using a 5-point scale (*Strongly Agree – Strongly Disagree*).

For the purposes of this investigation, the STEBI was adapted to suit the specific context of teaching URM students in a junior high classroom. In order to reflect a change to the junior high classroom two references to elementary science (items 3, 12) were reworded to remove the grade-level cue. Synonymous group labels (minority, on-level, underrepresented) were then added to items to specifically direct teachers to consider teaching African American, Hispanic, and low-SES students as a whole. For example, “When a *minority* student does better than usual in science, it is often because the teacher exerted a little extra effort.” This adaptation has been utilized by other studies seeking to measure TSE specifically as it relates to identified student groups, including English Language Learners (Ross, 2014) and diverse student groups (Ritter, Boone, & Rubba, 2001). Ritter et al. (2001) specifically identify individual student groups (e.g., girls, African American, ELL, low-SES) in their scale, utilizing the same stem with each group. Individuals’ prejudice and biases are dependent upon the specific out-group being considered, and the relevant stereotypes associated with that representative (Devine, 1989). In an effort to maintain the structure and variety of items represented in the original STEBI, the decision was made to utilize larger group labels that encompass URM students. While the use of group terms such as on-level allow for more items addressing science-specific measures of efficacy, it may also have had the effect of masking teachers' specific biases regarding any one student group.

The STEBI instrument was also modified to reflect recent guidance from Bandura (2006) concerning the construction of valid self-efficacy scales. Two recommendations are reflected in the changes made to the STEBI. First, negative statements were reworded to reflect positive judgments of teachers' ability. Bandura especially stresses the use of "can do" statements to ensure construct validity. The original item "Even when I try very hard, I don't teach science as well as I do most subjects." was adapted to "I can teach science as well as I would like.". Secondly, scales with more intervals are recommended as they provide stronger and more sensitive measures of self-efficacy. This adjustment is also recommended as studies frequently report mean TSE levels above the mid-point (Hoy & Spero, 2005; Lakshmanan et al., 2011). With this in mind, the original 5-point scale was changed to a 9-point scale (*Strongly Disagree, Strongly Agree)*.

The second operationalization of self-efficacy is Personal Teaching Efficacy. The *Teachers' Sense of Efficacy Scale* short form is utilized to measure this survey of teaching self-efficacy (Tschannen-Moran et al., 1998; Tschannen-Moran & Hoy, 2001) (see Appendix L). This instrument is a shortened version of the original 24-item scale first developed from Bandura's (2006) Teacher Self-Efficacy Scale (Tschannen-Moran & Hoy, 2001). Teachers utilize a 9-point scale (*None at all, Very Little, Some Degree, Quite a Bit, A Great Deal*) to answer twelve items that assess teachers' self-efficacy with respect to three areas:

- *Efficacy for Student Engagement* – "How much can you do to motivate students who show low interest in school work?"

- *Efficacy for Instructional Strategies* - "How much can you use a variety of assessment strategies?"
- *Efficacy for Classroom Management* - "How much you do to control disruptive behavior in the classroom?"

Factorial analyses of results utilizing the TSES show that the three sub-scales load on one factor. Results are commonly reported as both one overall measure of self-efficacy, and the three constituent sub-scales.

Prejudice. Three survey instruments utilized in research on cross-group contact were employed to uncover teachers' attitudes and emotions towards underrepresented minority students (see Appendix M). Allport (1954) defines prejudice as "an antipathy based upon a faulty and inflexible generalization" (p. 9) towards a group or an individual representative of the group. Prejudice involves both cognitive judgments and feelings towards an out-group (Allport, 1954). The instruments included here served to operationalize prejudice in three ways, through direct measurement, and cognitive and affective representations.

Affective aspects of prejudice are particularly important as they are regarded as a "less semantically filtered [measure] and less subject to consistency pressures" (Pettigrew & Meertens, 1995, p. 60) in participants. In Western countries where egalitarian values have reduced blatant racism, an aversive, subtle form of racism persists reflected in the feelings of discomfort, fear, and anxiety towards out-groups (Pearson et al., 2009; Pettigrew & Meertens, 1995). Measures of anxiety in particular have consistently been reported as a critical factor influencing cross-group contact (Dovidio, Gaertner, & Kawakami, 2003; Pettigrew et al., 2011; Stephan & Stephan, 1985).

To begin, two items from the positive emotions sub-scale of the Subtle Prejudice Scale were utilized (Pettigrew & Meertens, 1995). The scale asks participants if they "ever felt the following ways about [ethnic group]." The two items assess how often the participant has felt sympathy and admiration towards the identified out-group using a 7-point scale (*Very often, Fairly often, Not too often, Never*). This scale is reverse-scored to reflect the notion that an individual with more subtle prejudice denies positive emotions towards the out-group.

The Intergroup Anxiety Scale is a second instrument designed to assess the level of anxiety associated with cross-group contact (Stephan & Stephan, 1985). Adapted from the original 10-item assessment from Stephan and Stephan (1985), 6 items utilize a specified emotion to answer the question: "If you were the only member of your ethnic group and you were interacting with people from a different racial or ethnic group (e.g., talking with them, working on a project with them), how would you feel compared to occasions when you are interacting with people from your own ethnic group?" A 5-point scale (*Not at all – Very*) is utilized to characterize if the subject would feel awkward, self-conscious, defensive, happy, confident, and accepted. The three positive emotions are reverse-scored and averaged with the remaining three, yielding an average with a direct relationship to anxiety.

The final survey is the General Evaluation Scale, a 6-item instrument that assessed participants' intergroup attitudes (Wright et al., 1997). This final scale reflects a cognitive judgment of out-group members. Individuals are asked to "describe how you feel about [ethnic group] in general" utilizing six pairs of emotions: warm-cold, negative-positive, friendly-hostile, suspicious-trusting, respect-contempt, admiration-disgust. A 7-point scale separates the two emotions for each item, and scoring is such that the positive emotion receives the higher value.

Content assessment. A 29-item assessment was included to assess teachers' understanding of concepts in physics related to force, motion, acceleration, and Newton's laws (Urquhart, n.d.). A multiple choice format was utilized to answer items that both mirror the content teachers are expected to teach students in junior high science as indicated in local education content standards, and extensions of the same content that go beyond the expectations specified in the standards. Example items included:

- A wheeled cart with a mass of 1.0 kg sits at rest on a low-friction track. One student pushes the cart with a force of 5.0 N to the left. At the same time a second student pushes the same cart with a force of 7.0 N to the right. Which best describes the motion of the cart in response to the forces the two students apply?

- A moving dot car makes the pattern shown with the 1 second intervals between dots, with each measurement numbered in the order in which it was taken. What is true about the motion of the car?

Correct answers were summed to produce a content score.

Urquhart (n.d.) drew upon her familiarity with concepts in the Force Concept Inventory (Hestenes, Wells, & Swackhamer, 1992), the Force and Motion Conception Evaluation (Thornton & Sokoloff, 1998), content taught through the WestEd Force & Motion training (Daehler et al., 2011), and Texas physics content standards for JH to construct the instrument. Published validity and reliability data are not available, however the instrument was reviewed for content validity by physics faculty at the University of Texas at Dallas, and one high school physics teachers during construction. For this study, the original 35-item content assessment was edited to remove items assessing physics content relating to energy (Kinetic Energy, Potential Energy) and energy transformations, and one item assessing teacher confidence.

The assessment had previously been utilized to assess teachers' growth in content knowledge as part of a statewide professional development initiative in Texas to improve instruction in Physics. This initiative conducted through the Texas Regional Collaboratives utilized the same WestED materials to train science teachers as was utilized here. Results from an initial administration of the assessment with 279 junior high science teachers prior to beginning their participation in the initiative revealed a mean pretest score below the midpoint, M = 42.2%, SD = 12.5% (Busby, 2017).

Observation. The Reformed Teaching Observation Protocol (RTOP) is an observation instrument utilized to evaluate teacher instructional practices in the classroom (Piburn & Sawada, 2000) (see Appendix N). Piburn and Sawada (2000) drew on national education reform publications in mathematics and science to develop an instrument that uncovers reform-oriented instructional practices in the classroom. The instrument consists of 25-items covering three subsets: Lesson Design and Implementation, Content, and Classroom Culture. The last two subsets, Content and Classroom Culture, are further divided into two subscales each, yielding five subscales in total for the RTOP. Sample items include:

- Lesson Design and Implementation – "The lesson encouraged students to seek and value alternative modes of investigation or of problem solving."
- Content – "Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena."
- Classroom Culture – "There was a climate of respect for what others had to say."

Observers utilize a 4-point scale for each item (*Never Occurred – Very Descriptive*). A total score ranging from 0-100 is produced by summing each item, with a higher score indicating more reformed practices. Correlational analyses indicate that each of the five subscales are good predictors of the overall RTOP score, leading the authors to assert that the instrument measures one single dimension – inquiry orientation.

Reflection. The final instrument was a reflection survey (see Appendix O) that utilized 3 constructed response questions:

- What components of the [investigation] did you find to be most useful in your teaching assignment?
- How have you integrated the new knowledge and skills you gained through the [investigation] into your practices?
- How could future professional development be improved to impact teachers' work with diverse students?

These three items were designed to further elicit teachers' experiences through the intervention. The first item sought to understand which attributes of the training were most important to participants, and to see if the classroom videos were specifically found to be beneficial. The second item provided a more complete picture to the question of classroom application. While observations conducted with the RTOP quantified a few classrooms, this item provided all participants the chance to expand on their practice since returning to the classroom. Teachers' language also provided greater insight in to their internal changes towards science practices. The final item asked for guidance in order to get respondents to reflect on their experiences with both professional development and the challenges with educating diverse students in a deeper way.

A fourth item was included and served as a control that asked participants to indicate "what other science professional development [they] attended." This would partially account for any external events that took place over the timeframe of this intervention that could be attributed for changes in teachers' self-efficacy.

Fidelity of Implementation

To ensure that the intervention was constructed, delivered, and received by participants at an acceptable level in alignment with the logic model and theory of change, three general components were evaluated: (a) quality of materials, (b) delivery of PD instruction, and (c) receipt of the PD by teachers (see Appendix I) (Saunders et al., 2005).

Quality. A primary area of evaluation centered on determining whether PD materials (e.g., teacher workbook, inquiry activities, and classroom vignettes) were constructed with fidelity to the theory of treatment, and contained quality components necessary to affect participants' biases towards URM. Fidelity was determined by comparing PD materials against studies in virtual cross-group contact (Joyce & Harwood, 2014; Mazziotta et al., 2011). High fidelity materials would mirror published attributes known to influence teachers, while low fidelity materials would be absent many of these aspects.

One indicator evaluated the quality of instructional materials utilized during the intervention: quality of contact materials. Contact materials included the video segments designed to influence teachers' self-efficacy and biases towards URM. A locally developed rubric using a 5-point scale (*Not Present – Present*) assessed four factors theorized to be critical to virtual cross-group contact, including: (a) positive valence, (b) successful interaction, (c) self-relevance between in-group model and observer, and (d) models are representative examples of their groups (Mazziotta et al., 2011). A total score indicated the quality of each video segment.

Delivery. A second area of evaluation would be the day-to-day implementation of the program components by presenters (Saunders et al., 2005). Two indicators measured fidelity in the delivery of PD materials: duration and delivery of PD components. Both measures ascertained whether activities or materials integral to the theory of treatment were presented, and furthermore the quality of that delivery by presenters.

The duration of the intervention was measured on a time log; data from both presenters and meeting agendas was collected following the summer session, and after each session during the school year. Data would indicate both the completion of an overall session, and the duration in hours. While a minimum dosage is not indicated in the research, extended duration where PD persists over several hours and across the school year is a consistent component of effective science PD that improves teacher practice (Desimone, 2009; Garet et al., 2001; National Academies of Sciences, Engineering, and Medicine, 2015; Penuel et al., 2007).

The delivery of instructional components during the PD was evaluated to ensure integral activities and content were conveyed to teachers as outlined (O'Donnell, 2008). A simple checklist (*Absent – Present*) verified the delivery of essential instructional components throughout the entire PD. Going even further, structured interviews with presenters evaluated their delivery of instruction to participants, allowing information to be gathered on differentiation or changes made to suit participants' needs. Sample questions included:

- Were you able to present all the material from today's agenda to the teachers?
- How well do you feel you were able to convey information to the teachers?

A high degree of fidelity occurred when the program was completed in its totality, and the presenters delivered essential components of the intervention in an effective manner. The cancellation of days, PD components being left out, and poor delivery as expressed by the presenters constituted a low level of fidelity.

Receipt. The final focus for FOI assessed through three indicators the extent to which teachers received the program materials (Saunders et al., 2005). The first, participant attendance, tracked the number of hours participants were present over the entirety of the 5-day training and any follow-up sessions. As noted above, implementation of science practices following science PD is related to intervention duration (Desimone, 2009). A percentage score denoted a participant's level of attendance.

Participant engagement, the second indicator, further evaluated participants' level of engagement during the intervention. Returning to the theory of treatment, science PD is effective when teachers are given opportunities to actively participate in science practices during trainings (Garet et al., 2001). The effectiveness of this intervention was diminished if participants did not actively engage in the essential activities of the training. A completion guide utilized at the end of each day assessed the percentage of tasks completed within the teacher workbook for each participant. A high percentage of completion constituted a higher level of engagement. This simple measure does run the risk of under-identifying engagement in participants. Some teachers may have been fully engaged mentally in the learning, but they might not have reciprocated by writing answers in their workbook.

The last indicator, participant perception, evaluated teachers' reactions to the classroom videos. A questionnaire provided to participants at the end of each day allowed them to provide their perceptions on that session's video(s) using a 5-point scale (*Strongly Disagree – Strongly Agree*). The importance of showing positive representations of cross-group interactions with a teacher model that allows participants to self-identify is critical to this study (Bandura, 1977;

Mazziotta et al., 2011). Items ascertained their reactions to the classroom interactions in order to determine if the vital attributes for cross-group contact and vicarious self-efficacy information were met.

Attendance above 80% and a high level of participation during the program by participants constituted high fidelity, while absences and a low level of participation marked low fidelity. Furthermore, as a primary goal of the classroom videos was to increase teacher self-efficacy and biases towards URM, high fidelity was marked by participants' reactions indicating that at least two of the three videos were positive and representative depictions of a diverse classroom (Bandura, 1977; Mazziotta et al., 2011).

Procedure

Intervention

This intervention was based on the understanding that science teachers must be provided professional learning opportunities that engage them in active learning experiences where they can build their content knowledge and experience with science practices (Desimone, 2009; Loucks-Horsley et al., 2003). Opportunities must be sustained over a course of time to engender reflection, and to allow for the integration of newly obtained experiences into a teacher's classroom and curriculum (Loucks-Horsley et al., 2003; Penuel et al., 2007). Moreover, teachers' beliefs must also be directly addressed in order for instructional changes to occur. Through this intervention teachers participated in a 5-day face-to-face professional development experience situated during the summer. Follow-up sessions were offered in the fall semester to support teacher implementation. All sessions were focused on physical concepts surrounding forces and motion. A timeline of the intervention is included in Table 10.

Table 10

Intervention Timeline

Date	Event
June	Treatment group receives intervention
July	Control group receives intervention
September-October	Participants teach Forces & Motion to students
	Follow-up sessions provided over lesson materials
November	Final survey administered

The foundation of this intervention was a PD utilizing the WestEd *Making Sense of SCIENCE*: *Force & Motion for Teachers of Grades 6-8* materials (Daehler et al., 2011) The WestEd materials were selected both for their focus on important Physics concepts, and their use of best practices for effective science PD throughout the training (Desimone, 2009; Loucks-Horsley et al., 2003).

The Making Sense of SCIENCE series of professional developments is built upon research around adult learning and cognitive psychology (Daehler et al., 2011). Each PD is constructed to explicitly improve teachers' content knowledge in science, and their pedagogical content knowledge about teaching science to young students. These outcomes in turn result in "changes in classroom practices, such as increased accuracy of science representations and explanations, a focus on conceptual understanding, greater opportunity for students to read and write to learn, and explicit development of academic language" (Heller, 2012, p. 8).

To achieve these outcomes WestEd PD engage teachers around four core attributes:

- Hands-on, active learning of science content through investigations constructed for teachers.
- Case studies of instructional vignettes that engage teachers in critical analyses and collaborative discussions of student thinking and teacher pedagogy.
- Language and literacy skills designed to help teachers engage students in discussions and reading about science.
- Classroom connection time that returns the focus of discussion to teachers' classrooms in order to focus on how to utilize their learning with students.

These aspects provide teachers with the hallmarks of quality PD: an in-depth focus on content knowledge, an opportunity to participate in active learning, a coherence with teachers' teaching standards and classroom practice, a chance for collective participation with one's colleagues, and learning that extends over several days. Studies evaluating the impact of the Force & Motion training and other WestEd PD have repeatedly shown a significant impact on elementary and junior high teachers' content knowledge and their confidence to teach science (Heller, 2012; Heller, Daehler, Wong, Shinohara, & Miratrix, 2012).

With the merits of the WestEd materials firmly established, each participant within the Treatment Group and Control Group received the entire training. High school physics teachers with extensive content knowledge, and that were trained by the same university instructor delivered all the PD sessions. Teachers were grouped with their colleagues and participated in collaborative work throughout the training. As highlighted above, participants' content knowledge was developed through successive sessions that carefully built conceptual ideas concerning motion, forces (balanced, unbalanced), Newton's Laws, and acceleration. Each day teachers engaged in scientific investigations that reinforced the conceptual content of the day.

Classroom cases studies allowed time for teachers to understand common misconceptions and the progression of student learning with physical concepts.

Following the investigation and case study portion of the training, participants in the Treatment Group and Control Group each worked collaboratively to evaluate a lesson for the JH classroom that used the same equipment contained in the professional development. Classroom lessons were evaluated for three of the five days of the training: Day 2 – Change in Motion (Dot Cars), Day 3 – Force & Acceleration (Fan Cart), and Day 5 – Acceleration & Mass (Gravity Cart). The other two days had time for a general discussion of how to implement the day's content in to the classroom.

The hands-on investigations contained in the Force & Motion training are written to engage adults in learning at their level. To provide further coherence to the training, student-level investigations were produced that translated the equipment from the PD to the classroom. As an example (see Appendix P), the Dot Car utilized by teachers to investigate changes in motion (Day 2) was employed to engage students in learning about motion. Each of the three example lessons were constructed to allow teachers time within the classroom to engage student in hands-on play with the lab materials, and to prompt student conversation about their observations. Teachers had the opportunity to provide the instructors with feedback on the quality of the classroom materials.

Prior to working with this curriculum, participants in the Treatment Group received the intervention treatment - virtual cross-group contact by watching a classroom vignette. Each of the three videos showed underrepresented minority students from an on-level science classroom within the District interacting with one JH science teacher. In the videos students actively worked through the same lesson plants teachers were evaluating as part of the training. Videos were of a moderate length: Day 2 - 14 minutes, Day 3 - 10 minutes, and Day 5 - 10 minutes. In total teachers in the treatment group received 34 minutes of virtual cross-group contact; control group participants did not watch any videos prior to working with the lessons.

The videos were produced from footage collected over three days in the classroom. I edited the final videos to adhere to the needs of virtual cross-group contact, namely positive and successful interactions between representative members of an out-group, and a representative model of the in-group (Bandura, 1977; Mazziotta et al., 2011). As such, while videos illustrated students completing the labs so that teachers could see the lessons in action, care was taken to ensure scenes centered on conversations where students successfully explained their thinking, plans, and results with the instructor.

The model teacher in the videos was a White, female curriculum specialist with 11 years of experience (5 elementary, 2 junior high, and 4 centrally). Like the majority of JH science teachers within the District, the model teacher had a degree outside of science. A degree in architecture forced the model to develop her expertise with science on the job and through professional development. Although the model teacher worked full-time within the Secondary Science Curriculum & Instruction Department developing curriculum and supporting teacher learning, a large part of her job also included working alongside teachers as a member of campus professional learning communities, and actively teaching struggling students through Tier II and III remediation efforts.

The 5-day training represented the majority of this intervention, however to provide participants with extended learning opportunities, job-embedded professional development sessions were held in September and October. Sessions were offered during regularly scheduled team meetings as a part of the district's focus on professional learning communities. Each meeting would focus on implementing the three lessons included in the intervention materials, including the use of equipment, understanding the lesson design, and differentiation needs for students.

Data Collection

Data as a part of this intervention were collected throughout the Force & Motion PD, and following the implementation of student lessons in October. Data include both outcome evaluation measures and fidelity of implementation measures (see Appendix I).

Outcome measures. Participants completed outcome measures through both paper and electronic administrations at various points of the intervention. Teacher background, teacher self-efficacy, cross-group prejudice, and the program reflection surveys were administered online through Google Forms. The content assessment was administered with paper copies and completed using a multiple choice answer sheet. Teachers were provided a formula chart with common physics formulas that exceeded those needed for the assessment. Calculators were provided.

On the first day of the Force & Motion PD, prior to any instructions or content, teachers completed the initial surveys of teacher self-efficacy (STEBI and TSES), the background information, and the content knowledge assessment. Upon arriving to the training, teachers were directed to a separate room with computers for them to complete the online assessments. The content assessment was then completed within the training room after all participants had been welcomed.

Assessments were repeated on the fifth day of the training. Participants completed the final content assessment within the training room. When done, they were then directed to another room with computers to complete the second administration of the teacher self-efficacy surveys, and the only administration of the cross-group prejudice survey.

At the end of the overall intervention in October, teachers were emailed with an electronic link and asked to complete the third administration of the teacher self-efficacy surveys, and the program reflection survey. A reminder email was sent to teachers in November prior to closing the survey.

Observations were scheduled with study participants during the targeted units of instruction on Force and Motion. An email was sent to all participants asking for volunteers to conduct one observation as they taught any of the three provided lessons. Time was scheduled with teach teacher that respondent. I conducted each observation in class utilizing the RTOP protocol, documenting classroom activities and student-teacher exchanges. Scoring was completed immediately after each observation using RTOP documentation as a guide.

Fidelity of implementation. Through the course of the training I collected several fidelity measures. First, attendance was logged using a sign-in sheet available to participants as they entered. The sheet was collected and attendance visually verified for each participant by the investigator. Second, a time log was maintained with each day's agenda where presenters noted the actual start and end times for each day of the training. Presenters also noted on the agenda when they completed aspects of the program, or if components were not addressed. Third, as the final aspect of each day's activities and teachers' exit ticket, participants completed their reflection survey on the videos using a paper copy. Fourth, at the end of each training day once participants had left, the investigator utilized the structured interview questions to reflect with the presenters. The conversations were recorded using a digital recording device. The investigator then utilized the participation rubric to assess each teacher's workbook. Paper copies of the rubric were utilized to ease in management of the data. For each instance the investigator documented each data point addressed above in the same Excel spreadsheet listed above. During the school year the same procedure was followed to document attendance at follow-up planning meetings.

Data Analyses

The primary goal of this analysis was to determine if the intervention had a differential impact on the outcome variables for the treatment group as compared to the two controls groups. Multiple univariate analyses of variance (ANOVA) were conducted to explore the impact of the intervention on: (a) content knowledge, (b) teacher efficacy, and (c) science teaching efficacy. Specifically, a 2 (treatment group, control group) x3 (pretest, posttest 1, posttest 2) mixed-design analysis of variance was utilized to determine within-group and between-group changes in our three primary outcome variables.

The secondary goal of the outcome modeling here was to explore the interactions between teachers' backgrounds, biases, and change in science teaching efficacy as conducted through a regression-adjusted covariate design (Henry, 2010). As recommended by Henry (2010), control variables were informed by self-efficacy theory and contact theory (Allport, 1954; Bandura, 1977). Multiple linear regression was utilized to predict science teaching efficacy from campus SES, prior cross-group contact, intergroup attitude, intergroup anxiety, and subtle prejudice. Furthermore, mediational analysis was conducted to explore if the hypothesized pathway through teachers' anxiety, attitudes, and prejudice accounted for variations in teacher self-efficacy as a result of cross-group contact.

Coding was utilized to analyze responses to the constructed response items included in the delayed post-test survey. First-order coding utilized both emergent and a priori coding. Second-order coding was finally used to categorize initial coding into relevant themes.

Chapter 5

Findings and Discussion

The intervention was implemented with fidelity to the procedure detailed in Chapter 4. Participants were led through five days of training where instructors engaged them in active learning on the topics of Force and Motion. Several sources of fidelity data collected as part of this intervention strongly suggest that the training was both delivered with fidelity to the theory of treatment and the details of the procedure. Participant data indicate that teachers were present and active throughout the intervention. The following three sections detail the fidelity data collected during the intervention.

Process of Implementation

Delivery

Time logs collected throughout the study indicate that the five days of the initial intervention took place, and that vital components of the professional development were all presented to participants. Interviews conducted with presenters also indicated that they were successful in presenting the crucial components of the training with fidelity to the training materials as written by, Daehler et al. (2011). Participants in the treatment group received 25 hours, 15 min of contact time, while the control received 27 hours, 25 minutes. Follow-up planning time prior to the implementation of the lessons within the classroom did not occur for the majority of the study participants. One campus with three study participants in the treatment group elected to have the author help them prepare for one of the lessons. This follow-up session lasted 45 minutes.

Receipt

All study participants were present for a majority of the professional development – 25 (83.3%) were present for all 5 days, while 5 (16.7%) were present for four days. These five participants all missed the first day of the intervention. Participation logs further indicate a high level of engagement among teachers. Two teachers, one from the control and one from the treatment group, completed less than 50% of the written activities as part of the training. Teachers in the treatment group completed on average 78% (46% - 100%) of the activities, and 79% (44% - 100%) within the control group. Engagement calculations accounted for participants who were absent for one day.

Session surveys were collected from participants each day of the professional development. Surveys were anonymous; however, participants were directed to indicate if they were participating in the study. The number of surveys returned on the three critical days containing cross-group contact ranged from 14 (82.4%) surveys on Day 2, 18 (105%)[2] on Day 3, and 17 (100%) on Day 5. Means (*M*) and standard deviations (*SD*) of survey items assessing participants' thoughts concerning the videos of cross-group contact were calculated across the three days. Responses show that the videos reflected attributes of positive cross-group contact. The videos illustrated: a positive exchange (*M* = 4.75, *SD* = .34), and successful work (*M* = 4.78, *SD* = .30) between teacher and student; the students in the videos were representative of the school system (*M* = 4.72, *SD* = .33); and, participants could relate with the teacher in the videos (*M* = 4.57, *SD* = .65). Finally, participants in the treatment group were asked to rank the importance of the various components of the PD to their "overall learning" on Day 5. The videos

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[2] A greater than 100% response rate reflects that one teacher did not correctly identify themselves on the survey sheet as a non-participant in the study.

were of moderate importance to the teachers on a scale of *1* to *5* (*M* = 2.82, *SD* = 1.02, range 2 – 5).

The fidelity data presented above importantly indicate that the training was completed with fidelity. All aspects of the training were presented to teachers as planned with a high level of fidelity, and participants were highly engaged for a vast majority of the training. Finally, the surveys show that the videos constructed to illustrate positive cross-group contact were successful in presenting positive cross-group contact. These data indicate that the results provided in the subsequent sections are the result of a fully implemented intervention. The following section will continue the quantitative data analyses.

Observations

Observations were conducted with six participants using the RTOP procedure. Scoring of the six classes yielded a mean RTOP total score of 29 (23 – 39) and a standard deviation of 6.48. These values reflect lower scores as compared to those reported by Pilburn and Sawada (2000) for junior high (*M = 50.0, SD* = 14.1) and high school science (*M = 41.8, SD* = 20.2) classrooms.

Findings

Research Question 1: Participants' Science Teaching Efficacy

Content knowledge. Participants' content knowledge was assessed before and after the intervention, see Table 11 for descriptive statistics. An independent samples t-test was conducted to determine if an initial difference in CK was evident between the two groups. The treatment group's initial CK score was higher, *M* = .318, 95% CI [-3.03, 3.67], however the difference between the two groups at the beginning of the intervention was not significant, $t(26) = -.195$, $p = .847$.

Gain scores were then calculated for the change in CK for each participant. An independent samples t-test showed a greater increase in CK for the treatment group, *M* = .08, 95% CI [-1.98, 2.15], but the difference was not significant, $t(26) = .082$, $p = .936$. Paired sample t-tests were then conducted for each group. Both the control, $t(12) = 5.34$, $p = .000$, and the treatment, $t(14) = 7.34$, $p = .000$, groups showed significant increases in science content knowledge as a result of the intervention. These data support the fidelity of implementation data addressed in the previous section, indicating that both groups received an effective PD training. With an increase in content knowledge established, this analysis will transition to the focus of this study, teachers' sense of self-efficacy.

Table 11

Means, Standard Deviations, and Gain Scores for Participant Content Knowledge Assessment Scores by Group

	Pretest			Posttest			Gain	
	N	*M*	SD	*N*	*M*	*SD*	*M*	*SD*
Control	13	13.62	4.65	13	18.00	4.62	4.38*	2.96
Treatment	15	13.94	3.84	17	17.76	3.68	4.47*	2.36

Note. Test scores are number of items from a total of 29 items.
*$p = .000$.

Efficacy scores. Principal-axis factoring with varimax rotation of the 12-item TSES scale utilizing data from the pre-test yielded three factors with eigenvalues greater than 1, accounting for 71% of the variance in participants' scores. When items with the highest loadings were assigned to the three factors, 11 of the items matched the factors determined by Tschannen-Moran and Hoy (2001); one item considered part of the *Instructional Strategies* factor loaded only on *Classroom Management*. Given the small sample size of this study, I draw on the work of Tschannen-Moran and Hoy (2001) and calculate one score on the TSES. The TSES showed high reliability across the three administrations (α = .921, .912, and .911).

Principal-axis factoring with varimax rotation of the edited 25-item STEBI scale was conducted specifying two factors, as determined in previous studies (Gibson & Dembo, 1984; Riggs & Enochs, 1990). Using data from the first and second administrations, the two factors accounted for 41% and 43% of the variance, respectively. Although analysis of a Scree plot strongly suggested that a greater number of factors could be extracted, the limited sample size of this study could be a source of factor instability as compared to previous findings (MacCallum, Widaman, Zhang, & Hong, 1999). Given this context and that items were only changed to modify the subjects of each item, and not the content of the item, two scales (PSTE and STOE) were maintained and the values calculated from the means of the identified items. Calculated reliabilities were low for the first administration of the STOE scale (α = .417), and good for the post administrations (α = .670, .687). Reliabilities for the PSTE scale were high across all administrations (α = .843, .851, and .896).

Participants' self-efficacy was assessed before and after intervention, see Table 12 for descriptive statistics. Analyses were first conducted to determine if any initial differences were evident within and between the groups. Teachers' initial self-efficacy was first compared against four control variables: gender, undergraduate degree, certification pathway, and experience. Table 13 contains descriptive statistics for these factors for all teachers participating through the intervention. No significant differences were found for teachers based on degree, certification, or experience. Gender, however was significant for teachers' self-efficacy for science with URM, $t(28) = 2.356$, $p = .026$. Male teachers reported a significantly higher level as compared to their female counterparts, $M = .849$, 95% CI [.11, 1.59].

Independent samples *t*-tests were next conducted for each efficacy instrument to determine if initial differences in self-efficacy were evident between the two groups. No significant differences were found for the TSES scale, $t(28) = .440$, $p = .663$, the STOE scale, $t(28) = -.525$, $p = .604$, or the PSTE scale, $t(28) = -.917$, $p = .367$.

Table 12

Means and Standard Deviations of Three Measures of Efficacy

	Control (n = 9)			Treatment (n = 12)		
	Pretest	Post	Delayed Post	Pretest	Post	Delayed Post
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
TSES	7.19 (1.16)	7.27 (1.14)	7.07 (1.10)	6.93 (1.07)	7.41 (.71)	7.26 (.91)
PSTE	7.15 (.94)	6.82 (1.09)	7.02 (1.05)	6.79 (1.06)	7.13 (.60)	6.83 (.88)
STOE	5.81 (.78)	5.64 (1.05)	5.81 (1.14)	5.80 (.58)	6.20 (.75)	6.06 (.73)

Table 13

Means and Standard Deviations of Initial Self-Efficacy Scores by Teacher Background Variable

		TSES		STOE		PSTE	
	N	*M*	SD	*M*	*SD*	*M*	*SD*
Degree							
Other	14	6.88	1.08	5.55	.60	6.90	1.09
STEM	15	7.23	1.03	5.83	.71	7.04	.85
Certification							
Alternative	12	7.15	.98	5.85	.49	7.21	1.05
Traditional	18	7.06	1.12	5.60	.74	6.81	.85
Experience							
Novice	12	6.79	1.08	5.85	.72	6.76	1.11
Veteran	18	7.29	1.01	5.60	.61	7.12	.81
Gender							
Female	22	7.11	1.17	5.59	.64	6.75*	.94
Male	8	7.05	.68	5.98	.61	7.60*	.64

Note. Test scores are number of items from a total of 29 items.
*$p < .05$.

Establishing that the treatment and control groups showed similar levels of TSE at the outset of the training, a 2 (treatment, control) x 3 (pretest, posttest, delayed posttest) mixed-design ANOVA was conducted for each measure of teacher self-efficacy (TSES, PSTE, and STOE) to measure changes following the training. No statistically significant interaction was found between the intervention and time on the TSES scale, $F(2, 38) = 1.985$, $p = .15$, partial $\eta^2 = .095$, the PSTE scale, $F(2, 38) = 2.372$, $p = .11$, partial $\eta^2 = .111$, or the STOE scale, $F(2, 38) = 2.257$, $p = .12$, partial $\eta^2 = .106$. The main effect of time approached significance for TSES at the three points, $F(2, 38) = 2.574$, $p = .089$, partial $\eta^2 = .119$.

Personal teaching efficacy (TSES) data show a similar trend for both groups. Teachers experienced an increase in TSE at the end of the 5-day training, but then exhibited a decrease in self-efficacy at the end of the intervention during the Fall semester. While both groups reported lower levels at the third assessment, the treatment group maintained a level of TSE greater than their initial starting point. The control group reported lower levels of self-efficacy as compared to their initial starting point.

Science teaching efficacy for URM students showed opposite trends for the control and treatment groups. The treatment group experienced a similar increase and decrease in science TSE as they did personal self-efficacy. Moreover, final levels of science self-efficacy remained greater than initial levels collected prior to the intervention. Data for the control group illustrate an opposite trend. Teachers reported a decrease in science teaching self-efficacy at the end of the training, and then improved by the third assessment. Interestingly, final levels on the PSTE scale remained lower still than at the outset of the training, while levels on the STOE returned to their initial level. These data suggest that the treatment effect of virtual cross-group contact had a positive influence on teachers. While experiences in the classroom seemingly had a sobering effect on their self-perceived abilities, the treatment had a lasting effect on teachers.

The positive results illustrated in the data must be interpreted with caution, as a considerable percentage (30%) of study participants did not complete the delayed post-test. The effect of this drop in participation reduced the sample sizes of both groups: the treatment from 17 to 12 (29.4% difference), and the control from 13 to 9 (30.8% difference). Although the cause of the missing data is unknown and considered random, the impact of this missing data on the small initial sizes of both groups could be considerable. Moreover, the third assessment of self-efficacy was designed to assess teachers following the completion of a physics unit of instruction. Survey responses collected as part of the third assessment indicate that three teachers had not completed that unit as hoped. Given the limited nature of the third assessment, data analyses were completed to focus on teachers' change directly at the end of the training.

A 2 (treatment, control) x 2 (pretest, posttest) mixed-design analysis of variance was conducted for each measure of teacher self-efficacy (TSES, PSTE, and STOE). The data showed a significant interaction between group and time for the PSTE scale, $F(1, 28) = 5.937$, $p = .021$, partial $\eta^2 = .176$. The control group exhibited a decrease (-.267) in PSTE during the PD, while the treatment group had an increase (+.289) in PSTE.

There was no significant interaction for the STOE scale, $F(1, 28) = .510$, $p = .104$, partial $\eta^2 = .092$, or the TSES scale, $F(1, 28) =1.467$, $p = .236$, partial $\eta^2 = .050$. The main effect of time, however, showed significant differences for the STOE scale [$F(1, 28) = 4.974$, $p = .034$, partial $\eta^2 = .151$] and TSES scale [$F(1, 28) = 5.361$, $p = .028$, partial $\eta^2 = .161$]. In both cases teachers in both groups reported increases in self-efficacy; see Table 14 for means and standard deviations.

These results support the hypothesized effects of the treatment on teachers' science teaching self-efficacy. They suggest that the presence of virtual cross-group contact within professional development can positively influence teachers' self-efficacy for diverse student groups. The STEBI instrument was modified to directly assess teachers' self-efficacy with regards to teaching URM students, while the TSES remained general. Previous research has shown the ability of different scales targeting specific populations (Ross, 2014) and subjects (Tschannen-Moran & Johnson, 2011) to return significantly different results as compared to generalized teaching self-efficacy. As expected, a general and equal increase in personal teaching efficacy as measured by the TSES would occur for both groups as a result of participating in this PD intervention. The significant interaction for group and time with the PSTE, however, suggests that the treatment group's self-efficacy towards URM increased as a result of the virtual cross-group contact. The absent difference between groups as measured by the STOE scale is not unexpected. Previous research has shown Science Teaching Outcome Expectancy to be fairly resistant to change (Cakiroglu et al., 2012). To further uncover factors associated with these changes in self-efficacy, the next section will look at correlates of self-efficacy change.

Table 14

Means and Standard Deviations of Three Measures of Efficacy at Two Points

	Control (n = 13)		Treatment (n = 17)	
	Pretest	Post	Pretest	Post
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*
TSES	6.99 (1.06)	7.10 (1.11)	7.17 (1.08)	7.51 (.74)
PSTE	7.15 (.84)	6.89 (.97)	6.84 (1.01)	7.12 (.64)
STOE	5.77 (.72)	5.83 (.98)	5.64 (.62)	6.07 (.69)

Correlates of efficacy change. Change scores for the TSES, PSTE, and STOE scales were calculated by subtracting the pretest score from the posttest score. A positive change score indicates that efficacy increased from the beginning of the training to the end. Table 15 shows that a change in the TSES is correlated with a change in PSTE (r = .471, p = .009), but not the STOE. Table 15 also includes other background characteristics for the participants, including the content gain score, years of experience, campus SES, intergroup friends diversity, and ELL contact.

Surprisingly, an increase in content knowledge as measured by the physics content assessment was not correlated with a change in teachers' self-efficacy, regardless of measure. Content knowledge and quality professional development have been shown to positively influence TSE across efficacy studies (Tschannen-Moran & Johnson, 2011). Another measure of mastery, years of experience, was negatively correlated with self-efficacy for the TSES (r = -.475, p = .011) and PSTE (r = -.378, p = .048) (i.e., a greater increase in self-efficacy with less years of experience). This data mirrors Bandura's (1997) assertion of the influence experience has on reducing the malleability of self-efficacy. Novice teachers presumably gain the most from PD early in their careers before they've established a firm sense of their abilities, resulting in larger gains in TSE as compared to their veteran colleagues.

Finally, contextual factors related to cross-group attitudes, intergroup friends, campus SES, and ELL contact were not correlated with measured changes in efficacy. This data suggests that the differential gains in self-efficacy for diverse students experienced by the treatment group were related to the addition of cross-group contact, and not external contextual factors. The following research question takes a more direct look at the internal factors influencing participants' change in self-efficacy.

Table 15

Correlations of Efficacy and Background Measures

Measure	*M*	*SD*	1	2	3	4	5	6	7	8
1. TSES Gain	.24	.54	-	-.062	$.471^{**}$	-.127	-.137	.195	-.086	$-.475^{*}$
2. STOE Gain	.27	.62		-	.228	-.343	-.096	.295	.349	.054
3. PSTE Gain	.05	.67			-	-.007	-.037	.148	-.046	$-.378^{*}$
4. Content Gain	4.43	2.60				-	-.019	-.274	-.380	-.099
5. Campus SES	55.04	16.80					-	-.236	$.421^{*}$	.107
6. Intergroup Friends	11.97	1.99						-	.092	.212
7. JH ELL Contact	1.11	2.11							-	.169
8. Years of Experience	7.77	9.06								-

Note. $^{*}p < .05$, $^{**}p < .01$.

Research Question 2: Participants' Affect and Beliefs

Intergroup attitudes and beliefs. Table 16 provides means and standard deviations, and Table 17 provides intercorrelations for all variables measuring intergroup affect and beliefs. Independent *t*-tests revealed that the treatment group reported less positive emotions towards

Hispanics, $t(28) = 2.567$, $p = .016$, as compared to the control group. No other significant differences were found between groups.

The data below importantly illustrate that both teacher groups hold very positive beliefs and attitudes about each group of students. Means for each measure of teachers' attitudes and beliefs reflect values above the midpoint in each case. Measures of positive emotions and intergroup attitudes specifically are well above the midpoint on a 7-point scale. Moreover, teachers also reported very diverse friend networks. Means for intergroup friends illustrate high ratings on a totaled scale of 1 – 15 for five items, indicating teachers self-reported very diverse groups of friends. The high ratings reported across each measure may account for the lack of a significant difference between groups. Although the treatment group received virtual cross-group contact, the limited interaction may not have been sufficient to create a difference given such positive attitudes and beliefs.

Table 16

Means and Standard Deviations of Intergroup Measures

	Control	Treatment
	M (SD)	*M (SD)*
Intergroup Friends	11.54 (1.71)	12.29 (2.17)
Contact ELL	1.44 (2.50)	.79 (1.71)
Positive Emotions		
ELL	6.23 (.67)	6.35 (.66)
African American	5.73 (.56)	5.24 (.94)
Hispanic	6.12* (.58)	5.29* (1.03)
Intergroup Attitudes		
ELL	6.12 (.94)	5.96 (.86)
African American	5.91 (1.00)	5.73 (1.05)
Hispanic	5.88 (1.11)	5.77 (1.15)
Intergroup Anxiety	3.64 (1.13)	3.56 (.80)

Note. *$p < .05$

The data in Table 17 indicate strong positive relationships between contact with ELL students and intergroup attitudes for Hispanics, AA, and ELLs. The contact variable measured both the frequency of contact with ELL students at JH, and whether contact was subjectively rated as positive or negative by the participant. A positive number indicates both frequent and positive cross-group contact with ELLs. This strong interaction suggests that positive interactions with ELL students are directly related to the attitudes teachers have about diverse students. Whether positive interactions are impacting a teacher's attitudes, or that the attitudes a teacher holds about various student groups influences their rating of cross-group contact is not evident here.

Important relationships illustrated in Table 17 are the moderate and positive correlations found between positive emotions and intergroup attitudes for each identified group. The data also indicate a moderate and positive correlation between intergroup anxiety and intergroup attitudes for African American (r = .418, p = .021) and Hispanic (r = .367, p = .046) students. Intergroup anxiety was scored so that higher scores reflect a diminished level of anxiety within a cross-group situation. Taken together, these results are in alignment with Allport's (1954) contact theory. Although causality cannot be determined from these results, they show an alignment between respondents' cross-group attitudes and beliefs.

Table 17

Pearson Correlations of Intergroup Measures

Measure	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Intergroup Friends	11.97	1.99	-	.092	.247	.146	.195	.084	.254	.219	-.200
2. Contact ELL	1.11	2.11		-	.142	.257	.301	.561**	.551**	.551**	.251
3. PE – ELL	6.30	.65			-	.511**	.288	.247	.413*	.469**	-.155
4. PE – AA	5.45	.82				-	.772**	.413*	.368*	.345	-.064
5. PE – HISP	5.65	.95					-	.535**	.520**	.488**	.199
6. IA – AA	5.81	1.02						-	.863**	.654**	.418*
7. IA – HISP	5.82	1.12							-	.880**	.367*
8. IA - ELL	6.03	.89								-	.315
9. Intergroup Anxiety	3.59	.94									-

Note. * $p < .05$, ** $p < .01$.

Surprisingly, intergroup friends did not correlate with any indicator of teachers' attitudes or beliefs. As I reported above, participants reported very diverse personal networks. At the risk that a totaled score masked individual measures of friends' race, responses to *friends of another race* was individually analyzed. This specific item, however, returned the greatest result of the set, with $M = 2.62$ ($SD = .51$) for the control group, and $M = 2.71$ ($SD = .47$) for the treatment group on a 3-point. This factor is known to influence cross-group attitudes and beliefs (Pettigrew & Meertens, 1995; Wright et al., 1997), and is fundamental to Allport's (1954) contact theory. The lack of a correlation between teachers' reported network of friends and their attitudes and beliefs is an unexpected result.

Correlations of efficacy and intergroup measures. The previous section established that expected associations between teachers' cross-group attitudes and beliefs were evident in the data, and that no significant differences existed between groups for the majority of measures. Turning to the hypothesized relationship between self-efficacy and intergroup attitudes, Table 18 provides intercorrelations between intergroup measures and the three TSE scales, utilizing the posttest assessment data. Frequent and positive contact with ELL students at school did not correlate with any self-efficacy scale: TSES, $r = .174$, $p = .404$; PSTE, $r = .323$, $p = .115$; and, STOE, $r = .110$, $p = .602$. No significant relationship was found for either teachers' friend network or intergroup anxiety.

Analyzing relationships between teachers' attitudes and emotions for specific student groups and their self-efficacy revealed significant relationships for ELLs, and partially for Hispanic students. Relationships approached significance for African American students. Personal self-efficacy (TSES) was positively correlated with teacher's attitudes ($r = .531$, $p = .003$) and emotions ($r = .423$, $p = .020$) for ELL students. A positive correlation with ELL students was also obtained for the PSTE scale: attitudes ($r = .517$, $p = .003$) and emotions ($r = .498$, $p = .005$). With Hispanic students, intergroup attitudes were correlated with both TSES ($r = .448$, $p = .013$) and PSTE ($r = .458$, $p = .011$) scores. A significant relationship between self-efficacy and positive emotions for Hispanics was only found for the TSES scale, $r = .371$, $p = .043$. Finally, teachers' self-efficacy exhibited positive relationships with attitudes and emotions for AA students. Personal self-efficacy (TSES) and emotions approached significance, $r = .347$, $p = .060$, while positive relationships between science TSE and emotions ($r = .358$, $p = .052$) and attitudes ($r = .330$, $p = .075$) both approached significance.

The data in Table 18 provides less than resounding support of the proposed relationship between teachers' self-efficacy and their cross-group attitudes and beliefs. That said, the data so far does further support the notion that a teachers' beliefs are related to their self-efficacy in the classroom. To this final point, Figure 3 illustrates the significant relationships between teachers' beliefs and self-efficacy observed here.

Table 18

Correlations of Efficacy and Intergroup Measures

Measure	TSES Post	PSTE Post	STOE Post
1. Intergroup Friends	.267	.093	-.066
2. Contact ELL	.174	.323	.110
3. PE – ELL	.423*	.498**	.174
4. PE – AA	.347	.358	.034
5. PE – HISP	.371	.245	-.139
6. IA – AA	.301	.330	.043
7. IA – HISP	.448*	.458*	.023
8. IA - ELL	.531**	.517**	-.061
9. Intergroup Anxiety	.302	.191	-.044

Note. $^{*}p < .05$, $^{**}p < .01$.

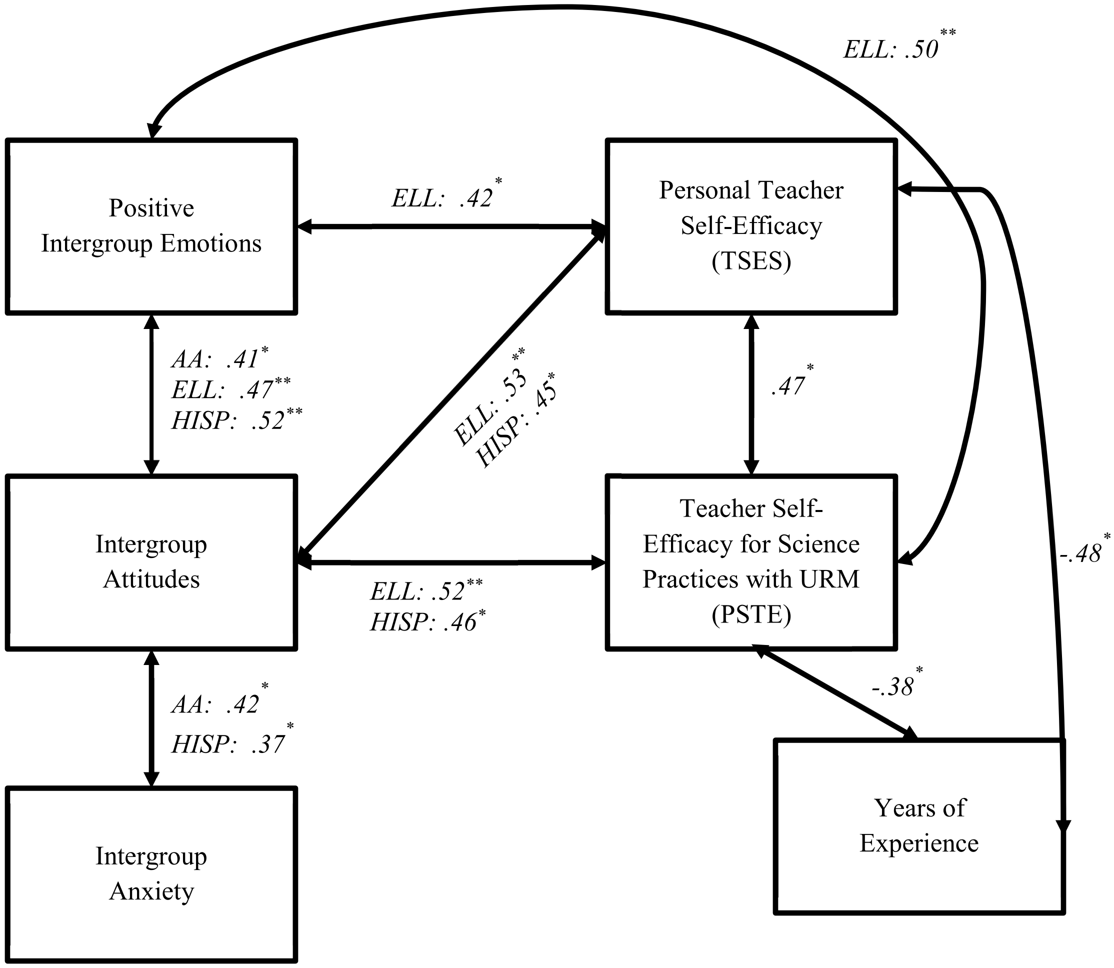


Figure 3. Model showing the correlations between teachers' beliefs and self-efficacy, and other variables.
$^{*}p < .05$, $^{**}p < .001$. Only significant relationships are reported.

Linear regression. In order to determine if teachers' attitudes or beliefs were influencing teacher self-efficacy for URM as measured by the PSTE, a multiple linear regression was calculated with several predictor variables, including: treatment group; PSTE Pretest; campus SES; intergroup friends; ESL contact; positive emotions of ELL, AA, and Hispanic students; intergroup attitudes of ELL, AA, and Hispanic; and, intergroup anxiety. This test failed the test for multicolinearity between positive emotions for Hispanics and AA, and intergroup attitudes for Hispanics and African Americans as assessed by tolerance values greater than 0.1. Hispanic students are a large proportion of both total students in schools, and the ELL population, so values for Hispanic students were dropped in favor of maintaining participants' scores for African Americans.

A multiple regression was rerun without measures for Hispanic students. Regression coefficients and standard errors can be found in Table 19. The multiple regression predicted PSTE with significance, $F(9, 15) = 5.088$, $p = .003$, adj. $R^2 = .605$. Only a teacher's pretest score was statistically significant to the prediction, $p = .001$; treatment with virtual cross-group contact was not a significant factor in predicting teachers' self-efficacy as hypothesized. Given this negative result, mediational analysis was not conducted.

Table 19

Summary of Multiple Regression Analysis for PSTE Scale

Variable	*B*	SE_B	β
Intercept	1.511	1.429	
Cross-group Contact	.341	.274	.215
PSTE Pre-test	.598	.141	.723*
Intergroup Friends	-.035	.060	-.088
ELL Contact	.033	.063	.087
Positive Emotions ELL	.128	.291	.102
Positive Emotions AA	-.055	.264	-.058
Intergroup Attitude ELL	.373	.203	.434
Intergroup Attitude AA	-.265	.200	-.348
Intergroup Anxiety	.061	.137	.073

Note. *p = .001

Finally, a hierarchical multiple regression was conducted in order to further explore the specific impacts of the various variables on teachers' final self-efficacy for science with URM. The majority of the variables from the previous regression were included again over three steps: model 1 included teachers' initial PSTE, model 2 added variables relating to cross-group contact (attitudes, emotions, and prior contact experience), and model 3 added content knowledge gain to the regression. Cross-group contact as the treatment was removed. Also, although my previous analyses found no direct relationship between content knowledge and self-efficacy change, the significance of CK to other studies on self-efficacy in science made it an important addition to the regression.

The full model of teachers' initial PSTE score, teachers beliefs, and content gain was statistically significant, $R^2 = .731$, $F(9, 13) = 3.921$, $p = .013$, adjusted $R^2 = .544$. See Table 20 for full details on the three regression models. The addition of teachers' beliefs to the prediction of PSTE (Model 2) was not significant, with an increase in R^2 of .188, $F(7, 14) = 1.388$, $p = .284$.

Equally, the addition of teachers' content gain score to the model was also not a significant addition, R^2 of .001, $F(1, 13) = .067$, $p = .800$. These data further isolate teachers' initial PSTE score as the only significant factor predicting their final level of self-efficacy.

Table 20

Hierarchical Multiple Regression Predicting PSTE From Initial PSTE, Beliefs, and Content Knowledge Gain

	PSTE					
	Model 1		Model 2		Model 3	
Variable	*B*	β	*B*	β	*B*	β
Constant	2.68^{**}		.590		.716	
PSTE Pre-test	$.606^{***}$	.736	$.591^{**}$	.718	$.586^{**}$	.712
Intergroup Friends			.013	.030	.006	.015
ELL Contact			.024	.056	.014	.033
Positive Emotions ELL			.424	.317	.415	.311
Positive Emotions AA			-.318	-.334	-.310	-.326
Intergroup Attitude ELL			.256	.285	.271	.302
Intergroup Attitude AA			-.097	-.123	-.098	-.124
Intergroup Anxiety			.050	.060	.045	.053
Content Gain					-.014	-.044
R^2	.542		.729		.731	
F	24.817^{***}		4.718^{**}		3.921^{*}	
ΔR^2			.188		.001	
ΔF			1.388		.067	

Note. $^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$

Survey

A total of 21 participants (70%) completed the final survey in the fall. Analysis of constructed response item responses began with a holistic reading of the participants' answers. Coding was then done for each question using in-vivo coding and descriptive coding (Saldaña, 2009). Following initial coding, codes were grouped into categories to identify common concepts running throughout the responses.

The first item of the survey assessed whether other sources may account for teachers' self-efficacy at the time of the delayed post-test. Responses indicated that less than half (8) of the teachers participated in science PD outside the intervention. Of the 12 teachers that reported not participating in any other training, 8 of those teachers had participated in non-science trainings, including PD focused on special populations (Gifted & Talented, ELL) and technology.

The second item assessed participants' views on the components they felt were "most useful" during the training. Coding revealed 7 common factors important to teachers, see Table 21. In several cases, in vivo coding provided an identifying term that was shared across several responses - "I found the *collaboration* with other teachers to generate understand new analogies and examples". For others, conceptual terms were utilized to codify a response. Hands-on investigations identified responses referencing the teacher investigations from the training - "The labs that we did during PD helped me get a better understanding of some Physics concepts".

Categorizing the first-order codes for the second item revealed responses relating to the best practices of effective professional development (Loucks-Horsley et al., 2003). Table 21 identifies both first-order coding and categorization using these best practices. Responses are fairly well distributed equally across these 4 categories.

Table 21

Frequencies of Participant Responses for Most Useful Component of Training

Category	*Frequency*
Active Learning	
Hands-on Investigations	8
Collective Participation	
Discussions	3
Teacher Collaboration	5
Content Focus	
Deepen Understanding	6
Explanations from Trainers	2
Misconceptions	1
Coherence	
Lesson Materials	4

The third item from the survey asked teachers to share how the training had been integrated in to their classroom over the Fall semester. One-third (7) of the respondents either indicated they had not yet conducted any of the provided labs, or their answers were too brief or unrelated to the prompt – "It was so beneficial for my physics course and even the physics that we cover in 8th grade science". The remaining responses illustrated 9 various ways in which the teachers had integrated their new knowledge to the classroom. One participant indicated how "it has helped me address many misconceptions early on in physics". When the various items were categorized, responses were differentiated by who was most affected by the training, teacher or students. Half of the responses indicated how the teacher's actions had changed – "Practices in graphing really helped me in explaining graphing practices to my 8th graders and physics students". This stands in stark contrast to the other half of responses that indicated how students' actions in the classroom had changed. This response best illustrates this category: "Everyday the students were interacting with materials whether it is lab, stations, videos, card sort, or manipulatives. The students did not have to sit and take notes or listen to lectures to learn the material. They were more engaged." In all, six teachers reported that students completed the provided labs in the classroom.

The final constructed response item asked teachers how future PD could be improved to impact teachers working with diverse students. Responses mirrored their earlier answers to those aspects most influential in the training, including primarily the request for PD that included active learning – "The more engaging hands-on activities we learn, the better. My kids loved seeing science in action!". A small number (5) of respondents specifically identified the need to address diverse and struggling students within future PD. One respondent indicated the need for opportunities where teachers could understand the cultural diversity on their campus. Another referenced the case studies from the training and their ability to "provide a framework for teaching different students and answer tough situations". A third suggested that all future PD include "video filmed in an on level classroom to show what is effective when doing labs with a diverse population". While this singular comment speaks to the goal of this study, a final respondent expressed that they "never got the impression that the PD was oriented towards addressing underrepresented students". This same teacher goes on to express "I just don't understand what I need to be doing differently, specifically targeted for these [URM] students".

Conclusion

This intervention sought to explore how professional development could improve the self-efficacy of junior high science teachers in order to contribute to the national conversation around STEM education. Improving educational outcomes for African American, Hispanic, ELL, and low SES students has a direct impact on the human capital available to STEM industry. Data from researchers and government resources document an expanding knowledge and technology-intensive industry that requires an education work force (Brynjolfsson & McAfee, 2012; NSF, 2014). This need has brought the deficiencies of the STEM pipeline into clear focus for legislators, researchers, and public educators alike.

Science teachers have a direct impact on the achievement and career aspirations of their students (Bandura et al., 2001; Rivkin et al., 2005). Through the classroom environment they enact, and the pedagogy they utilize, teachers can both positively and negatively affect students' interests and academic success (Bolshakova et al., 2011; Reyes et al., 2012; Rice et al., 2013). The effects of the classroom in turn impact students' self-efficacy in STEM, which then impact goals and career aspirations (Bandura et al., 2001; Byars-Winston et al., 2010). It's in understanding this pathway that I focused on improving the pedagogy utilized by teachers in the District.

Creating change in teacher practice is a large area of research in education. The work of Loucks-Horsley (2003) and the National Academies of Science, Engineering, and Medicine (2015) document the best practices of educating science teachers shown to reform classroom practice. Within this larger framework of teacher education, this study focuses on teachers' sense of self-efficacy as a critical cognitive factor known to influence teacher practice in science (Cakiroglu et al., 2012). My first research question assessed the impact of a 5-day professional development intervention on the content knowledge and self-efficacy of junior high science teachers. Participants engaged in a research-based program designed to explicitly improve teachers' knowledge of physics topics around force and motion (Daehler et al., 2011). Results indicate that teachers experienced significant increases in physics content knowledge and personal teaching self-efficacy by the end of the training.

Interestingly, although teachers' content knowledge and self-efficacy improved through the training, a relationship between the two factors was not found. The literature often identifies an increase in content knowledge as an important, though insufficient factor for improving TSE (Cakiroglu et al., 2012). Content knowledge was explicitly a focus of this training as teachers within the District report a low level of content knowledge, as measured by undergraduate major. This result further strengthens the results of the needs assessment data presented in Chapter 3, where no relationship between content knowledge and self-efficacy was evident.

While the quantitative data does not indicate a statistical link, survey responses do support the idea that deepening participant's physics knowledge was an important aspect of the training for teachers. More importantly, teachers' responses identified the various best practices of effective PD reflected in the training (Garet et al., 2001; Loucks-Horsley et al., 2003). Engaging in conversation with peers and participating in hands-on science investigations (active learning) during the training were frequently listed as key components of the training that were influential to the teachers. These data suggest that these other attributes, outside solely improving content mastery, explain teachers' improvement in self-efficacy.

In addition to general teacher self-efficacy, this study contributes to the research in this area by exploring self-efficacy within the context of teaching diverse student groups. Bandura (1977) explains that self-efficacy is an individual's notion of their ability to complete a task within a specific situation. As such, teacher self-efficacy is far from being an all-encompassing measure that applies to all classrooms, all subjects, or all student groups.

My focus is specifically on improving teachers' practice with underrepresented minorities. I draw on recent work, which suggests that an individual's biases, attitudes, and beliefs of various student groups impact, their self-efficacy to teach those groups (Crowson & Brandes, 2014; Plant & Butz, 2006). It is this link between beliefs and self-efficacy that this study seeks to explore. See Figure 2 for an illustration of these interactions.

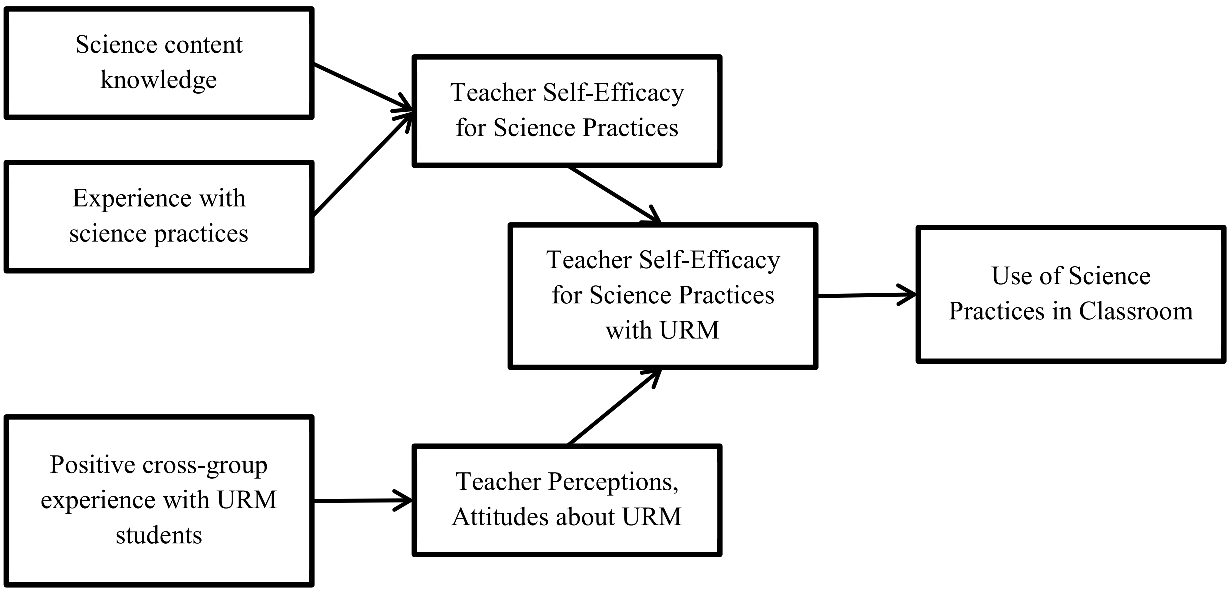


Figure 2. A causal diagram illustrating the theory of treatment supporting the intervention.

To influence participants' beliefs and attitudes, I draw upon recent work based on Allport's (1954) contact theory. Researchers have successfully utilized virtual cross-group contact to improve participants' attitudes of out-group members (Joyce & Harwood, 2014), while Mazziotta et al. (2011) also found self-efficacy to be related to participants' change. In order to explore teachers' self-efficacy to teach science to URM students, virtual cross-group contact was added to the professional development. Three videos showed positive interactions between a model science teacher and URM students as they completed lesson materials provided in the training.

Results showed that the intervention had a significant impact on teachers' science self-efficacy for URM, as well as personal self-efficacy as described above. Teachers in the treatment group exhibited an increase in PSTE, while control group participants that did not watch the videos exhibited a decrease through the training. Importantly, the divergence in self-efficacy for

URM remained three months into the school year. Data results show that the initial increase in PSTE scores realized at the end of the training decreased after time in the classroom. As for the control group, PSTE scores increased following the initial decrease measured at the end of the training. In relation to their original starting points, teachers who had the opportunity to watch the treatment videos retained a level of self-efficacy for URM students (PSTE) that remained higher than where they had started. Conversely, control group participants retained a final level of self-efficacy still lower than where they began when arriving at the training.

In their investigation with novice teachers, Hoy and Spero (2005) obtained a similar pattern of change in personal teaching self-efficacy (TSES) as they followed teachers across their first year. Initial increases in self-efficacy at the end of student teaching were followed by significant decreases in TSE following participants' year in the classroom. The authors described the resulting decrease in self-efficacy as result of truly realizing the complexity of teaching once removed from the supports of student teaching. In what may be a similar occurrence, teachers in the treatment group returned to a diverse classroom ready to implement the desired change, only to find the reality of leading students through complex science practices a more difficult task. While experiences with URM had a negative impact, teachers' in the treatment group still retained a greater level of self-efficacy for diverse students.

Unlike the treatment group, the pattern of change in self-efficacy for the control group was inverted. Teachers' self-efficacy with diverse students decreased as a result of participating in this professional development. Teachers who were similar in many aspects (experience, diversity of friends, contact with ELLs, etc.) decreased their own perceived ability to lead URM students through science practices as a result of the program. In spite of the various attributes that increased their general sense of teaching self-efficacy, without receiving any context-specific input from the training, participants felt less prepared to engage their diverse students.

In response to my first research question, these data suggest that videos as part of a professional development can effectively provide teachers with virtual cross-group contact that positively influences participants' self-efficacy for diverse student groups. These results also further stress the importance of considering Bandura's (1977) posited relationship between context and self-efficacy when crafting professional development meant to target specific classroom situations.

The second research question sought to explore any change in self-efficacy for URM following contact as being mediated by teachers' affect and beliefs of out-group students. Researchers have shown a direct relationship between self-efficacy with out-group members, and participants' anxiety and beliefs of such groups (Crowson & Brandes, 2014; Plant & Butz, 2006). As a means of intervening and improving people's negative feelings and beliefs of other groups, contact theory and positive cross-group contact have shown promise in studies (Mazziotta et al., 2011; Pettigrew et al., 2011). While data showed expected interactions between teachers' attitudes and beliefs (Figure 3), no attribute had a significant impact on self-efficacy as was hypothesized. Two aspects may account for this result. First, diverse friend networks and high measures of intergroup attitudes and beliefs for teachers of both groups may be obscuring changes. Second, the small sample sizes of both groups reduce the power of this study to determine significant interactions. A future study with a much larger sample of teachers may reveal the hypothesized effects of teachers' attitudes and beliefs on their self-efficacy.

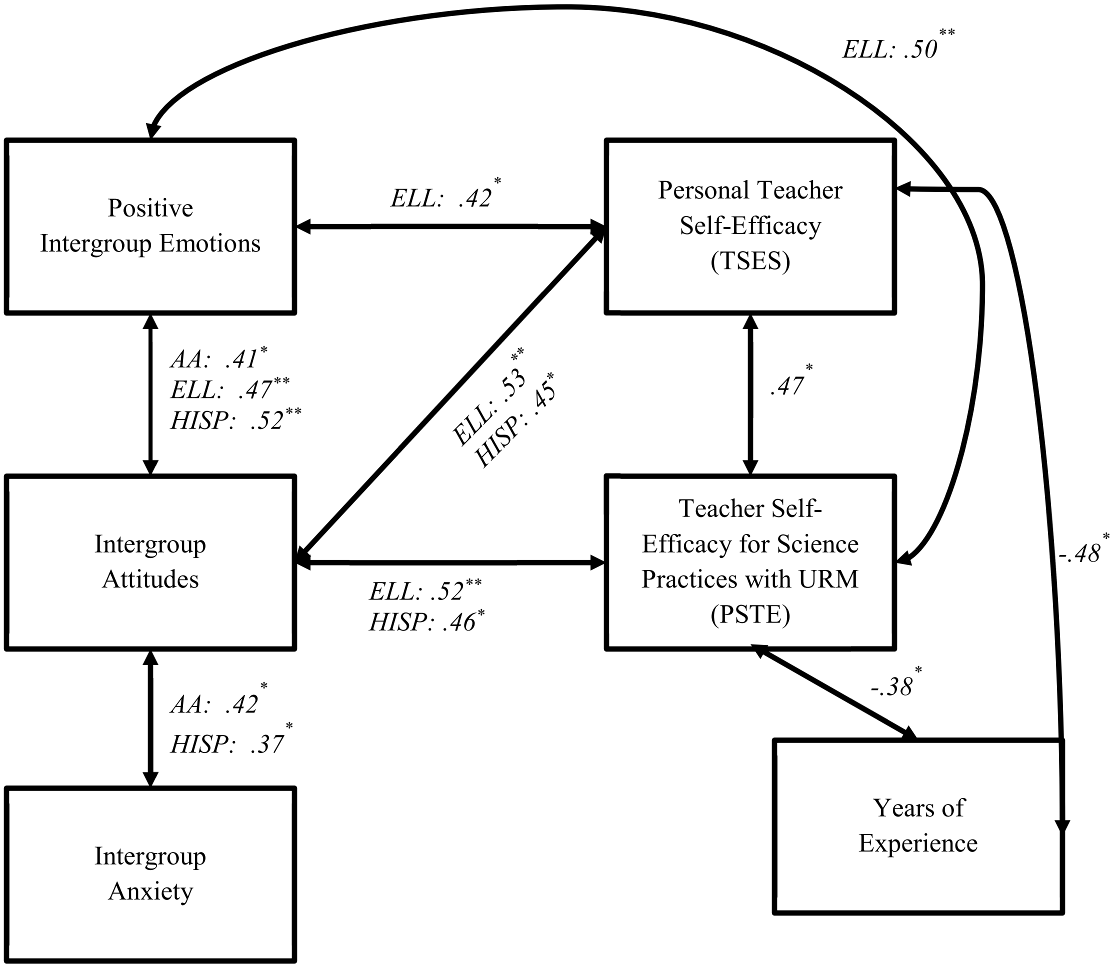


Figure 3. Model showing the correlations between teachers' beliefs and self-efficacy, and other variables.
*$p < .05$, ** $p < .001$. Only significant relationships are reported.

The discussion thus far has illustrated that most of the short-term outcomes included in the logic model (Figure 1) were realized. The quantitative data suggest that the intervention was successful at improving content knowledge and teacher self-efficacy. These results provide important information for administrators crafting professional development for science teachers. Before I transition to a discussion of such recommendations, I will elaborate on the data addressing the medium-term outcomes of changing teacher practice.

Observation data and survey results bring to light the limited effects of a singular intervention on classroom practices within science education. Researchers have documented the varying effects of even well planned professional development on change in participants' practices (Capps & Crawford, 2013; Jeanpierre et al., 2005; Lotter et al., 2013; McNeill & Knight, 2013; Yerrick et al., 1997). Here, survey responses indicate that this intervention did have an impact on teachers and that at least 6 teachers (20%) changed how they planned their practice with students. But, indeed this number reflects a minority of the study's participants. The majority of respondents either did not or had not implement the lessons yet, or they indicated that it changed what they personally did with students (e.g., explaining content in a more effective manner). This distinction highlights the difference between teacher-centered change, and the student-centered change desired with reform-oriented practices in science. The latter is illustrated in the use of science investigations that engage students in the actual practices of scientists.

The Reformed Teaching Observation Protocol was specifically designed to identity classrooms where this change to student-oriented practice has occurred. Data I collected through the RTOP further suggest that progress towards the medium-term goal of changing classroom practice requires more attention. The six observed classrooms exhibited a teacher-centered environment. The average observation score ($M = 29$, $SD = 6.48$) is below the minimum score of 50, which identifies a reformed classroom (MacIsaac & Falconer, 2002). The obtained average is also below the average value ($M = 50.0$, $SD = 14.1$) reported for 15 junior high science classrooms by Pilburn and Sawada (2000) as part of their original factor analysis. Because of the small numbers both reported by Pilburn and Sawada, and observed as a part of this study, any comparison must be qualified. Furthermore, since the observation data reflects only one occurrence collected by an untrained observer without validation from a second observer, the observations are far from definitive.

Together the teacher surveys and classroom observations do indicate that although this intervention had marked impacts on desired short-term outcomes, medium-term outcomes require further attention. This outcome is neither a surprise, nor inconsistent with the research reported here on professional development in science. A great deal of work by various researchers has documented the lengthy and sustained treatments needed to create classroom change (Desimone, 2009; Johnson, 2006; Loucks-Horsley et al., 2003; Supovitz & Turner, 2000). One PD spanning 25 hours is not sufficient; it should be situated within a larger effort sustained through the school year that supports teachers throughout the implementation (Akerson & Hanuscin, 2007; Desimone, 2009; Penuel et al., 2007). This could conceivably also serve to bolster teachers' self-efficacy as they try new practices with students, possibly preventing the decrease in self-efficacy observed in the data.

A final area uncovered by teachers' responses is the need to directly address diversity within professional development, above just videos of positive interactions. This study's focus on impacting change within diverse classrooms adds another level of complexity to the goal of bringing about pedagogical change. To specifically address this goal, I drew upon the work of multicultural education and contact theory (Allport, 1954; Banks, 2016). Multicultural education, and specifically an equity pedagogy ask teachers to "modify their teaching in ways that will facilitate the academic achievement of students from diverse racial, cultural, and social-class groups" (Banks, 2016, p. 5). To prepare science teachers for this goal, virtual cross-group contact was included to directly target teachers' beliefs and attitudes. The results are less than definitive on whether this result was obtained. Teachers' specific self-efficacy for science with diverse students was impacted as a result of the training, but a relationship between self-efficacy and cross-group beliefs was not uncovered as hypothesized. This result highlights the response from one teacher included on the final constructed response survey:

> I never got the impression that the PD was oriented towards addressing underrepresented students or differentiating the lessons beyond grade level other than when we watched the videos. We need a side-by-side video comparisons of a lesson targeted for minority vs majority students if possible. The side-by-side comparison should not be pre-ap vs. on-level either. I understand minority student may benefit more from hands-on learning, but we do that for all of our students. I understand I can use these strategies for all of my students, but it seems that teachers are expected to differentiate. How do I differentiate for these students without segregating my class? I just don't understand what I need to be doing differently, specifically targeted for these students. "Minority" or "underrepresented" is such a blanket term too and the individuals are going to vary widely (demographics, ELL, what?) Should we somehow be incorporating a type of cultural awareness? Future PD should address these questions more clearly.

The teacher's feelings suggest the added need to attend to teachers' cross-cultural competencies, that is their skills to interact successfully with students from diverse groups (Banks, 2016; Sue et al., 1982). Including Banks's (2016) multicultural pedagogy in parallel within science training as we implemented could target both teachers' beliefs and cultural competency in unison. Further studies combining science PD, virtual cross-group contact, and multicultural education are needed to uncover the impact of such a design on teacher practice.

Recommendations

We end here with recommendations to further the efforts of learning organizations laboring to change teachers' practice within the science classroom. The results uncovered through this study have significant implications for PD efforts within learning organizations to improve teacher outcomes in science. First, these outcomes importantly illustrate the need to diverge from traditional, didactic workshops and construct high-quality professional development experiences (Borko, 2004; Loucks-Horsley et al., 2003; National Academies of Sciences, Engineering, and Medicine, 2015). Even within science and with teachers with less science content knowledge, offerings that focus solely on providing teachers with content are seemingly insufficient to create change. The ability of this intervention to target all sources of efficacy-building information theorized by Bandura (1977) would account for measured outcomes.

Second, professional development that does not address the context of the diverse classroom may be negatively influencing teachers' self-efficacy. District leaders and PD providers should actively address the knowledge and skills necessary to be successful with diverse student group. To this end, videos of cross-group contact are an effective, yet seemingly insufficient way to target teachers' work with diverse students. Videos are only one aspect of what must be a larger, districtwide effort to directly improve instruction for diverse science classrooms. The results obtained here suggest the need to include explicit multicultural instruction to educate teachers about their cultural identity and to improve their cultural competency (Banks, 2016).

Finally, true reform within the classroom that results in a change for students' and teachers' roles will take more than one intervention. Cohesive and long-lasting efforts are needed if schools hope to significantly alter classroom practice. Realizing improved results for underrepresented minority students that lead to more students entering the STEM pipeline necessitates greater change in teachers than what was ultimately accomplished here.

Appendix A

District Research Approval Letter

ACCOUNTABILITY AND CONTINUOUS IMPROVEMENT

April 6, 2015
Ricardo Romanillos

Re: Request to Conduct Research

Dear :

The Independent School District (ISD or the District) reviewed your proposal to conduct the following research:

Teacher Self-Efficacy and Student Engagement in Science

Approved Campuses: Junior High, Junior High

Subject to the conditions stated herein, we are pleased to grant approval for your requested study. Although we expect a trouble-free, cooperative relationship, ISD reserves the right to withdraw its approval for the study at any time and to cease further participation in the research when, in the sole determination of ISD, such action serves the best interests of the District

Conditions for Project Approval:

- Research may be conducted only on the topic(s) and scope described in your request for approval.
- A copy of the project approval by your Institutional Review Board (IRB) or other approving body must be submitted to the undersigned before any research may begin. Contact information for such approving body must be included with the submission.
- Approval must be obtained from the principal at each school at which you wish to obtain data before any research may begin. The campus principal retains the right to decline to participate in a study and to set additional conditions for campus participation.
- Any research activities may not be conducted in a manner that in any way disrupts the operations of the campus or interrupts the work of ISD employees.
- All costs of the research must be borne by the researcher. ISD will not incur any cost in connection with the study and researcher agrees to promptly reimburse ISD if any such costs are incurred.
- Researcher may not access any identifiable student information unless and until written authorization is obtained from each student whose information is accessed. This authorization does not allow publication of information that could identify any student.
- Researcher must follow all District and campus rules when on ISD premises.
- Upon completion of your research, please submit a copy of your full report for our records.

Thank you for choosing the District to participate in your study. Please let us know if we can be of further assistance.

Sincerely,

Director, Research and Evaluation

Appendix B

Homewood Institutional Review Board Approval

JOHNS HOPKINS
UNIVERSITY

Homewood Institutional Review Board
3400 N. Charles Street
Baltimore MD 21218-2685
410-516-6580 http://web.jhu.edu/Homewood-IRB/

Michael McCloskey, PhD Chair

Date: March 21, 2014

PI Name: Christine Eith
Study #: HIRB00001701
Study Name: Research Methods 1: Needs Assessment Research as coursework for online doctoral students

Date of Review: 3/21/2014
Date of Approval: 3/21/2014

The Homewood IRB reviewed the information provided for the abovementioned project and has determined that this research does not qualify as federally regulated human subjects research, and therefore does not require IRB approval. This determination has been made with the understanding that the proposed research either (a) does not involve a systematic research investigation designed to develop or contribute to generalizable knowledge, or (b) does not collect identifiable private data about a human participant.

You may proceed with the study at any time. No further communications with the HIRB are necessary unless the procedures in your project are changed in such a manner that would require IRB review or approval.

Please keep this message in your files for future reference. Thank you for contacting the Homewood IRB about this research and for providing the requested information to make this determination. Your cooperation is greatly appreciated.

Approved Documents:

Written Consents:
Needs Assessment Consent Form Template online survey.docx
Consent form template

Written Assents:
Student Parent Consent Form Template.docx

Parental Permissions:
Student Parent Consent Form Template.docx

APPROVAL IS GRANTED UNDER THE TERMS OF **FWA00005834** FEDERALWIDE ASSURANCE OF COMPLIANCE WITH DHHS REGULATIONS FOR PROTECTION OF HUMAN RESEARCH SUBJECTS

Appendix C

Student Information Letter and Consent/Assent Form

Johns Hopkins University
Department of Education
April 7, 2015

STUDENT NAME
TEACHER - PD

Dear STUDENT,

Preparing students for the jobs of the future is a large concern for this nation. Most of the new jobs being created require the skills and knowledge gained through science and math. This survey is about how to make the science classroom more interesting, and how to make students more successful. The results will lead to new lessons and activities that science teachers will conduct in the classroom.

Teachers play a part in creating interest in a subject. The questions in this survey focus on your feelings and experiences in the science classroom. It should take no more than 15 minutes to complete.

We are asking every 7^{th} grade student at SCHOOL to participate in the survey. Your participation and answers are important to the success of this survey!

Your student ID will be utilized to gather information from the District to help answer critical questions in this study. **You can be confident, however, that your answers will be completely confidential; no one at your school or in the District will have access to your survey!**

I will be present **April 13^{th}** to conduct the survey. Please have your parents sign the attached form, and bring it back to your teacher before then. I am available to answer any questions!

Thank you for your help!

Sincerely,

Ricardo Romanillos
Doctoral Candidate

Protocol Number: HIRB00001701
Student Participant Code:______________

Johns Hopkins University
Homewood Institutional Review Board (HIRB)

Student Assent and Parental Informed Consent

Title: Research Methods 1: Needs Assessment - Research as coursework for online doctoral students
Principal Investigator: Christine Eith

Date: 3/29/2015

PURPOSE OF RESEARCH STUDY:
You are invited to participate in a research study designed to examine factors that affect students' interest and engagement in science class. Approximately 780 students will be invited to participate in this study. Your response is important in ensuring that all students' views are reflected. Your response is also needed to ensure that this study is valid.

PROCEDURES:
Participation in this study will involve completing a survey asking about your feelings and experiences in the science classroom. We anticipate that it will take 15 minutes to complete the survey.

RISKS/DISCOMFORTS:
There are no anticipated risks to students.

BENEFITS:
Although this study will not benefit you personally, we hope that our results will add to the knowledge about how to increase students' interest in science.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:
Your child's participation in this study is entirely voluntary. You choose whether to allow your child to participate, and your child will indicate below whether he or she agrees to take part in the study. If you decide not to allow your child to participate, or your child chooses not to participate, there are no penalties, and neither you nor your child will lose any benefits to which you would otherwise be entitled.

You or your child can stop participation in the study at any time, without any penalty or loss of benefits. If you want to withdraw your child from the study, or your child wants to stop participating, please contact Ricardo Romanillos via phone or email.

CONFIDENTIALITY:
Any study records that identify you or your child will be kept confidential to the extent possible by law. The records from your child's participation may be reviewed by people responsible for

making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the Office for Human Research Protections. (All of these people are required to keep your identity and the identity of your child confidential.) Otherwise, records that identify you or your child will be available only to people working on the study, unless you give permission for other people to see the records.

Surveys will be collected in paper format. Student ID will initially be collected; however data will be entered so that all identifiable information is removed by study personnel.

All research data including paper surveys will be kept in a locked office. Electronic data will be stored on the PI's computer, which is password protected. Any paper documents will be shredded ten years after collection.

Only group data will be included in publication; no individual achievement data will ever be published.

COMPENSATION:
Your child will not receive any payment or other compensation for participating in this study.

IF YOU HAVE QUESTIONS OR CONCERNS:
You and your child can ask questions about this research study at any time during the study by contacting Ricardo Romanillos via phone or email.

If you [or your child] have questions about your child's rights as a research participant or feel that your child has not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES
WHAT YOUR SIGNATURE MEANS:
Your signature below means that you understand the information in this consent form. Your signature also means that you agree to allow your child to participate in the study. Your child's signature indicates that he or she agrees to participate in the study.

By signing this consent form, you and your child have not waived any legal rights your child otherwise would have as a participant in a research study.

____
Child's Name

____
Child's Signature **Date**

____
Signature of Parent or Legal Guardian **Date**

____
Signature of Person Obtaining Consent **Date**
(Investigator or HIRB-Approved Designee)

Universidad Johns Hopkins
Departamento de Educación

07 de abril 2015

Estimado «STUDENTFIRSTNAME»,

Preparar a los estudiantes para los empleos del futuro es una gran preocupación para esta nación. La mayoría de los nuevos puestos de trabajo creados requieren las habilidades y conocimientos adquiridos a través de la ciencia y las matemáticas. Esta encuesta es sobre cómo hacer que el aula de ciencias más interesante, y cómo hacer que los estudiantes más exitosos. Los resultados darán lugar a nuevas lecciones y actividades que los profesores de ciencias llevará a cabo en el aula.

Los maestros juegan un papel en la creación de interés en un tema. Las preguntas de esta encuesta se centran en sus sentimientos y experiencias en el aula de ciencias. Se debe tomar más de 15 minutos para completar.

Estamos pidiendo a todos los estudiantes de grado 7° en «CAMPUSNAME» a participar en la encuesta. Su participación y respuestas son importantes para el éxito de esta encuesta!
Su carnet de estudiante será utilizado para recoger información del Distrito para ayudar a responder preguntas críticas en este estudio **puede ser confiado, sin embargo, que sus respuestas serán completamente confidenciales.; nadie en su escuela o en el Distrito tendrá acceso a su encuesta!**

Estaré presente en [Fecha] para realizar la encuesta. Por favor, haga que sus padres firmen el formulario adjunto, y traerlo de vuelta a su maestro antes de esa fecha. Estoy a su disposición para responder cualquier pregunta!

Gracias por su ayuda!

Un Saludo Cordial,

Ricardo Romanillos
Candidato Doctoral

Número Protocolo: HIRB00001701
Estudiante Código del participante: _____________

Universidad Johns Hopkins

Junta de Revisión Institucional Homewood (HIRB)

Consentimiento del estudiante/Consentimiento Informado de los Padres

Título: Métodos de Investigación 1: Evaluación de Necesidades - Investigación como cursos para estudiantes de doctorado en línea
Investigador Principal: Christine Eith
Fecha: 03/29/2015

PROPÓSITO DE LA INVESTIGACIÓN DE ESTUDIO:
Usted está invitado a participar en un estudio de investigación diseñado para examinar los factores que afectan el interés y el compromiso de los estudiantes en la clase de ciencias. Se invitará a aproximadamente 780 estudiantes a participar en este estudio. Su respuesta es importante para asegurar que las opiniones de todos los estudiantes se reflejan. También se necesita su respuesta para asegurarse de que este estudio es válido.

PROCEDIMIENTOS:
La participación en este estudio es la comprobación de completar una encuesta preguntando acerca de sus sentimientos y experiencias en el aula de ciencias. Anticipamos que tomará 15 minutos para completar la encuesta.

Riesgos / las molestias:
No hay riesgos previstos para los estudiantes.

BENEFICIOS:
Aunque este estudio no le beneficiará personalmente, esperamos que nuestros resultados se suman a los conocimientos sobre la forma de aumentar el interés de los estudiantes en la ciencia.

PARTICIPACIÓN VOLUNTARIA Y DERECHO A RETIRAR:
La participación de su hijo en este estudio es completamente voluntaria. Usted elige si desea permitir que su hijo participe, y su hijo se indique a continuación si él o ella está de acuerdo en participar en el estudio. Si decide no permitir que su hijo participe, o su hijo decide no participar, no hay sanciones, y ni usted ni su hijo se perderá ningún beneficio al que tendría derecho. Usted o su hijo puede dejar de participar en el estudio en cualquier momento y sin ninguna sanción o pérdida de beneficios. Si desea retirar a su hijo del estudio, o su hijo quiere dejar de participar, por favor póngase en contacto con Ricardo Romanillos por teléfono o correo electrónico.

CONFIDENCIALIDAD:
Todos los registros de estudio que usted o su hijo se identifican serán confidenciales en la medida posible por la ley. Los registros de participación de su hijo pueden ser revisados por los responsables de asegurarse de que la investigación se realiza correctamente, incluidos los miembros de la Universidad Homewood Junta de Revisión Institucional de Johns Hopkins y funcionarios de agencias gubernamentales como la Oficina de Protección de Estudios Humanos. (Todas estas personas tienen la obligación de mantener su identidad y la identidad de su hijo confidencial.) De lo contrario, los registros que identifican a usted o su hijo va a estar disponible sólo para personas que trabajan en el estudio, a menos que usted le da permiso para que otras personas vean la registros.

Las encuestas serán recogidas en formato papel. Identificación del Estudiante estará inicialmente recogido; Sin embargo los datos se introducirá de manera que toda la información de identificación se elimina por el personal del estudio.

Todos los datos de la investigación, incluyendo encuestas en papel se mantendrán en una oficina cerrada con llave. Los datos electrónicos serán almacenados en el ordenador del PI, que está protegido por contraseña. Todos los documentos en papel serán triturados diez años después de la recolección.

Sólo los datos del grupo se incluirán en la publicación; alguna vez se publicarán datos de logros individuales.

COMPENSACIÓN:

Su niño no recibirá ningún pago u otra compensación por participar en este estudio.

SI TIENE ALGUNA PREGUNTA O DUDA:

Usted y su hijo pueden hacer preguntas acerca de este estudio de investigación en cualquier momento durante el estudio poniéndose en contacto con Ricardo Romanillos por teléfono o correo electrónico.

Si usted [o su hijo] tiene preguntas acerca de los derechos del niño como sujeto de investigación o siente que su hijo no ha sido tratado de manera justa, por favor llame a la Junta de Revisión Institucional Homewood de la Universidad Johns Hopkins, al (410) 516-6580.

FIRMAS

¿QUÉ SIGNIFICA SU FIRMA?:

Su firma abajo significa que usted entiende la información de este formulario de consentimiento. Su firma también significa que usted está de acuerdo en permitir que su hijo participe en el estudio. La firma de su hijo indica que él o ella está de acuerdo en participar en el estudio.

Al firmar este formulario de consentimiento, usted y su hijo no ha renunciado a cualquier derecho legal de lo contrario su hijo tendría como participante en un estudio de investigación.

____

El nombre del niño

____

Del niño Firma Fecha

____

Firma del padre o tutor legal Fecha

____

Firma de la persona que obtiene el consentimiento Fecha
(Investigador o Designado Aprobado-HIRB)

Appendix D

Teacher Information Letter and Consent Form

Johns Hopkins University
Department of Education
April 3, 2015

Dear Science Teachers,

Preparing students for the jobs of the future is a large concern for this nation. Most of the new jobs being created require the skills and knowledge gained through science and math. This survey is about how to support science teachers in engaging students in the classroom. The results will lead to program and professional development changes that will focus on increasing student interest and persistence in science.

The questions in this survey focus on your feelings, beliefs, and challenges in working with students in the science classroom. It should take no more than 20 minutes to complete.

We are asking every science teacher in the District to participate in the survey. Your participation and answers are important to the success of this survey; we want to gather the views of all teachers!

Your identity will not be gathered during this process. **You can be confident that your answers will be completely anonymous!** Furthermore, all reports to the District will be in aggregate form.

I am available to answer any questions you might have regarding his survey. Please sign the attached consent form and return it to my office via email.

Sincerely,

Ricardo Romanillos
Doctoral Candidate

Protocol Number: HIRB00001701
Instructor Participant Code:____________

Johns Hopkins University
Homewood Institutional Review Board (HIRB)

Teacher Consent

Title: Research Methods 1: Needs Assessment - Research as coursework for online doctoral students

Principal Investigator: Christine Eith

Date: 3/21/2014

PURPOSE OF RESEARCH STUDY:
You are invited to participate in a research study designed to examine factors that affect students' interest and engagement in science class. Approximately 140 science teachers will be included in this study. Your response is important as it will ensure a diverse sample of respondents is included in the study.

PROCEDURES:
Participation in this study will involve completing a survey asking about your feelings, beliefs, and challenges in the science classroom. We anticipate that it will take 20 minutes to complete the survey.

RISKS/DISCOMFORTS:
There are no anticipated risks.

BENEFITS:
Although this study will not benefit you personally, we hope that our results will add to the knowledge about how to increase students' interest in science.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:
Your participation in this study is entirely voluntary. You choose whether to participate and take part in the study. If you decide not to participate, you will lose any benefits to which you would otherwise be entitled.

You can stop participation in the study at any time, without any penalty or loss of benefits. If you want to withdraw from the study please contact Ricardo Romanillos via phone or email.

CONFIDENTIALITY:
Any study records that identify you will be kept confidential to the extent possible by law. The records from your participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies such as the Office for Human Research Protections. (All of these people are required to keep your identity confidential.)

Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

Title: Research Methods 1: Needs Assessment - Research as coursework for online doctoral students PI: Christine Eith Date: 3/21/2014

Surveys will be collected in electronic format. Survey data will be collected via a password protected Google account. If you are unable to complete the survey electronically, paper copies will be provided. In both electronic and paper format, these data will not include identifiable information.

All research data including paper surveys will be kept in a locked office. Electronic data will be stored on the PI's computer, which is password protected. Any original electronic files will be erased and paper documents shredded, ten years after collection.

Only group data will be included in publication; no individual data will ever be published.

COMPENSATION:
You will not receive any payment or other compensation for participating in this study.

IF YOU HAVE QUESTIONS OR CONCERNS:
You can ask questions about this research study at any time during the study by contacting Ricardo Romanillos via phone or email.

If you have questions about you're your rights as a research participant or feel that you have not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES

WHAT YOUR SIGNATURE MEANS:
Your signature below means that you understand the information in this consent form.
Your signature also means that you agree to participate in the study.

By signing this consent form, you have not waived any legal rights you otherwise would have as a participant in a research study.

____
Name

____
Signature **Date**

____
Signature of Person Obtaining Consent **Date**
(Investigator or HIRB-Approved Designee)

Appendix E

Student Survey

We want to know what you think!

This is NOT a test. There are NO wrong answers. We want to know what you think about your classes, homework, and clubs.

Your answers are confidential. No one will be told what you answered. Your answers will be combined with those of other students in your school and across the city to describe what students think, do, and experience.
These connections allow us to understand how to help students succeed in school.

This survey is voluntary. You do NOT have to answer any question that you do not wish to answer, but we hope you will answer as many questions as you can.

This is your chance to help improve your school—Don't pass it up!
Thank you for your help.

Using the scale from 1 (*strongly disagree*) to 4 (*strongly agree*), answer how much you agree with the following statements about your science class.

1 Strongly disagree *2 Disagree* *3 Agree* *4 Strongly agree*

1	I usually look forward to this class.	1 2 3 4
2	I work hard to do my best in this class.	1 2 3 4
3	Sometimes I get so interested in my work I don't want to stop.	1 2 3 4
4	The topics we are studying are interesting and challenging.	1 2 3 4

Using the scale from 1 (*never*) to 5 (*almost every day*), how often do you do the following in your SCIENCE class this year?

1 Never   2 Once or twice a semester   3 Once or twice a month   4 Once or twice a week   5 Almost every day

1	Use laboratory equipment or specimens.	1 2 3 4 5
2	Write lab reports.	1 2 3 4 5
3	Generate your own hypotheses.	1 2 3 4 5
4	Use evidence/data to support an argument or hypothesis.	1 2 3 4 5
5	Find information from graphs and tables.	1 2 3 4 5

Using the scale from 1 (*not confident at all*) to 6 (*completely confident*), answer the questions about your SCIENCE class.

1   2   3   4   5   6

Not confident at all ... Completely Confident

1	How confident are you that you will **pass science class at the end of this semester?**	1 2 3 4 5 6
2	How confident are you that you will pass science at the end of this semester with **a grade better than a D?**	1 2 3 4 5 6
3	How confident are you that you will get **a grade better than a C**?	1 2 3 4 5 6
4	How confident are you that you will get **a grade better than a B**?	1 2 3 4 5 6
5	*How confident are you that you will get* **an A?**	1 2 3 4 5 6

Identificación del estudiante: _____________

Queremos saber lo que piensa de su clase de ciencia. Esto nos ayudará a cambiar nuestras lecciones y actividades para hacerlos más interesantes, ya que todo el mundo con éxito.

Esto no es una prueba. No hay respuestas equivocadas.

Sus respuestas son confidenciales. A nadie se le dirá lo que contestaste. Sus respuestas serán combinadas con las de otros estudiantes en su escuela y en toda la ciudad para describir lo que piensan los estudiantes, lo hacen, y la experiencia. Estas conexiones permiten comprender cómo ayudar a los estudiantes a tener éxito en la escuela.

Esta es tu oportunidad para ayudar a mejorar su escuela!

Gracias por su ayuda.

Utilizando la escala de 1 (muy en desacuerdo) a 4 (muy de acuerdo), responder qué tan de acuerdo con las siguientes declaraciones acerca de su clase de ciencias.

		Muy en desacuerdo	*Discrepar*	*Estar De Acuerdo*	*Muy de acuerdo*
1	Por lo general deseoso de esta clase.	1	2	3	4
2	Trabajo duro para hacerlo lo mejor posible en esta clase.	1	2	3	4
3	A veces me siento tan interesado en mi trabajo yo no quiero parar.	1	2	3	4
4	Los temas que estamos estudiando son interesantes y desafiantes.	1	2	3	3

Utilizando la escala del 1 (nunca) a 5 (casi todos los días), ¿con qué frecuencia lo hace lo siguiente en su clase de ciencias de este año?

		Que Nunca	*Una o dos veces por semestre*	*Una o dos veces al mes*	*Una o dos veces a la semana*	*Casi todos los días*
1	Utilice equipos de laboratorio o muestras.	1	2	3	4	5
2	Escribir informes de laboratorio.	1	2	3	4	5
3	Genere sus propias hipótesis.	1	2	3	4	5
4	Utilice evidencias / datos para apoyar un argumento o hipótesis.	1	2	3	4	5
5	Encuentra información de gráficos y tablas.	1	2	3	4	5

Utilizando la escala de 1 *(no confía en absoluto)* a 6 *(completamente seguro),* responder a las preguntas acerca de su clase de ciencias.

		Ninguna confianza					*Completamente Confiado*
1	¿Qué tan seguro está de que se **pasa a la clase de ciencias al final de este semestre?**	1	2	3	4	5	6
2	¿Qué tan seguro está de que se pasa a la ciencia, al final de este semestre con **una calificación mejor que un D?**	1	2	3	4	5	6
3	¿Qué tan seguro está de que obtendrá **una calificación mejor que un C?**	1	2	3	4	5	6
4	¿Qué tan seguro está de que obtendrá **una calificación mejor que un B?**	1	2	3	4	5	6
5	*¿Qué tan seguro está de que obtendrá* **una A?**	1	2	3	4	5	6

Appendix F

Teacher Survey

Background

Please answer the following questions.

1.	Indicate your campus level.	Junior High…………………………… High School………………………..	1 2
2.	Which best describes you?	American Indian or Alaskan Native.. Asian or Pacific Islander…………... Hispanic, regardless of race……….. Black, not of Hispanic Origin……... White, not of Hispanic Origin……..	1 2 3 4 5
3.	Counting this year, how many years have you taught at the elementary or secondary level?	__ __ years	
4.	What is the highest academic degree you hold?	Bachelor's …………………………. Master's …………………………… Doctorate ………………………….. Professional Degree (e.g., D.D.S, M.D., J.D.)..……………………….	1 2 3 4
5.	What was your major field of study for your bachelors?		
6.	What was your minor field of study for your bachelors, if any?		
7.	If you earned a graduate degree, what was your major field of study for your highest graduate degree?		
8.	What type of certification program did you complete?	Traditional (University-Based)……. Alternative …………………………	1 2

Teacher Beliefs - TSES

This questionnaire is designed to help us gain a better understanding of the kinds of things that create challenges for teachers. Your answers are confidential.

Directions: Please indicate your opinion about each of the questions below by marking any one of the nine responses in the columns on the right side, ranging from (1) "None at all" to (9) "A Great Deal" as each represents a degree on the continuum.

Please respond to each of the questions by considering the combination of your *current* ability, resources, and opportunity to do each of the following in your present position.

	None at all		Very Little		Some Degree		Quite A Bit		A Great Deal
1. How much can you do to get through to the most difficult students?	1	2	3	4	5	6	7	8	9
2. How much can you do to help your students think critically?	1	2	3	4	5	6	7	8	9
3. How much can you do to control disruptive behavior in the classroom?	1	2	3	4	5	6	7	8	9
4. How much can you do to motivate students who show low interest in school work?	1	2	3	4	5	6	7	8	9
5. To what extent can you make your expectations clear about student behavior?	1	2	3	4	5	6	7	8	9
6. How much can you do to get students to believe they can do well in school work?	1	2	3	4	5	6	7	8	9
7. How well can you respond to difficult questions from your students?	1	2	3	4	5	6	7	8	9
8. How well can you establish routines to keep activities running smoothly?	1	2	3	4	5	6	7	8	9
9. How much can you do to help your students value learning?	1	2	3	4	5	6	7	8	9
10. How much can you gauge student comprehension of what you have taught?	1	2	3	4	5	6	7	8	9
11. To what extent can you craft good questions for your students?	1	2	3	4	5	6	7	8	9
12. How much can you do to foster student creativity?	1	2	3	4	5	6	7	8	9
13. How much can you do to get children to follow classroom rules?	1	2	3	4	5	6	7	8	9
14. How much can you do to improve the understanding of a student who is failing?	1	2	3	4	5	6	7	8	9
15. How much can you do to calm a student who is disruptive or noisy?	1	2	3	4	5	6	7	8	9
16. How well can you establish a classroom management system with each group of students?	1	2	3	4	5	6	7	8	9
17. How much can you do to adjust your lessons to the proper level for individual students?	1	2	3	4	5	6	7	8	9
18. How much can you use a variety of assessment strategies?	1	2	3	4	5	6	7	8	9
19. How well can you keep a few problem students form ruining an entire lesson?	1	2	3	4	5	6	7	8	9
20. To what extent can you provide an alternative explanation or example when students are confused?	1	2	3	4	5	6	7	8	9
21. How well can you respond to defiant students?	1	2	3	4	5	6	7	8	9
22. How much can you assist families in helping their children do well in school?	1	2	3	4	5	6	7	8	9
23. How well can you implement alternative strategies in your classroom?	1	2	3	4	5	6	7	8	9
24. How well can you provide appropriate challenges for very capable students?	1	2	3	4	5	6	7	8	9

Appendix G

District Research Approval Letter

ACCOUNTABILITY AND CONTINUOUS IMPROVEMENT

May 23, 2016
Mr. Ricardo Romanillos

Re: Request to Conduct Research

Dear Mr. Ricardo Romanillos:

The Independent School District (ISD or the District) reviewed your proposal to conduct the following research:

Improving science teachers' self-efficacy for science practices with diverse students
Approved Campuses: All Elementary and Junior High Schools

Subject to the conditions stated herein, we are pleased to grant approval for your requested study. Although we expect a trouble-free, cooperative relationship, ISD reserves the right to withdraw its approval for the study at any time and to cease further participation in the research when, in the sole determination of ISD, such action serves the best interests of the District.

<u>Conditions for Project Approval</u>:

- Research may be conducted only on the topic(s) and scope described in your request for approval.
- A copy of the project approval by your Institutional Review Board (IRB) or other approving body must be submitted to the undersigned before any research may begin. Contact information for such approving body must be included with the submission.
- Approval must be obtained from the principal at each school at which you wish to obtain data before any research may begin. The campus principal retains the right to decline to participate in a study and to set additional conditions for campus participation. If researcher is a principal, the executive director of the approved campus must give approval for the research.
- Teacher consent must be obtained before teachers participate in your study.
- Any research activities may not be conducted in a manner that in any way disrupts the operations of the campus or interrupts the work of ISD employees.
- All costs of the research must be borne by the researcher. ISD will not incur any cost in connection with the study and researcher agrees to promptly reimburse ISD if any such costs are incurred.
- Researcher may not access any identifiable student information unless and until written authorization is obtained from each student whose information is accessed. This authorization does not allow publication of information that could identify any student.
- Researcher must follow all District and campus rules when on ISD premises.
- Upon completion of your research, please submit a copy of your full report for our records.

Thank you for choosing the Independent School District to participate in your study. Please let us know if we can be of further assistance.

Sincerely,

Director, Research & Evaluation
Accountability and Continuous Improvement

Appendix H

Homewood Institutional Review Board Approval

JOHNS HOPKINS
U N I V E R S I T Y

Homewood Institutional Review Board
3400 N. Charles Street
Baltimore MD 21218-2685
410-516-6580
http://web.jhu.edu/Homewood-IRB/

Michael McCloskey, PhD
Chair

Date: June 7, 2016

PI Name: Carolyn Parker
Study #: HIRB00004425
Study Name: Improving science teachers' self-efficacy for science practices with diverse students

Date of Review: 6/1/2016
Date of Approval: 6/1/2016
Expiration Date: 6/1/2019

The above referenced study has been *approved*.

Review Type:	Exempt
Funding Agency:	Not funded Private
Grant or Contract Number:	null
International Sites:	No
Maximum number of participants:	102
Vulnerable populations:	None
Consent process:	Written Informed Consent
Assent Process:	

Please keep in mind that it is your responsibility to inform the HIRB of any adverse consequences to participants that occur in the course of the study, as well as any complaints from participants regarding the research. In conducting this research, you are required to follow the requirements listed in the *HIRB Policies and Procedures Manual*.

Approved Documents:

Written Consents:
Teacher Consent Form

Recruiting Materials:
irb_Teacher Recruitment Script.docx
Recruiting PowerPoint

Study Team Members:
Ricardo Romanillos

APPROVAL IS GRANTED UNDER THE TERMS OF **FWA00005834** FEDERAL-WIDE ASSURANCE OF COMPLIANCE WITH DHHS REGULATIONS FOR PROTECTION OF HUMAN RESEARCH SUBJECTS

Appendix I

Summary Matrix

Indicator	Role of Indicator	Instrument	Frequency
Research Question 1			
Teacher Background			
Years of experience	Control	Survey	Once/Prior to intervention
Undergraduate degree	Control	Survey	Once/Prior to intervention
Race/ethnicity	Control	Survey	Once/Prior to intervention
Campus percent low socioeconomic status	Control	Extant	Once/Prior to intervention
Prior cross-group contact	Control	Survey (Voci & Hewstone, 2003)	Once/Prior to intervention
Cross-group friends	Control	Survey (Pettigrew & Meertens, 1995)	Once/Prior to intervention
Content knowledge	Mediating variable	Local assessment	On first and last day
Teacher efficacy	Nonequivalent dependent variable	Teacher Sense of Equity Scale (Tschannen-Moran & Hoy, 2001)	Prior to intervention and on last day
Science teaching efficacy	Outcome variable	Survey adapted from Science Teaching Efficacy Belief Instrument (Riggs & Enochs, 1990)	Prior to intervention and on last day

Research Question 2

Intergroup attitude	Mediating variable	General evaluation scale (Wright et al., 1997)	On last day
Intergroup anxiety	Mediating variable	Intergroup anxiety (Stephan & Stephan, 1985)	On last day
Subtle Prejudice	Mediating variable	Subtle prejudice scale (Pettigrew & Meertens, 1995)	On last day
Reflection survey	Outcome variable	Constructed response	End of program

Appendix J

Teacher Background Survey

Please answer the following questions.

1.	Indicate your campus level.	Elementary………………………… 1 Junior High ……………………….. 2
2.	Which best describes you?	American Indian or Alaskan Native.. 1 Asian or Pacific Islander………….. 2 Hispanic, regardless of race……….. 3 Black, not of Hispanic Origin……... 4 White, not of Hispanic Origin…….. 5
3.	Counting this year, how many years have you taught at the elementary or secondary level?	__ __ years
4.	What is the highest academic degree you hold?	Bachelor's …………………………. 1 Master's …………………………… 2 Doctorate ………………………….. 3 Professional Degree (e.g., D.D.S, M.D., J.D.)..………………………. 4
5.	What was/were your major field(s) of study for your bachelor's degree?	
6.	What was your minor field of study for your bachelor's degree, if any?	
7.	If you earned a graduate degree, what was your major field of study for your highest graduate degree?	
8.	What type of certification program did you complete?	Traditional (University-Based)……. 1 Alternative ………………………… 2
9.	How much of your day do you spend teaching on-level, inclusion, and/or ESL classes?	[*None 1…2…3…4…5 All*]
10.	When you teach this/these class(es), in general how do you find it?	
	10a.	[*Unpleasant 1…2…3…4…5 Pleasant*]
	10b.	[*Natural 1…2…3…4…5 Forced*]
	10c.	[*Disengaging 1…2…3…4…5 Engaging*]
11.	How much of your day do you spend teaching PreAP, Gifted & Talented classes, and/or accelerated classes?	[*None 1…2…3…4…5 All*]
12.	When you teach this/these class(es), in general how do you find it?	
	12a.	[*Unpleasant 1…2…3…4…5 Pleasant*]
	12b.	[*Natural 1…2…3…4…5 Forced*]
	12c.	[*Disengaging 1…2…3…4…5 Engaging*]

13.	In your network of friends, how many friends of ______ do you have?	
	13a. another nationality	None ……………………………… 1 A Few ……………………………... 2 Many………………………………. 3
	13b. a different religion	None ……………………………… 1 A Few ……………………………... 2 Many………………………………. 3
	13c. a different race	None ……………………………… 1 A Few ……………………………... 2 Many………………………………. 3
	13d. a different sexual orientation	None ……………………………… 1 A Few ……………………………... 2 Many………………………………. 3
	13e. a different economic level	None ……………………………… 1 A Few ……………………………... 2 Many………………………………. 3

Appendix K

Science Teaching Efficacy Beliefs Instrument

Directions: Please indicate the degree to which you agree or disagree with each statement below by circling a response.

1 Strongly Disagree…………… 5 Uncertain……………9 Strongly Agree

1. When a minority student does better than usual in science, it is often because the teacher exerted a little extra effort.
2. I am continually finding better ways to teach science to on-level students.
3. I can teach science as well as I would like.
4. When the science grades of on-level students improve, it is most often due to their teacher having found a more effective teaching approach.
5. I know the steps necessary to teach science concepts effectively to minority students.
6. I can effectively monitor science experiments with underrepresented students.
7. If underrepresented students are underachieving in science, it is most likely due to ineffective science teaching.
8. I can generally teach science effectively.
9. The inadequacy of a minority student's science background can be overcome by good teaching.
10. The low science achievement of some students cannot generally be blamed on their teachers.
11. When a struggling student progresses in science, it is usually due to extra attention given by the teacher.
12. I understand science concepts well enough to be effective in teaching on-level science.
13. Increased effort in science teaching produces little change in underrepresented students' science achievement.
14. The teacher is generally responsible for the achievement of all students in science.
15. Students' achievement in on-level science is directly related to their teacher's effectiveness in science teaching.
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
17. I can explain to minority students why science experiments work.
18. I can answer students' science questions.
19. I have the necessary skills to teach on-level science.
20. Effectiveness in science teaching has little influence on the achievement of minority students with low motivation.
21. Given a choice, I would not invite the principal to evaluate my science teaching.
22. When an underrepresented student has difficulty understanding a science concept, I can help the student understand it better.
23. When teaching science, I usually welcome student questions.
24. I can turn all underrepresented students on to science.
25. Even teachers with good science teaching abilities cannot help some kids learn science.

Appendix L

Teacher Self-Efficacy Survey – Short Form

Teacher Beliefs - TSES

This questionnaire is designed to help us gain a better understanding of the kinds of things that create challenges for teachers. Your answers are confidential.

Directions: **Please indicate your opinion about each of the questions below by marking any one of the nine responses in the columns on the right side, ranging from (1) "None at all" to (9) "A Great Deal" as each represents a degree on the continuum.**

Please respond to each of the questions by considering the combination of your *current* ability, resources, and opportunity to do each of the following in your present position.

	None at all		Very Little		Some Degree		Quite A Bit		A Great Deal
1. How much can you do to control disruptive behavior in the classroom?	1	2	3	4	5	6	7	8	9
2. How much can you do to motivate students who show low interest in school work?	1	2	3	4	5	6	7	8	9
3. How much can you do to get students to believe they can do well in school work?	1	2	3	4	5	6	7	8	9
4. How much can you do to help your students value learning?	1	2	3	4	5	6	7	8	9
5. To what extent can you craft good questions for your students?	1	2	3	4	5	6	7	8	9
6. How much can you do to get children to follow classroom rules?	1	2	3	4	5	6	7	8	9
7. How much can you do to calm a student who is disruptive or noisy?	1	2	3	4	5	6	7	8	9
8. How well can you establish a classroom management system with each group of students?	1	2	3	4	5	6	7	8	9
9. How much can you use a variety of assessment strategies?	1	2	3	4	5	6	7	8	9
10. To what extent can you provide an alternative explanation or example when students are confused?	1	2	3	4	5	6	7	8	9
11. How much can you assist families in helping their children do well in school?	1	2	3	4	5	6	7	8	9
12. How well can you implement alternative strategies in your classroom?	1	2	3	4	5	6	7	8	9

Appendix M

Intergroup Attitudes & Beliefs Survey

The next four sections will ask you about your feelings regarding the various student groups (ELLs, African American, Hispanic, White) within your classroom.

1 - never …*3* - not too often…*5* - fairly often…*7* - Very often

1. How often have you felt sympathy for [ethnic group]?
2. How often have you felt admiration for [ethnic group]?

Describe how you feel about [ethnic group] in general using the following descriptors.

1….2….3….4….5…6…7

1. Warm – Cold
2. Negative – Positive
3. Friendly – Hostile
4. Suspicious – Trusting
5. Respect – Contempt
6. Admiration – Disgust

In a hypothetical situation, how would you feel if you were the only person among a group of strangers all of whom were from a different racial or ethnic group?

[Not at all – *1…2….3….4…. 5* – Very]

1. Awkward
2. Self-conscious
3. Defensive
4. Happy
5. Confident
6. Accepted

Appendix N

Reformed Teaching Observation Protocol

Appendix II
Reformed Teaching Observation Protocol (RTOP)

Daiyo Sawada
External Evaluator

Michael Piburn
Internal Evaluator

and

Kathleen Falconer, Jeff Turley, Russell Benford and Irene Bloom
Evaluation Facilitation Group (EFG)

Technical Report No. IN00-1
Arizona Collaborative for Excellence in the Preparation of Teachers
Arizona State University

I. BACKGROUND INFORMATION

Name of teacher ____________________ Announced Observation? ____________________
(yes, no, or explain)

Location of class ____
(district, school, room)

Years of Teaching ______________ Teaching Certification ______________
(K-8 or 7-12)

Subject observed ____________________ Grade level ____________________

Observer ____________________ Date of observation ____________________

Start time ____________________ End time ____________________

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.

III. LESSON DESIGN AND IMPLEMENTATION

		Never Occurred				Very Descriptive
1)	The 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

IV. CONTENT

Propositional knowledge

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 when 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 thought-provoking 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

V. CLASSROOM CULTURE

Communicative Interactions		Never Occurred				Very Descriptive
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 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

Student/Teacher Relationships

21)	Active participation of students was encouraged and valued.	0	1	2	3	4
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

Additional comments you may wish to make about this lesson.

Appendix O

Reflection Survey

1. What other science professional development have you attended this summer or fall? Please include general topics and duration, for example: Differentiation in Science – 6 hrs.

2. What components of the Force & Motion professional development provided this summer and fall did you find to be most useful in your teaching assignment?

3. How have you integrated the new knowledge and skills you gained through the physics professional development into your practices?

4. How could future professional development be improved to impact teachers' work with diverse students?

Appendix P

Dot Car Lesson Plan

Forces and Motion, WestEd

LP – Dot Cars: Velocity, Speed and Acceleration

<u>TEKS</u>

6.8 Force, motion, and energy. The student knows force and motion are related to potential and kinetic energy. The student is expected to:

C calculate average speed using distance and time measurements; **(SS)**

D measure and graph changes in motion; **(SS)**

8.6 Force, motion, and energy. The student knows that there is a relationship between force, motion, and energy. The student is expected to:

B differentiate between speed, velocity, and acceleration; **(SS)**

<u>KUDs</u>

Understand

G7 Systems are interdependent, not independent.
G8 All motions are governed by the laws of physics.
Physics Motion is predictable.

Know

6.8C Speed is determined from measurements of distance and time.
6.8D Motion measurements represented on a graph are used to describe motion.
8.6B Speed, velocity, and acceleration are measurements of motion.
8.6B Velocity indicates both speed and direction.
8.6B Acceleration is any change in the velocity (speed and/or direction) of an object.
Physics The different states of motion are rest, constant, and accelerated.
Physics The movement of an object must be described in relation to a point of origin.
Physics Distance is the measure of length without regard to direction.
Physics Speed is the rate at which distance is covered.
Physics Acceleration is a change in motion.
Physics Motion can be graphically represented.

Do

6.8C Calculate average speed using the formula (s=d/t) from collected data or data table.
6.8D Interpret sample graphs (distance vs. time; speed vs. time) to identify changes in motion.
8.6B Define speed, velocity and acceleration.
8.6B Given an everyday example of an object in motion, describe the object's motion in terms of speed, velocity, and acceleration, and differentiate between the applicable descriptors.
Physics Identify and describe motion relative to different frames of reference.
Physics Generate and interpret graphs and charts describing different types of motion.

<u>Materials per Group</u>

Day 1 – (3) foam tube sections, 1 CPO steel marble, 1 WS-Direction Card Day 1, a pad of post it notes
Day 2 – meter stick, dot car, (2) 3m x 15cm paper strips, sharpie marker, (1) steel ramp, (1) ramp stand, 1 WS-Direction Card Day 2
Day 3 – meter stick, dot car, (1) 3m x 15cm paper strips, sharpie marker, (2) steel ramp, (1) ramp stand, 1 ramp stand cardboard box (or any 3cm tall platform to use to prop up the ramp), 1 WS-Direction Card Day 3, 1 WS-Dot Car Data Table Student Page, 1 WS- Dot Car Graph Table Student Page

<u>Procedure</u>

Teacher Activity Setup:

1. Establish a method for grouping the students (3-4 students per group) to determine the number of sets you need to prepare.
2. Preview Change in Motion section, pg 2-1 – 2-11, the dot car segments in WestEd Force and Motion Teacher book.

Warm up:

Have a roller coaster segment playing as students come in.
https://youtu.be/dQA1Ien24fc

Activity

Day 1

1. Engage: Each group builds a portion of a roller coaster by holding the 3 tubes end to end. This could be any section of the roller coaster. Have 2 people hold the 3 parts together, and have 3rd person let the marble "ride" your exciting roller coaster. Marble has to go all the way through the 3 sections of track, from start to finish.
2. Students describe the marble's motion as if they were telling their friends how cool the roller coaster was. What motions happened? Write all the description motion words on post-it notes, 1 word per note. Students will bring their groups post-its to add to the list, amassing the student words to make an "Everyday Words for Motion" word wall of motion descriptors (on the big chart paper or white board at the front).
3. Brainstorm with the students to create a "Science Words for Motion wall, to turn their words into Science words. Direct the Science word discussion to be about "acceleration," meaning speeding up, slowing down, and changing direction.

   Ask: How do you hear the word acceleration used when they are not in Science class?
   Ask: A car has 3 accelerators; what are they? *gas pedal, the brakes and the steering wheel*

Day 2

1. Engage: Entire class circles around the teacher who has a constant rate car. Explain that students will have a washer to put down at 5 second time intervals to mark the rate the car is moving. Students will see the distance in between washers is the same, showing the car is moving at a constant speed. Repeat the same demo going the opposite direction to show that constant speed is not affected by direction or distance traveled.
2. Explain to students there is a dot car at each lab table. They will need to set up on the floor in a 10ft long area. They will follow the (guided) directions on the instruction cards, using ramps, meter sticks, dot cars and markers.
   - Put the long paper on the ramp, taping it to the top ramp end, and making sure the paper is flat for the dot car "track."
   - Turn on the dot car and let it roll down the ramp.
   - Pick up the car when it reaches the end of the paper.
   - Collect your data – use the front of the marker lines on the paper made by the car
   - Make a data table.
   - Calculate the change in time and the distance between dots.
   - Make a graph.
   - Write up your conclusions:
     What can you say about the motion of the dot car? (CLAIM)
     What EVIDENCE supports your claim?
     Explain your REASONING. (Use words and math.)
3. Record data – going down the ramp, and when the track flattens out.

Day 3

1. Entrance ticket from WestEd book, page "Task M"
2. Graphing... See Directions Card with table and graph

Direction Card – Day 1

Materials:

3 foam tubes, 1 marble, 1 pencil, post-it notes

Challenge:

Build an exciting portion of a roller coaster by holding the tubes end to end. This could be any section of a roller coaster. Have 2 people hold the tubes together, and have the 3rd person let the marble "ride" your exciting roller coaster. Goal: The marble has to go all the way through the 3 sections of track, from start to finish.

Tell about it:

Each person takes turns describing the marble's motion using everyday words, as if you were telling your friends how cool the roller coaster was. Write each of your motion words on separate post-it notes, one word per post-it note.

Direction Card – Day 2

Materials, in the order you will need them:

1 table-length paper, 1 dot car, 2 markers, 1 ramp, 1 stand, 1 long paper, 1 meter stick, 1 data table

Warm-Up – No Ramp:

TRIAL 1 -

1. Put the dot car at the end of the paper.
2. Put the Sharpie marker (without the cap) into the car.
3. Turn on the dot car.
4. Give the dot car a gentle push (it cannot fall off the table!!!)
5. Pick up the car when it reaches the end of the paper, or when it stops (whichever happens first).
6. What do you notice about the marks?

TRIAL 2 -

7. Repeat steps 1-5 using a different color pen.
8. Are the results the same as Trial 1?

Set-Up: Place the ramp and stand on the floor JUST LIKE IT IS on the table.

¡¡CAUTION: THE RAMP EDGES ARE SUPER SHARP!!

Follow the 8 steps below:

RAMP RELEASE 1 -

1. Put the long paper on the ramp, taping it to the top ramp end, and making sure the paper is flat and smooth for the entire dot car "track."
2. Put the dot car at the top of the ramp.
3. Put the Sharpie marker (without the cap) into the car.
4. Turn on the dot car.
5. Let the car roll down the ramp.
6. Pick up the car when it reaches the end of the paper, or when it stops (whichever happens first).
7. Collect your data –
    a. Mark the front of the marker lines on the paper
    b. Number each line – 1st mark is 1, 2nd mark is 2, etc. (These are called POSITION points.)
    c. Measure (in cm. using the meter stick) the distance between each mark.

RAMP RELEASE 2 -

8. Repeat steps 1-7 using a different color pen.
9. Are the results close to Ramp Release 1?
10. Fill in the data table from your measurements FROM EITHER Release 1 or Release 2

Direction Card – Day 3

Materials:

1 dot car, 2 markers, 1 ramp, 1 stand, 1 long paper, 1 meter stick, 1 data table, 1 graph

Set-Up: Place the ramp and stand on the floor JUST LIKE IT IS on the table.

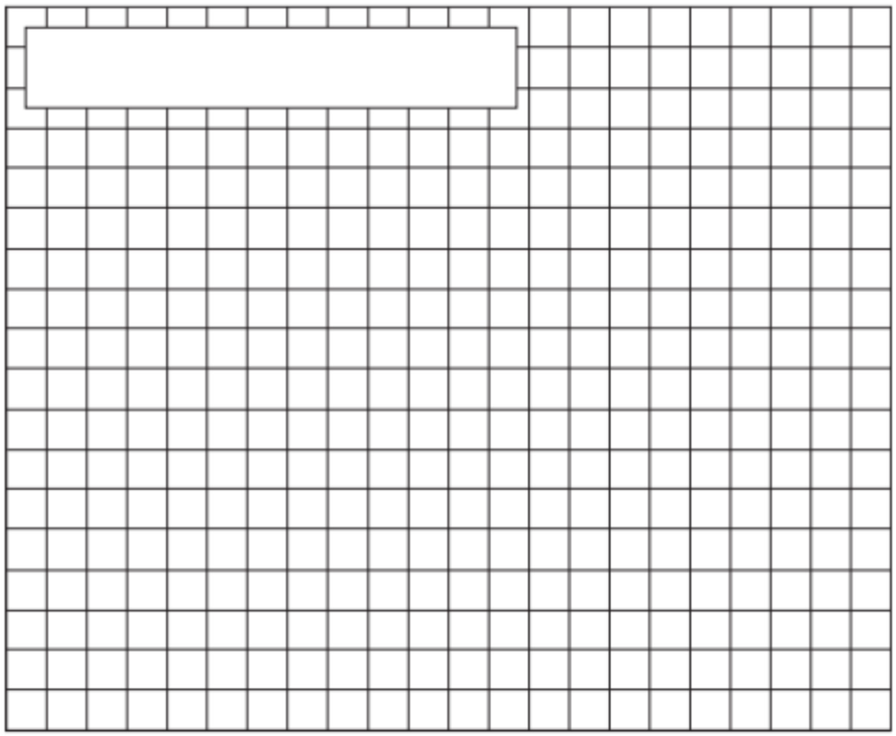
¡¡CAUTION: THE RAMP EDGES ARE SUPER SHARP!!

1. Put the long paper on the ramp, taping it to the top ramp end, and making sure the paper is flat and smooth for the entire dot car "track."
2. Put the dot car at the top of the ramp.
3. Put the Sharpie marker (without the cap) into the car.
4. Turn on the dot car.
5. Let the car roll down the ramp.
6. Pick up the car when it reaches the end of the paper, or when it stops (whichever happens first).

7. Collect your data –
    a. Mark the front of the marker dot lines on the paper
    b. Measure the distance between each mark (use cm.)
    c. Number each dot line – 1st mark is 1, 2nd mark is 2, etc.
8. Fill in the data table from your measurements.

Dot#	time (sec)	distance (cm)	change in time Δt	change in distance Δd	final velocity $\frac{\Delta d}{\Delta t}$
1	0.5		0.5		
2	1.0		0.5		
3	1.5		0.5		
4	2.0		0.5		
5	2.5		0.5		
6	3.0		0.5		
7	3.5		0.5		
8	4.0		0.5		
9	4.5		0.5		
10	5.0		0.5		
11	5.5		0.5		
12	6.0		0.5		

Graph your data!



1. Label the X-axis TIME.
2. Label the Y-axis DISTANCE.
3. Put the increments on the X and Y axis using the Δt, and Δd.
4. Plot the points.
5. Title your graph!

References

Ackerman, P. L., Kanfer, R., & Calderwood, C. (2013). High school advanced placement and student performance in college: STEM majors, non-STEM majors, and gender differences. *Teachers College Record, 115*(10), 1-43. Retrieved from http://www.tcrecord.org

Akerson, V. L., & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching, 44*(5), 653-680. doi:10.1002/tea.20159

Allport, G. W. (1954). *The nature of prejudice*. Reading, MA: Addison-Wesley.

Appleton, J. J., Christenson, S. L., Kim, D., & Reschly, A. L. (2006). Measuring cognitive and psychological engagement: Validation of the student engagement instrument. *Journal of School Psychology, 44*(5), 427-445. doi:10.1016/j.jsp.2006.04.002

Appleton, J. J., & Lawrenz, F. (2011). Student and teacher perspectives across mathematics and science classrooms: The importance of engaging contexts. *School Science and Mathematics, 111*(4), 143-155. doi:10.1111/j.1949-8594.2011.00072.x

Armor, D., Conroy-Oseguera, P., Cox, M., King, N., McDonnell, L., Pascal, A., . . . Zellman, G. (1976). *Analysis of the school preferred reading program in selected Los Angeles minority schools.* (No. R-2007-LAUSD). Santa Monica, CA: RAND.

Avery, L. M., & Meyer, D. Z. (2012). Teaching science as science is practiced: Opportunities and limits for enhancing preservice elementary teachers' Self-Efficacy for science and science teaching. *School Science and Mathematics, 112*(7), 395-409. doi:10.1111/j.1949-8594.2012.00159.x

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. doi:10.1037/0033-295X.84.2.191

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, N.J.: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman and Co.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares, & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307-337). Grenwhich, CT: Information Age.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187-206. doi:10.1111/1467-8624.00273

Banks, J. A. (2016). *Cultural diversity and education: Foundations, curriculum, and teaching*. New York, NY: Routledge.

Battey, D., & Franke, M. (2015). Integrating professional development on mathematics and equity: Countering deficit views of students of color. *Education and Urban Society, 47*(4), 433-462. doi:10.1177/0013124513497788

Bianchini, J. A., Dwyer, H. A., Brenner, M. E., & Wearly, A. J. (2015). Facilitating science and mathematics teachers' talk about equity: What are the strengths and limitations of four strategies for professional learning? *Science Education, 99*(3), 577-610. doi:10.1002/sce.21160

Bolshakova, V. L. J., Johnson, C. C., & Czerniak, C. M. (2011). "It depends on what science teacher you got": Urban science self-efficacy from teacher and student voices. *Cultural Studies of Science Education, 6*(4), 961-997. doi:10.1007/s11422-011-9346-2

Bolyard, J. J., & Moyer-Packenham, P. S. (2008). A review of the literature on mathematics and science teacher quality. *Peabody Journal of Education, 83*(4), 509-535. doi:10.1080/01619560802414890

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15. doi:10.3102/0013189X033008003

Bouchey, H. A., & Harter, S. (2005). Reflected appraisals, academic self-perceptions, and math/science performance during early adolescence. *Journal of Educational Psychology, 97*(4), 673. doi:10.1037/0022-0663.97.4.673

Boutakidis, I. P., Rodríguez, J. L., Miller, K. K., & Barnett, M. (2014). Academic engagement and achievement among latina/o and non-latina/o adolescents. *Journal of Latinos and Education, 13*(1), 4-13. doi:10.1080/15348431.2013.800815

Bransford, J. D., Brown, A. L., & Cocking, R. R. (1999). *How people learn: Brain, mind, experience, and school.* Washington, D.C.: National Academy Press.

Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. *Journal of Women and Minorities in Science and Engineering, 7*(4) doi:10.1615/JWomenMinorScienEng.v7.i4.10

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42. Retrieved from http://www.jstor.org/stable/1176008

Bruning, R. H., Schraw, G. J., & Norby, M. M. (2011). *Cognitive psychology and instruction*. Boston, MA: Pearson Education, Inc.

Brynjolfsson, E., & McAfee, A. (2012, January). *Race against the machine: How the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming* *employment and the economy.* Retrieved from MIT Sloan School of Management website: http://ebusiness.mit.edu/

Busby, K. B. (2017). *Texas science teacher characteristics and conceptual understanding of Newton's Laws of Motion* (Unpublished master's thesis). University of Texas at Dallas, Richardson, TX.

Byars-Winston, A., Estrada, Y., Howard, C., Davis, D., & Zalapa, J. (2010). Influence of social cognitive and ethnic variables on academic goals of underrepresented students in science and engineering: A multiple-groups analysis. *Journal of Counseling Psychology, 57*(2), 205-218. doi:10.1037/a0018608

Cakiroglu, J., Capa-Aydin, Y., & Hoy, A. (2012). Science teaching efficacy beliefs. In B. J. Fraser, K. Tobin & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 449-461) doi:10.1007/978-1-4020-9041-7_31

Campbell, S. (2012). For colored girls? Factors that influence teacher recommendations into advanced courses for black girls. *Review of Black Political Economy, 39*(4), 389-402. doi:10.1007/s12114-012-9139-1

Capps, D. K., Crawford, B. A., & Constas, M. A. (2012). A review of empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. *Journal of Science Teacher Education, 23*(3), 291-318. doi:10.1007/s10972-012-9275-2

Capps, D. K., & Crawford, B. A. (2013). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education, 24*(3), 497-526. doi:10.1007/s10972-012-9314-z

Caprara, G. V., Barbaranelli, C., Steca, P., & Malone, P. S. (2006). Teachers' self-efficacy beliefs as determinants of job satisfaction and students' academic achievement: A study at the school level. *Journal of School Psychology, 44*(6), 473-490. doi:10.1016/j.jsp.2006.09.001

Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher, 28*(2), 4-15. doi:10.3102/0013189X028002004

Coleman, J. S., Campbell, E., Hobson, C., McPartland, J., Mood, A., Weinfield, F., & York, R. (1966). *Equality of educational opportunity.* Washington, DC: US Congressional Printing Office.

Crowson, H., & Brandes, J. (2014). Predicting pre-service teachers' opposition to inclusion of students with disabilities: A path analytic study. *Social Psychology of Education, 17*(1), 161-178. doi:10.1007/s11218-013-9238-2

Daehler, K. R., Shinohara, M., & Folsom, J. (2011). *Making sense of SCIENCE: Force & motion for teachers of grades 6-8.* WestEd.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199. doi:10.3102/0013189X08331140

Devine, P. G. (1989). Stereotypes and prejudice: Their automatic and controlled components. *Journal of Personality and Social Psychology, 56*(1), 5-18. doi:10.1037/0022-3514.56.1.5

Devine, P. G., Forscher, P. S., Austin, A. J., & Cox, W. T. (2012). Long-term reduction in implicit race bias: A prejudice habit-breaking intervention. *Journal of Experimental Social Psychology, 48*(6), 1267-1278. doi:10.1016/j.jesp.2012.06.003

Diamond, B. S., Maerten-Rivera, J., Rohrer, R. E., & Lee, O. (2014). Effectiveness of a curricular and professional development intervention at improving elementary teachers' science content knowledge and student achievement outcomes: Year 1 results. *Journal of Research in Science Teaching, 51*(5), 635-658. doi:10.1002/tea.21148

Dovidio, J. F., Gaertner, S. L., & Kawakami, K. (2003). Intergroup contact: The past, present, and the future. *Group Processes & Intergroup Relations, 6*(1), 5-21.

Fisler, J., & Firestone, W. (2006). Teacher learning in a school-university partnership: Exploring the role of social trust and teaching efficacy beliefs. *The Teachers College Record, 108*(6), 1155-1185. Retrieved from http://www.tcrecord.org

Fives, H., & Buehl, M. M. (2010). Examining the factor structure of the teachers' sense of efficacy scale. *The Journal of Experimental Education, 78*(1), 118-134. doi: 10.1080/00220970903224461

Fredricks, J., McColskey, W., Meli, J., Mordica, J., Montrosse, B., & Mooney, K. (2011). *Measuring student engagement in upper elementary through high school: A description of 21 instruments* (REL 2011-no. 098). Retrieved from The University of North Carolina at Greensboro SERVE Center website: http://www.serve.org/RELSE.aspx

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945. doi:10.3102/00028312038004915

Gee, J. P. (2008). A sociocultural perspective on opportunity to learn. In P. A. Moss, D. C. Pullin, J. P. Gee, E. H. Haertel & L. J. Young (Eds.), *Assessment, equity, and opportunity to learn* (pp. 76-108). Cambridge, UK: Cambridge University Press.

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582. doi:10.1037/0022-0663.76.4.569

Gilbert, A., & Yerrick, R. (2001). Same school, separate worlds: A sociocultural study of identity, resistance, and negotiation in a rural, lower track science classroom. *Journal of Research in Science Teaching, 38*(5), 574-598. doi:10.1002/tea.1019

Goldhaber, D. (2002). The mystery of good teaching. *Education Next, 2*(1), 50-55. Retrieved from http://educationnext.org/the-mystery-of-good-teaching/

Heller, J. I. (2012). *Effects of Making Sense of SCIENCE [TM] professional development on the achievement of middle school students, including English Language Learners.* (Report No. 2012-4002). Retrieved from U.S. Department of Education, National Center for Education Evaluation and Regional Assistance website: https://eric.ed.gov/?id=ED530414

Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49*(3), 333-362. doi:10.1002/tea.21004

Heneman, H. G., III, Kimball, S., & Milanowski, A. (2006). *The teacher sense of efficacy scale: Validation evidence and behavioral prediction* (WCER Working Paper No. 2006-7). Retrieved from University of Wisconsin Center for Education Research website: http://www.wcer.wisc.edu/

Henry, G. (2010). Comparison group designs. In J. Wholey, H. Hatry & K. Newcomer (Eds.), *Handbook of practical program evaluation* (pp. 125-143). San Francisco, CA: Jossey-Bass.

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher, 30*(3), 141-158. doi: 10.1119/1.2343497

Hoy, A. W., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education, 21*(4), 343-356. doi:10.1016/j.tate.2005.01.007

Institute of Education Sciences. (1988). *National Education Longitudinal Study of 1988* [Data set]. Retrieved from https://nces.ed.gov/surveys/nels88/

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching, 42*(6), 668-690. doi:10.1002/tea.20069

Johnson, C. C. (2006). Effective professional development and change in practice: Barriers science teachers encounter and implications for reform. *School Science and Mathematics, 106*(3), 150-161. doi:10.1111/j.1949-8594.2006.tb18172.x

Joyce, N., & Harwood, J. (2014). Improving intergroup attitudes through televised vicarious intergroup contact: Social cognitive processing of ingroup and outgroup information. *Communication Research, 41*(5), 627-643. doi:10.1177/0093650212447944

Kanter, D. E., & Konstantopoulos, S. (2010). The impact of a project-based science curriculum on minority student achievement, attitudes, and careers: The effects of teacher content and pedagogical content knowledge and inquiry-based practices. *Science Education, 94*(5), 855-887. doi:10.1002/sce.20391

Kind, P. M. (2013). Conceptualizing the science curriculum: 40 years of developing assessment frameworks in three large-scale assessments. *Science Education, 97*(5), 671-694.

Klassen, R. M., Tze, V. M. C., Betts, S. M., & Gordon, K. A. (2011). Teacher efficacy research 1998-2009: Signs of progress or unfulfilled promise? *Educational Psychology Review, 23*(1), 21-43. doi:10.1007/s10648-010-9141-8

Lai, C. K., Marini, M., Lehr, S. A., Cerruti, C., Shin, J. L., Joy-Gaba, J. A., . . . Koleva, S. P. (2014). Reducing implicit racial preferences: A comparative investigation of 17 interventions. *Journal of Experimental Psychology: General, 143*(4), 1765-1785. doi:10.1037/a0036260

Lakshmanan, A., Heath, B. P., Perlmutter, A., & Elder, M. (2011). The impact of science content and professional learning communities on science teaching efficacy and standards-based instruction. *Journal of Research in Science Teaching, 48*(5), 534-551. doi:10.1002/tea.20404

Lee, B., Cawthon, S., & Dawson, K. (2013). Elementary and secondary teacher self-efficacy for teaching and pedagogical conceptual change in a drama-based professional development program. *Teaching and Teacher Education, 30*(0), 84-98. doi:10.1016/j.tate.2012.10.010

Leonard, J., Barnes-Johnson, J., Dantley, S., & Kimber, C. (2011). Teaching science inquiry in urban contexts: The role of elementary preservice teachers' beliefs. *Urban Review, 43*(1), 124-150. doi:10.1007/s11256-010-0173-7

Lotter, C., Rushton, G. T., & Singer, J. (2013). Teacher enactment patterns: How can we help move all teachers to reform-based inquiry practice through professional development? *Journal of Science Teacher Education, 24*(8), 1263-1291. doi:10.1007/s10972-013-9361-0

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S. E., & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, California: Corwin Press, Inc.

Lovelace, M. D., Reschly, A. L., Appleton, J. J., & Lutz, M. E. (2014). Concurrent and predictive validity of the student engagement instrument. *Journal of Psychoeducational Assessment, 32*(6) doi:10.1177/0734282914527548

Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*(5), 517-534. doi:10.1080/09500690121307

MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological Methods, 4*(1), 84-99. doi:10.1037/1082-989X.4.1.84

MacIsaac, D., & Falconer, K. (2002). Reforming physics instruction via RTOP. *The Physics Teacher, 40*(8), 479-485. doi:10.1119/1.1526620

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*(5), 877-907. doi:10.1002/sce.20441

Mazziotta, A., Mummendey, A., & Wright, S. C. (2011). Vicarious intergroup contact effects applying social-cognitive theory to intergroup contact research. *Group Processes & Intergroup Relations, 14*(2), 255-274. doi:10.1177/1368430210390533

Mazziotta, A., Rohmann, A., Wright, S. C., De Tezanos-Pinto, P., & Lutterbach, S. (2015). (How) does positive and negative extended cross-group contact predict direct cross-group contact and intergroup attitudes? *European Journal of Social Psychology, 45*(5), 653-667. doi:10.1002/ejsp.2110

McGee, J. R., & Wang, C. (2014). Validity-supporting evidence of the self-efficacy for teaching mathematics instrument. *Journal of Psychoeducational Assessment, 32*(5), 390-403. doi:10.1177/0734282913516280

McKinney, M., Sexton, T., & Meyerson, M. J. (1999). Validating the efficacy-based change model. *Teaching and Teacher Education, 15*(5), 471-485. doi:10.1016/S0742-051X(98)00051-1

McNeill, K. L., & Knight, A. M. (2013). Teachers' pedagogical content knowledge of scientific argumentation: The impact of professional development on K–12 teachers. *Science Education, 97*(6), 936-972. doi:10.1002/sce.21081

National Academies of Sciences, Engineering, and Medicine. (2015). *Science teachers' learning: Enhancing opportunities, creating supportive contexts.* Washington, DC: The National Academies Press.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads*. Washington, DC: The National Academies Press.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academies Press.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

National Science Foundation. (2014). *Science and engineering indicators 2014* (No. NSB 14-01). Retrieved from http://www.nsf.gov/

O'Donnell, C. L. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K–12 curriculum intervention research. *Review of Educational Research, 78*(1), 33-84. doi:10.3102/0034654307313793

O'Leary, Z. (2014). *The essential guide to doing research project.* (2nd ed.). Los Angeles, CA: Sage.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332. doi:10.3102/00346543062003307

Palmer, D. H. (2006). Sources of self-efficacy in a science methods course for primary teacher education students. *Research in Science Education, 36*(4), 337-353. doi:10.1007/s11165-005-9007-0

Pang, V. O., & Sablan, V. A. (1998). Teacher efficacy: How do teachers feel about their abilities to teach African American students. In M. E. Dilworth (Ed.), *Being responsive to cultural differences: How teachers learn* (pp. 39-58). Thousand Oaks, CA: Corwin Press.

Pearson, A. R., Dovidio, J. F., & Gaertner, S. L. (2009). The nature of contemporary prejudice: Insights from aversive racism. *Social and Personality Psychology Compass, 3*(3), 314-338. doi:10.1111/j.1751-9004.2009.00183.x

Penuel, W. R., Fishman, B. J., Yamaguchi, R., & Gallagher, L. P. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal, 44*(4), 921-958. doi:10.3102/0002831207308221

Pettigrew, T. F., & Meertens, R. W. (1995). Subtle and blatant prejudice in Western Europe. *European Journal of Social Psychology, 25*(1), 57-75. doi:10.1002/ejsp.2420250106

Pettigrew, T. F., & Tropp, L. R. (2011). *When groups meet: The dynamics of intergroup contact*. Philadelphia, PA: Psychology Press.

Pettigrew, T. F., Tropp, L. R., Wagner, U., & Christ, O. (2011). Recent advances in intergroup contact theory. *International Journal of Intercultural Relations, 35*(3), 271-280. doi:10.1016/j.ijintrel.2011.03.001

Piburn, M., & Sawada, D. (2000). *Reformed teaching observation protocol (RTOP) reference manual* (No. ACEPT-TR-IN00-3). Retrieved from Arizona State University, Arizona Collaborative for Excellence in the Preparation of Teachers website: http://eric.ed.gov/?id=ED447205

Plant, E. A., & Butz, D. A. (2006). The causes and consequences of an avoidance-focus for interracial interactions. *Personality & Social Psychology Bulletin, 32*(6), 833-846. doi:32/6/833 [pii]

Podell, D. M., & Soodak, L. C. (1993). Teacher efficacy and bias in special education referrals. *Journal of Educational Research, 86*, 247-253. doi:10.1080/00220671.1993.9941836

Powell-Moman, A., & Brown-Schild, V. (2011). The influence of a two-year professional development institute on teacher self-efficacy and use of inquiry-based instruction. *Science Educator, 20*(2), 47-53. Retrieved from http://eric.ed.gov/?id=EJ960637

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics.* Washington, DC: Executive Office of the President.

Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology, 104*(3), 700. doi:10.1037/a0027268

Rice, L., Barth, J., Guadagno, R., Smith, G., & McCallum, D. (2013). The role of social support in students' perceived abilities and attitudes toward math and science. *Journal of Youth & Adolescence, 42*(7), 1028-1040. doi:10.1007/s10964-012-9801-8

Riegle-Crumb, C., & Humphries, M. (2012). Exploring bias in math teachers' perceptions of students' ability by gender and race/ethnicity. *Gender & Society, 26*(2), 290-322. doi:10.1177/0891243211434614

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi:10.1002/sce.3730740605

Ritter, J. M., Boone, W. J., & Rubba, P. A. (2001). Development of an instrument to assess prospective elementary teacher self-efficacy beliefs about equitable science teaching and learning (SEBEST). *Journal of Science Teacher Education, 12*(3), 175-198. doi:10.1023/A:1016747713585

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. *Econometrica, 73*(2), 417-458. doi:10.1111/j.1468-0262.2005.00584.x

Rodenborg, N. A., & Boisen, L. A. (2013). Aversive racism and intergroup contact theories: Cultural competence in a segregated world. *Journal of Social Work Education, 49*(4), 564-579. doi:10.1080/10437797.2013.812463

Ross, K. (2014). Professional development for practicing mathematics teachers: A critical connection to english language learner students in mainstream USA classrooms. *Journal of Mathematics Teacher Education, 17*(1), 85-100. doi:10.1007/s10857-013-9250-7

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Los Angeles, CA: Sage Publications Ltd.

Saunders, R. P., Evans, M. H., & Joshi, P. (2005). Developing a process-evaluation plan for assessing health promotion program implementation: A how-to guide. *Health Promotion Practice, 6*(2), 134-147. doi:10.1177/1524839904273387

Schunk, D. H. (2008). Cognitive information processing system. *Learning theories: An educational perspective* (5th ed., pp. 130-182). Upper Saddle River, N.J.: Pearson.

Shadish, W., Cook, T., & Campbell, D. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.

Smith, J. A., McPherson, M., & Smith-Lovin, L. (2014). Social distance in the united states sex, race, religion, age, and education homophily among confidants, 1985 to 2004. *American Sociological Review, 79*(3), 432-456. doi:10.1177/0003122414531776

Soodak, L. C., & Podell, D. M. (1994). Teachers' thinking about difficult-to-teach students. *Journal of Educational Research, 88*(1), 44. doi:10.1080/00220671.1994.9944833

Stephan, W. G., & Stephan, C. W. (1985). Intergroup anxiety. *Journal of Social Issues, 41*(3), 157-175. doi:10.1111/j.1540-4560.1985.tb01134.x

Sue, D. W., Bernier, J. E., Durran, A., Feinberg, L., Pedersen, P., Smith, E. J., & Vasquez-Nuttall, E. (1982). Position paper: Cross-cultural counseling competencies. *The Counseling Psychologist, 10*(2), 45-52. doi:10.1177/0011000082102008

Sue, D. W. (2001). Multidimensional facets of cultural competence. *The Counseling Psychologist, 29*(6), 790-821. doi:10.1177/0011000001296002

Sue, D. W. (2004). Whiteness and ethnocentric monoculturalism: Making the" invisible" visible. *American Psychologist, 59*(8), 761. doi:10.1037/0003-066X.59.8.761

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980. doi:10.1002/1098-2736(200011)37:93.0.CO;2-0

Swarat, S., Ortony, A., & Revelle, W. (2012). Activity matters: Understanding student interest in school science. *Journal of Research in Science Teaching, 49*(4), 515-537. doi:10.1002/tea.21010

Thornton, R. K., & Sokoloff, D. R. (1998). Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture curricula, *American Journal of Physics, 66*(4), 338-352. doi: 10.1119/1.18863

Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School Science & Mathematics, 100*(7), 374-379. doi:10.1111/j.1949-8594.2000.tb18179.x

Tschannen-Moran, M., & McMaster, P. (2009). Sources of self-efficacy: Four professional development formats and their relationship to self-efficacy and implementation of a new teaching strategy. *The Elementary School Journal, 110*(2), 228-245. doi:10.1086/605771

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805. doi:10.1016/S0742-051X(01)00036-1

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202-248. doi:10.3102/00346543068002202

Tschannen-Moran, M., & Johnson, D. (2011). Exploring literacy teachers' self-efficacy beliefs: Potential sources at play. *Teaching and Teacher Education, 27*(4), 751-761. doi:10.1016/j.tate.2010.12.005

Tschannen-Moran, M., & Hoy, A. W. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23*(6), 944-956. doi:10.1016/j.tate.2006.05.003

University of Chicago Consortium on Chicago School Research (2014). CPS My Voice, My School Student Survey [Survey Instrument]. Retrieved from http://ccsr.uchicago.edu.

Urquhart, M. L. (n.d.). Texas Regional Collaborative physics assessment. [Measurement instrument]. Unpublished instrument. Richardson, TX: University of Texas at Dallas.

U.S. Census Bureau. (2013). *Disparities in STEM employment by sex, race, and hispanic origin.* (No. ACS-24). Retrieved from http://www.census.gov/library/publications.2013.html

van Driel, J. H., Meirink, J., Van Veen, K., & Zwart, R. (2012). Current trends and missing links in studies on teacher professional development in science education: A review of design features and quality of research. *Studies in Science Education, 48*(2), 129-160. doi:10.1080/03057267.2012.738020

van Uden, J. M., Ritzen, H., & Pieters, J. M. (2013). I think I can engage my students: Teachers' perceptions of student engagement and their beliefs about being a teacher. *Teaching & Teacher Education, 32*, 43-54. doi:10.1016/j.tate.2013.01.004

Voci, A., & Hewstone, M. (2003). Intergroup contact and prejudice toward immigrants in Italy: The mediational role of anxiety and the moderational role of group salience. *Group Processes & Intergroup Relations, 6*(1), 37-54. doi:10.1177/1368430203006001011

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Woodcock, A., Hernandez, P. R., Estrada, M., & Schultz, P. W. (2012). The consequences of chronic stereotype threat: Domain disidentification and abandonment. *Journal of Personality & Social Psychology, 103*(4), 635-646. doi:10.1037/a0029120

Wright, S. C., Aron, A., McLaughlin-Volpe, T., & Ropp, S. A. (1997). The extended contact effect: Knowledge of cross-group friendships and prejudice. *Journal of Personality and Social Psychology, 73*(1), 73. doi:10.1037/0022-3514.73.1.73

Yerrick, R., Parke, H., & Nugent, J. (1997). Struggling to promote deeply rooted change: The “filtering effect" of teachers' beliefs on understanding transformational views of teaching science. *Science Education, 81*(2), 137-159. doi:10.1002/(SICI)1098-237X(199704)81:23.0.CO;2-G

Youngs, C. S., & Youngs, G. A. (2001). Predictors of mainstream teachers' attitudes toward ESL students. *TESOL Quarterly, 35*(1), 97-120. doi:10.2307/3587861

Curriculum Vitae

Ricardo Romanillos was born in Austin, Texas in 1979. Ricardo started his undergraduate studies at Texas A&M University in College Station majoring in Biomedical Science. After two years he transferred to Southwestern University and completed a BA in Chemistry with a minor in Biology. As part of his capstone project, in 2001 he completed a National Science Foundation Research Experience for Undergraduates at Syracuse University, focused on Nanochemistry.

In 2004, Ricardo began his education career as a 10^{th} grade science teacher within the District. He completed his Masters in Educational Administration at the University of Texas at Arlington in 2008 as a member of the Urban Collaborative for Educational Leadership. Through this program he obtained his principal certificate.

In 2014, Ricardo began his EdD in Education at Johns Hopkins University with Carolyn Parker, PhD as his adviser.